ASSESSMENT OF BALANCED AND INDIGENOUS POPULATIONS IN LAKE NORMAN NEAR MARSHALL STEAM STATION

NPDES Permit No. NC0004987

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EXECUTIVE SUMMARY

Annual monitoring of physicochemical characteristics and assessments of macroinvertebrate and fish populations at selected locations in Lake Norman continued through 2013, in accordance with Duke Energy's agreement with the North Carolina Department of Environment and Natural Resources. This report presents data collected from 2009 through 2013. Results of data analyses completed since submittal of the previous report in 2008 are reported and support renewal of the existing permitted thermal limits for Marshall Steam Station (MSS).

The continuous operation of MSS from 2009 through 2013 was similar to previous years. Monthly average discharge water temperatures at MSS were in compliance with National Pollution Discharge Elimination System (NPDES) permitted thermal limits of 93.9 °F (34.4 °C) from July 1 through October 31, and 91.9 °F (33.3 °C) the rest of each year, over this five-year period.

Sampling of macroinvertebrate communities continued during 2009 – 2013. Water temperatures and dissolved oxygen levels, measured at each location since 2005, do not suggest any negative impact to the benthic communities. Macroinvertebrate data exhibit substantial variability; however, the variability is consistent with that observed for historical data. Although taxa numbers were somewhat lower during 2009 – 2013 as compared to 2004 – 2008, macroinvertebrate densities were generally similar between the two study periods. Current study results indicate that, overall, the macroinvertebrate densities and taxa diversity observed during 2009 – 2013 at locations uplake, downlake, and in the vicinity of MSS are indicative of balanced and indigenous macroinvertebrate populations.

A diverse fish community was present in the littoral surveys of Lake Norman near MSS from 2009 to 2013. Spring and summer electrofishing surveys documented 28 and 19 species, respectively, both numerically dominated by centrarchids, especially bluegill. Pollution-tolerant species comprised less of the spring MSS fish population relative to the reference area, and comprised only 16.6% of individuals collected during summer surveys. The assorted fish species typically found in Lake Norman near MSS encompass multiple trophic guilds (i.e., insectivores, omnivores, and piscivores) supporting a balanced fish community. Non-indigenous species such as spotted bass and green sunfish are abundant near MSS, but are also prevalent throughout Lake Norman.

Annual hydroacoustic estimates from fall 2009 to 2013 showed the regular availability of pelagic forage fish near MSS. Fall purse seine surveys indicate that threadfin shad continue to dominate the Lake Norman forage fish community with a consistent alewife composition of approximately 5% after 2004. Based on the catch per unit effort of littoral fish during spring, total length distributions of resident important species during summer, and the regular availability of forage fish, it is concluded that the thermal discharge of MSS has not impaired the Lake Norman fish community.

Comparison of MSS operation and environmental monitoring data indicate that balanced and indigenous populations of macroinvertebrates and fish continue to exist in Lake Norman in the vicinity of MSS. This supports a conclusion that the present thermal limits should be maintained when the MSS NPDES permit is renewed.

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CHAPTER 1

INTRODUCTION

Annual monitoring of physicochemical characteristics and assessments of macroinvertebrate and fish populations at selected locations in Lake Norman continued from January 2009 through December 2013 (Table 1-1 and Figure 1-1), in accordance with Duke Energy's agreement with the North Carolina Department of Environment and Natural Resources (NCDENR). Physicochemical and biological data were collected at locations near Marshall Steam Station (MSS) and included a location upstream of the facility (Location A), two sites within the immediate projected impact of MSS's discharge (Locations B and C) and three downstream recovery sites (Locations D, E, and F), presumably outside the influence of the effluent plume (Figure 1-1).

The objectives of this on-going monitoring program are to provide an assessment of the balanced and indigenous nature of the biological populations in Lake Norman with respect to the thermal discharge from MSS and evaluate renewal of thermal limits at the station. The thermal limit for MSS is a monthly average discharge (i.e., end-of-pipe) temperature limit of 93.9 °F (34.4 °C) from July 1 through October 31, and 91.9 °F (33.3 °C) the rest of each year.

Regulatory review of past studies has determined, pursuant to Section 316(a) of the Clean Water Act, that the thermal discharge of MSS ensures the protection and propagation of balanced, indigenous populations in Lake Norman. This report presents data collected since submittal of the previous summary reports (Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a) and includes data collected from 2009 through 2013. These data were also compared with other past and present on-going environmental monitoring programs conducted in this watershed.

Table 1-1. Description of Lake Norman sampling locations in the vicinity of MSS, Catawba County, NC.

Report Location Designation	Duke Energy Location No.	Location Description	County	Approximate River Miles Upstream of Cowans Ford Hydro	Longitude	Latitude
A	15.5	The first cove on the left upstream from MSS intake cove.	Catawba	16.9	-80.9461	35.6163
B	14.7	First cove along northern shoreline going into the MSS CCW discharge cove.	Catawba	13.9	-80.9573	35.5942
C	14.5	Inside MSS discharge canal.	Catawba	13.9	-80.9644	35.5951
D	13.0	Large cove halfway between channel markers 14 and 15 on the west side of the channel.	Catawba	12.7	-80.9527	35.5753
E	19.0	Cove formerly proposed for power plant site intake or discharge.	Iredell	9.0	-80.9301	35.5297
F	34.0	Left shoreline, approximately 100 m uplake of Channel Marker 13.	Catawba	11.5	-80.9569	35.5544

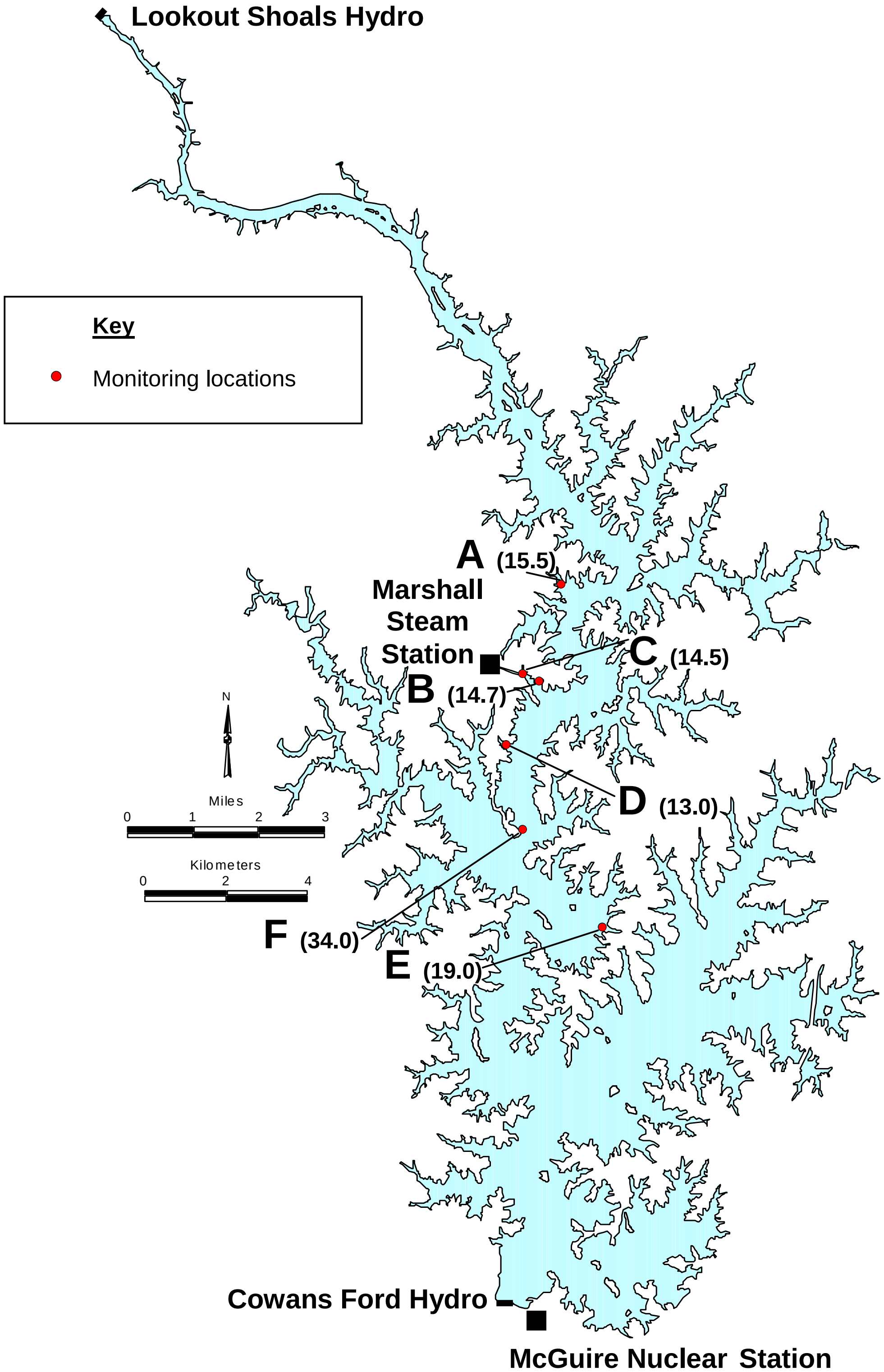

Figure 1-1. Sampling locations on Lake Norman. Duke Energy historical sampling location numbers are provided in parentheses.

CHAPTER 2

STATION OPERATION

BACKGROUND INFORMATION

Marshall Steam Station (MSS) is located on the western shore of Lake Norman (Figure 1-1) just north of Charlotte, NC, in Catawba County. Its four generating units have a combined operating capability of 2,090 MWE-net. Units 1 and 2 are each rated at 385 MWE-net and began commercial operation in 1965 and 1966, respectively. Units 3 and 4 are each rated at 660 MWE-net and began commercial operation in 1969 and 1970, respectively.

MSS receives once-through condenser cooling water (CCW) from below a skimmer wall located at the mouth of a 1.3-mi- (2.1-km-) long cove. The surface area of the cove is about 200 ac (81 ha) and its volume is approximately 250 million ft^3 (7 million m^3). The skimmer wall was designed to retain the upper 60 ft (18.3 m) of water on the lake side of the wall at full pond. The opening below the skimmer wall through which the station CCW is withdrawn is about 10 ft (3 m) high and 270 ft (82.3 m) wide.

Units 1 and 2 each have two condenser cooling water pumps, and Units 3 and 4 each have three condenser cooling water pumps. Typically, only one pump per generating unit is used during the cool winter months or when the unit is operating at reduced load. During the warmer summer months when units are operating at full-load, either two or three pumps per unit are generally used, depending on which units are operating. Maximum rates of cooling water flow are 423 cfs (12.0 cms) each for Units 1 and 2, and 709 cfs (20.1 cms) each for Units 3 and 4. Thus, the maximum possible station CCW flow rate is 2,264 cfs (64.1 cms). Under one-pump-per-unit operation, the maximum CCW flow rate for the entire station is 1,230 cfs (34.8 cms). Refer to Table 2-1 for a listing of CCW flow rates for each unit under one-, two-, and three-pump operation.

The CCW from MSS is discharged into a one-mile- (1.609 m-) long cove. The discharge cove varies from a width of 75 ft (22.9 m) and depth of 33 ft (10.1 m) at the discharge structure to a width of 850 ft (259.1 m) and a depth of 50 ft (15.2 m) at the mouth of the discharge cove. The total area of the discharge cove is about 75 ac (30.4 ha).

Lake Norman was recently classified as oligotrophic, or of low nutrient content and algal productivity, based on year 2012 water quality monitoring performed by the North Carolina Department of Environment and Natural Resource (NCDENR) in association with the Lake Assessment Program, which is conducted on a five-year cycle (NCDENR 2013). This classification is consistent with earlier assessments (NCDENR 2003, 2008) indicating that despite increases in population growth in the upper Catawba River Basin over the last two decades, Lake Norman continues to effectively assimilate nutrient inputs into the reservoir from the surrounding watershed.

Nutrient and algal biomass data, collected monthly from May through September 2012, ranged from low to moderate levels, with higher values reported in the upper portions of the reservoir, combined with progressively decreasing concentrations in the lower sections of the reservoir (NCDENR 2013). Turbidity levels were also low and Secchi depths ranged from 1.0 to 4.0 m, indicating very good water clarity. Surface dissolved oxygen (DO) concentrations ranged from 5.8 to 8.8 mg/L and surface water temperatures ranged from 76.1 °F to 94.28 °F (24.5 to 34.6 °C). Overall, these results are similar to those previously reported by the State (NCDENR 2003, 2008) and to other studies (MCDEP 2003, 2007; Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2008, 2009d, 2011, 2012, 2013) on Lake Norman.

THERMAL DATA

Duke Energy operates MSS as a base-load generating facility and station operation during the period from January 2009 through December 2013 was similar to previous years (Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a). From 2009 through 2013, MSS was operated continuously with peak pumping of CCW during the summer.

The seasonal cycle of discharge water temperatures at MSS over the period January 2009 through December 2013 was also similar to that observed in previous years (Figure 2-1; Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a). Monthly average discharge water temperatures at MSS were in compliance with NPDES-permitted thermal limits of 93.9 °F (34.4 °C) from July 1 through October 31, and 91.9 °F (33.3 °C) the rest of each year, over this five-year time period (Figure 2-1). Discharge water temperatures ranged from a minimum monthly average of 62.4 °F (16.9 °C) in February 2011 to a maximum monthly average of 93.9 °F (34.4°C) in August 2011 (Figure 2-1). Discharge temperatures are linked to a combination of local meteorological conditions and electrical generation.

CONCLUSIONS

MSS operated continuously from 2009 through 2013 and station operation during this period was similar to previous years. Monthly average discharge water temperatures at MSS were in compliance with NPDES-permitted thermal limits of 93.9 °F (34.4 °C) from July 1 through October 31, and 91.9 °F (33.3 °C) the rest of each year, over this five-year period.

Table 2-1. Marshall Steam Station CCW flow rate for each unit for one-, two-, and three-pump operation.

Unit Number	One-Pump CCW Flow Rate (cfs)	Two-Pump CCW Flow Rate (cfs)	Three-Pump CCW Flow Rate (cfs)
1	281	423	(423)[1]
2	281	423	(423)[1]
3	334	564	709
4	334	564	709
Station Total	1,230	1,974	2,264

[1] Units 1 and 2 have only two CCW pumps available.

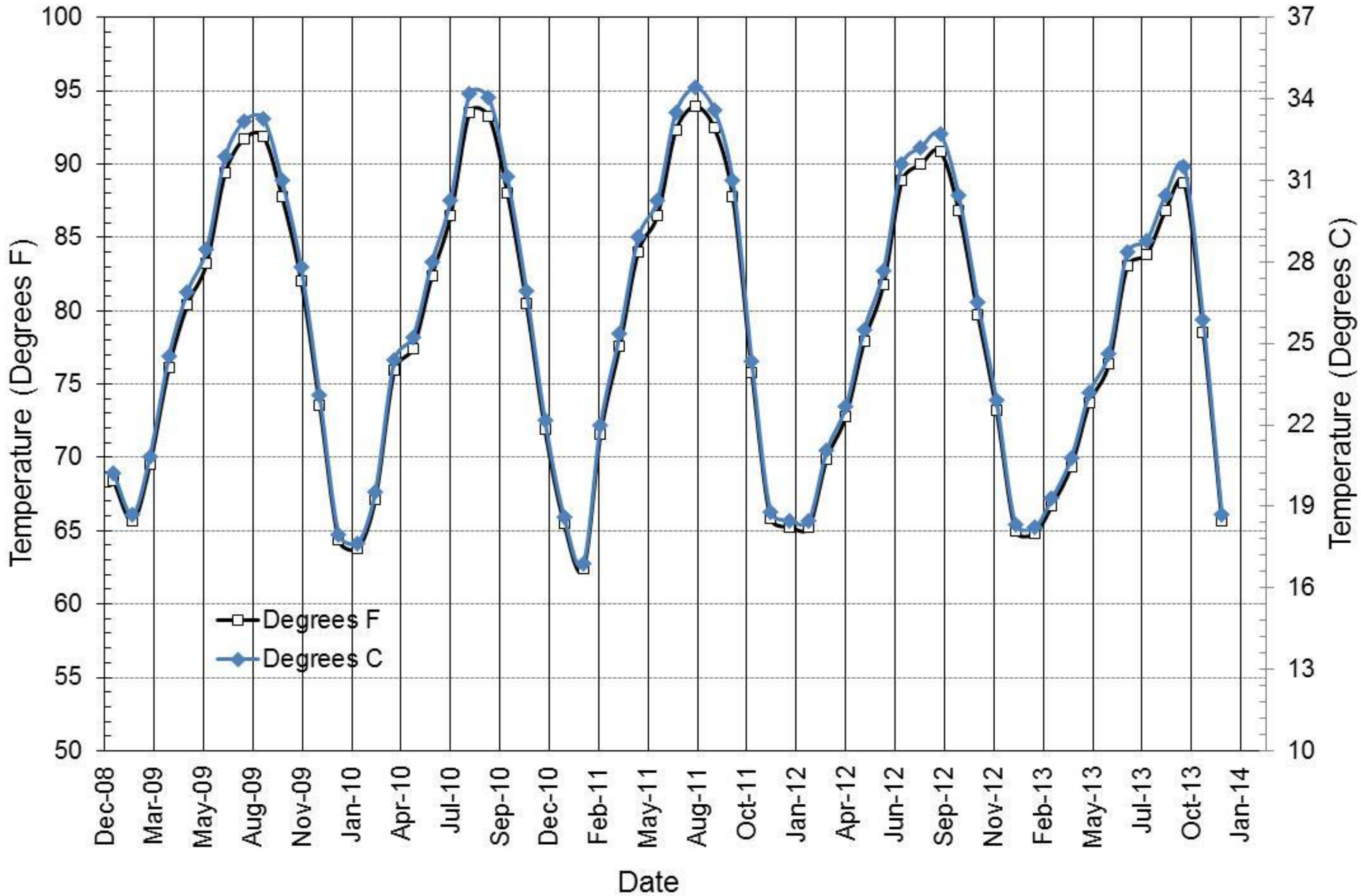

Figure 2-1. The monthly average water temperature of the condenser cooling water discharged from MSS from January 1, 2009 through December 31, 2013.

CHAPTER 3

MACROINVERTEBRATES

MATERIALS AND METHODS

Benthic macroinvertebrate sampling was conducted annually in the summer of each year from 2009 to 2013 as part of the continuing monitoring program for Marshall Steam Station (MSS). As in previous years, samples were collected from four locations on Lake Norman: Location A (uplake of MSS), Location B (MSS discharge canal), Location F (just north of Channel Marker 13), and Location E (downlake of MSS) (Table 1-1 and Figure 1-1).

A petite Ponar dredge (15.3 x 15.3 cm) was used to collect five sample replicates at each location. Samples were collected at depths ranging from 2 to 3 m to bracket the depth of peak benthic abundance commonly associated with lakes and reservoirs (Brinkhurst 1974). Samples were washed through a 500-µm mesh sieve and individually preserved with 70% ethanol containing rose bengal stain. The substrate at each location was visually identified and recorded during the sieving process. Organisms were sorted in the laboratory and identified to the lowest practicable taxon. Macroinvertebrate densities were determined from each replicate, averaged and expressed in No./m^2.

The NCDENR requested additional analyses to be performed based on their review and response to the 2009 MSS report (Duke Energy 2009a; NCDENR letter of November 19, 2009). In addition to current analyses, NCDENR requested additional information on the following groups: Non-chironomid Diptera, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Megaloptera, Odonata, Crustacea, and Mollusca. Ephemeroptera/Plecoptera/Trichoptera (EPT) densities and taxa richness were also requested for additional assessment of the balanced and indigenous nature of the benthic community in the vicinity of MSS. No Coleoptera, or Crustacea have been collected at locations in the vicinity of MSS in the last 10 years and Plecoptera were only collected once during 2006 (Duke Energy 2009a). The only Mollusca collected were represented by *Corbicula* and *Spheariidae*, which are addressed separately in this report.

Beginning in 2005, in conjunction with macroinvertebrate sampling, a calibrated YSI Model 55 handheld DO meter was used to measure water temperature and DO just above the sediment at each of the four sampling locations. Starting in 2008, water temperatures and DO concentrations were measured, in situ, using a calibrated Hach® HQ40d water quality meter.

RESULTS AND DISCUSSION

Substrate

Substrates at Lake Norman sampling locations consisted of varying amounts of silt, sand, organic material, and clay. Silt was the predominant component at most locations, while comparatively high amounts of clay and sand were often observed in the substrates at Location E (Table 3-1).

Water Quality

Water temperatures observed during sampling from 2009 to 2013 ranged from 26.4 to 31.1 °C (Table 3-2). No consistent spatial patterns among maximum and minimum temperatures were observed during 2009 – 2013 and temperatures at Location B in the discharge were not notably different from those at other sampling locations.

The DO concentrations observed during 2009 – 2013 ranged from 1.0 to 8.7 mg/L (Table 3-2). Minimum DO concentrations were most often recorded from Location B in the discharge, while maximum DO readings were most often observed at Location A. The comparatively high DO recorded in 2013 may have been due to the unusually cool and wet summer of that year, with a much higher level of water column mixing. Additionally, with the cool, wet conditions, MSS may have minimized operations. Minimum DO concentrations at the discharge were likely due to low-DO water from beneath the skimmer wall being entrained through MSS during summer periods of 2009 through 2012.

Taxa

The number of macroinvertebrate taxa collected at a location is typically a good indicator of the overall diversity and the presence of a balanced indigenous population. Taxa abundance from 2009 to 2013 varied temporally and spatially at Lake Norman (Tables 3-3 through 3-7 and Figure 3-1). Taxa abundance during 2009 – 2013 was slightly lower than during the 2004 – 2008 reporting period (Figure 3-1), with total taxa numbers ranging from 18 to 36. Temporally, taxa numbers generally declined from 2009 through 2011, and then increased between 2011 and 2013. Spatial maxima occurred at Location A in 2013, Location B in 2011, and Location F in 2009, 2010, and 2012. Spatial minima occurred at Location E in 2009, 2010, and 2011, and Location B in 2012 and 2013.

Density

During 2009 – 2013, overall annual macroinvertebrate densities varied substantially temporally and spatially, and total densities were not appreciably different from densities during 2004 – 2008 (Tables 3-3 through 3-7 and Figure 3-2). Macroinvertebrate densities in Duke Energy's piedmont reservoirs are typically characterized by very high temporal and spatial variability (Duke Energy 2009a, 2009b, 2009c, 2011). This was also true of the densities of major taxonomic groups. Variability may be due to macroinvertebrates and sediments not being homogenously distributed on the substrates. High spatial and temporal variability can often mask short-term or long-term environmental impacts. Total densities ranged nearly an order of magnitude from minimum to maximum during 2009 – 2013. As with total taxa numbers, densities generally declined from 2009 through 2011, and then increased between 2011 and 2013. No consistent trend in spatial maxima was observed. Minimum spatial densities were consistently recorded from Location E well downlake of the MSS discharge (Figure 3-2). This was also the case during the 2004 – 2008 reporting period. It is unlikely that thermal impacts would be manifested at this location to a greater extent than at other locations since no consistent temporal or spatial temperature patterns were observed (Table 3-2). The predominance of less suitable substrates (clay in 2009 and 2010, sand in 2011 – 2013), as well as substrate patchiness, may have resulted in less suitable conditions for benthic macroinvertebrate colonization and growth at Location E (Table 3-1).

Major Taxonomic Groups

Considerable variability was also observed among major taxonomic groups. Oligochaeta densities during 2009 – 2013 varied nearly 50 times from minimum to maximum (Tables 3-3 through 3-7 and Figure 3-3). Oligochaetes were dominant in Lake Norman macroinvertebrate samples approximately 40% of the time. Maximum oligochaeta densities occurred at Location B in 2009, 2012, and 2013, and they were most abundant at Locations

A and F in 2010 and 2011, respectively. Higher oligochaeta densities at the discharge were indicative of tolerance for the low DO conditions typically observed there. The lowest oligochaeta densities consistently occurred at Location E (Figure 3-3). The majority of oligochaetes at all locations were the Tubificidae. Milligan (1997) stated that Tubificids frequently form dense populations in organically enriched habitats with a silty or muddy substrate tending toward anoxic conditions. Sediment composition at most locations consisted primarily of silt with organic matter and some sand, while at Location E, clay and sand were often among primary components (Table 3-1). Oligochaeta densities showed an overall decline from 2009 through 2011, followed by increases between 2012 and 2013.

The family Chironomidae represents a ubiquitous and widespread group of insects that can be found in a broad variety of aquatic habitats. The Chironomidae tended to show temporal and spatial variability at Lake Norman, and densities during 2009 – 2013 were similar to those observed during 2004 – 2008 (Figure 3-4). Densities ranged nearly six fold from minimum to maximum during 2009 – 2013 (Tables 3-3 through 3-7 and Figure 3-4). Chironomids constituted the most abundant taxonomic group at Lake Norman locations, and were dominant in approximately 60% of samples collected during 2009 – 2013. Maximum chironomid densities were observed at Location F in 2009, 2010, and 2012; while maxima at Locations A and B were observed in 2011 and 2013, respectively. Minimum densities were most often recorded from Location E.

Non-chironomid dipteran taxa densities showed considerable variability, ranging from 0/m^2 up to over 600/m^2 (Tables 3-3 through 3-7 and Figure 3-5). In most cases, total densities were less than 50/m^2. Densities tended to decline from 2009 through 2012, followed by an increase in 2013. No consistent spatial trends were observed.

Mean annual densities of *Corbicula* during 2009 – 2013 tended to be lower than those recorded during 2004 – 2008 (Figure 3-6). Spatial maxima most often occurred at Location F, while minimum densities were generally recorded from Location B. Data from the previous 10 years show there has been an apparent long-term decline in clam densities since 2008. Densities ranged from 0/m^2 to over 1,300/m^2 and during most years from 2009 through 2013, *Corbicula* densities were less than 500/m^2 (Tables 3-3 through 3-7).

Mean annual densities of Ephemeroptera during 2009 – 2013 were generally higher than those of 2004 – 2008 (Figure 3-7), ranging from 0/m^2 to nearly 400/m^2 (Tables 3-3 through 3-7). The overall trend seemed to indicate increased densities through 2011, followed by a decline through 2013. This was the opposite of what was observed among total densities at Lake Norman locations (Figure 3-2). No consistent spatial trends were observed (Figure 3-7).

Mean annual densities of Trichoptera during 2009 – 2013 were somewhat higher than during the previous five-year sampling period (Figure 3-8). Densities ranged from $0/m^2$ to over $100/m^2$ (Tables 3-3 through 3-7). No consistent temporal or spatial trends were observed among Trichoptera during 2009 – 2013.

The presence and abundance of Megaloptera and *Spheariidae* were sporadic during 2009 – 2013 (Figures 3-9 and 3-10). Megaloptera were only observed at Locations A and E, and densities were always less than $45/m^2$ (Tables 3-3 through 3-7). Overall densities were slightly higher during 2009 – 2013 than during the previous five-year period (Figure 3-9). No *Spheariidae* were collected in 2010 or 2011, and overall densities were lower during 2009 – 2013 than during 2004 – 2008 (Figure 3-10). Odonata were observed infrequently during 2004 – 2008 and no odonates were collected in Lake Norman samples during 2009 – 2013 (Tables 3-3 through 3-7).

<u>EPT Densities and Taxa Richness</u>

Densities of EPT taxa (Ephemeroptera and Trichoptera only, no Plecoptera were collected during 2009 – 2013) showed slightly higher densities during 2009 – 2013 than during 2004 – 2008 (Figure 3-11). EPT densities ranged up to over 45 fold from minimum to maximum during 2009 – 2013 (Tables 3-3 through 3-7). Generally, densities appeared to increase between 2009 and 2011, and then decline from 2012 to 2013. No consistent spatial trends were observed among EPT densities.

The EPT taxa richness values during 2009 – 2013 were typically higher than during the 2004 – 2008 sampling period (Figure 3-12). Most taxa richness ratings ranged from Fair to Excellent. Excellent EPT richness was observed at Location A in 2010, Location B in 2011, and Location F in 2011 and 2013. Poor richness ratings were recorded from Location B in 2009 and 2012, at Location E in 2010 and 2011, and at Location F in 2012. Low ratings at Location B (the discharge) may have been due to low DO conditions (Table 3-2), while the low ratings at Location E may have resulted from substrate patchiness and occasionally poor substrate conditions. EPT richness ratings appeared to increase substantially from 2009 through 2011, and then decline at all but Location E in 2012. Ratings increased again through 2013 at all but Location E.

CONCLUSIONS

Substrates at Lake Norman locations generally consisted of varying proportions of silt, sand, organic matter and clay with somewhat higher composition of clay and sand at Location E. The water quality parameters (temperature and DO) taken at the time of macroinvertebrate collections did not suggest any negative impact to the benthic communities. The only water quality issue may be related to the low DO values at most times of sampling at Location B, which could be expected since MSS withdraws its condenser cooling water from the bottom of Lake Norman via an intake canal skimmer wall (Chapter 2).

The common characteristic among macroinvertebrate communities at Lake Norman locations was the high variability among total densities and the densities of major taxonomic groups. This is common at sampling locations on other piedmont reservoirs in North Carolina. Although taxa numbers were somewhat lower during 2009 – 2013 as compared to 2004 – 2008, macroinvertebrate densities were generally similar between the two study periods. Both taxa numbers and densities showed an apparent decline from 2009 through 2011, followed by an increase from 2011 through 2013. No consistent spatial trends in maximum densities were observed. Minimum taxa numbers were recorded at Location E during three of the five years represented, while minimum densities were consistently reported from this location.

Chironomids were the most abundant macroinvertebrates at most locations during 2009 – 2013, while oligochaetes constituted the second most abundant forms. The majority of oligochaetes were Tubificids, which often formed dense concentrations in organically enriched habitats. Chironomid maxima were most often recorded from Location F, while maximum oligochaete densities (mostly Tubificids) were most often recorded from Location B in the discharge. Comparatively high oligochaeta densities in the discharge were likely due to their tolerance of the low DO conditions observed there. Minimum densities of both groups typically occurred at Location E. Low total densities, as well as minimum densities of chironomids and oligochaetes at this location, may have been due to less suitable substrate and/or substrate patchiness.

Non-chironomid Diptera, *Corbicula*, Ephemeroptera, and Trichoptera densities showed considerable variability and few consistent spatial or temporal patterns were observed during 2009 – 2013. The presences and abundances of Megaloptera and *Spheariidae* were extremely sporadic during the recent five-year monitoring period, and no odonates were collected during 2009 – 2013.

EPT taxa richness and densities during 2009 – 2013 were typically higher than in 2004 – 2008 and most richness ratings during 2009 – 2013 were from Fair to Excellent. Poor ratings were observed occasionally from the discharge location and from Location E. This was likely due to low DO conditions in the discharge and possible poor substrate or substrate patchiness at Location E.

Some impacts were noted at the MSS discharge location due to low DO conditions; however, based on macroinvertebrate densities, total taxa numbers, and EPT densities and taxa richness observed during 2009 – 2013, it is concluded that thermal discharges from MSS have not impaired macroinvertebrate communities in the vicinity of the station.

Table 3-1. General descriptions of the substrate found at Locations A, B, F, and E in the vicinity of MSS from July 2009 – 2013. Substrates are listed in order of the most prevalent type first. Organic matter (om) is typically composed of small sticks, leaf and/or grass fragments, etc.

Year	Location A	Location B	Location F	Location E
2009	silt om sand	silt clay om sand	silt om sand	clay silt om sand
2010	silt om sand	silt sand om	silt om sand	silt clay om
2011	silt sand om	silt sand om	silt om sand	silt sand
2012	silt sand om	silt sand	om silt	silt sand om
2013	silt om	silt om sand	silt sand om	silt sand om

Table 3-2. DO and temperature measured near the sediments at the time of macroinvertebrate collection from locations A, B, F, and E from July 2009 – 2013.

Year	Location A	Location B	Location F	Location E
2009	8.3 mg/L 28.1 °C	1.6 mg/L 27.1 °C	7.1 mg/L 27.5 °C	8.2 mg/L 26.4 °C
2010	8.6 mg/L 29.9 °C	1.3 mg/L 31.1 °C	7.0 mg/L 30.2 °C	8.2 mg/L 30.0 °C
2011	7.7 mg/L 28.0 °C	1.0 mg/L 28.2 °C	7.1 mg/L 29.0 °C	7.7 mg/L 29.2 °C
2012	7.5 mg/L 30.1 °C	1.8 mg/L 29.4 °C	8.1 mg/L 30.0 °C	8.0 mg/L 30.8 °C
2013	8.7 mg/L 28.7 °C	5.3 mg/L 28.6 °C	8.2 mg/L 28.5 °C	7.9 mg/L 28.0 °C

Table 3-3. Macroinvertebrate taxa and densities (No./m^2) from each Lake Norman sampling location during summer sampling in 2009.

2009	Locations			
Taxa	**A**	**B**	**F**	**E**
Diptera				
Ceratopogonidae				
Palpomyia-Bezzia complex	77	17	17	17
Chaoboridae				
Chaoborus spp.		585	112	26
Chironomidae-Chironominae				
Chironomus spp.		9		52
Cladopelma spp.		17		112
Cladotanytarsus spp.	732	17	887	
Cryptochironomus spp.	26	9	138	17
Cryptotendipes spp.	34	362	189	60
Dicrotendipes neomodestus		26		
Nilothauma spp.			9	
Pagastiella spp.	17	77	26	9
Paralauterborniella nigrohalteralis		9	9	9
Paratendipes spp.				9
Polypedilum halterale gr.		250	17	43
Polypedilum scalaenum gr.	9	9	26	
Pseudochironomus spp.		17	112	
Stempellina spp.			26	17
Stenochironomus spp.			17	43
Stictochironomus spp.	258	121	103	
Tanytarsus spp.	310	60	336	43
Chironomidae-Orthocladiinae				
Parakiefferiella spp.		17		
Ablabesmyia annulata	9			17
Ablabesmyia mallochi		9	9	
Ablabesmyia ramphe gr.			9	
Clinotanypus spp.				172
Coelotanypus spp.	86	172	60	
Djalmabatista pulchra				
Procladius spp.	241	697	112	121
Ephemeroptera				
Caenidae				
Caenis spp.	60			
Ephemeridae				
Hexagenia spp.	26	17		9
Megaloptera				
Sialidae				
Sialis spp.	26			
Oligochaeta				
Naididae	9		60	
Dero trifida	9		146	

Table 3-3. (Continued).

2009	Locations			
Taxa	**A**	**B**	**F**	**E**
Oligochaeta				
Nais spp.	52		34	
Nais pardalis	9		26	
Tubificidae	870	1,093	456	155
Aulodrilus limnobius	43	250	138	
Aulodrilus pigueti	9	4,830		
Branchirua sowerbyi			17	
Other				
Glossiphoniidae				
Helobdella stagnalis	43	422	319	17
Planariidae				
Cura formanii		9	69	
Sabellidae				
Manayunkia speciosa	508		818	43
Tetrastemmatidae				
Prostoma graecens			69	
Nematoda	86	534	77	
Pelecypoda				
Corbiculidae				
Corbicula fluminea	146		827	284
Sphaeriidae				
Sphaerium spp.	310			215
Trichoptera				
Leptoceridae				
Oecetis spp.	17	17	17	43
Triaenodes ignitus			26	
Polycentropodidae				
Nyctiophylax spp.			26	
Polycentropus spp.			17	17
Total Density for Year	**4,022**	**9,652**	**5,356**	**1,550**
Total Taxa for Year	**27**	**27**	**36**	**24**

Table 3-4. Macroinvertebrate taxa and densities (No./m^2) at each Lake Norman sampling location during summer sampling in 2010.

2010	Locations			
Taxa	**A**	**B**	**F**	**E**
Diptera				
Ceratopogonidae				
Palpomyia-Bezzia complex	17	17	26	
Chironomidae-Chironominae				
Axarus spp.				
Chironomus spp.				95
Cladopelma spp.	9	34		
Cladotanytarsus spp.	723	17	887	77
Cryptochironomus spp.	69		284	69
Cryptotendipes spp.	77	413	336	9
Dicrotendipes neomodestus		60		
Nilothauma spp.		9		
Pagastiella spp.		103		
Paralauterborniella nigrohalteralis	43		60	
Polypedilum halterale gr.	43	9	43	26
Polypedilum scalaenum gr.	9		77	
Stempellina spp.	17		146	
Stenochironomus spp.	241	43	9	9
Stictochironomus spp.		17	207	
Stictochironomus caffranius			9	9
Tanytarsus spp.	422	34	189	34
Chironomidae-Orthocladiinae	17			9
Parakiefferiella spp.		26		
Ablabesmyia annulata	9	60		
Ablabesmyia ramphe gr.		52	17	26
Coelotanypus spp.	43	181		69
Djalmabatista pulchra				9
Procladius spp.	155	422	26	138
Ephemeroptera				
Baetidae				
Pseudocloeon spp.		86	198	
Caenidae				
Caenis spp.	241			
Ephemeridae				
Hexagenia spp.	26	103	9	
Megaloptera				
Sialidae				
Sialis spp.	43			34
Oligochaeta				
Naididae		9	69	
Arcteonais lomondi				9
Dero spp.		17		
Dero digitata	95	9		

Table 3-4. (Continued).

2010	Locations			
Taxa	**A**	**B**	**F**	**E**
Oligochaeta				
Dero trifida	155		439	
Nais spp.			9	
Nais pardalis	9			
Uncinais uncinata			9	
Tubificidae	1,903	121	250	207
Aulodrilus limnobius	801	34	232	52
Aulodrilus pigueti	138	844		
Branchirua sowerbyi	232	34	43	172
Illyodrilus templetoni	60			
Limnodrilus hoffmeisterei		26	9	
Tubifex tubifex			43	
Other				
Hirudinea				
Glossiphoniidae				
Helobdella stagnalis		336	26	34
Sabellidae				
Manayunkia speciosa	26		336	
Nematoda	164		77	
Pelecypoda				
Corbiculidae				
Corbicula fluminea	551		1,369	34
Trichoptera				
Leptoceridae				
Oecetis spp.		9		9
Triaenodes spp.			17	
Polycentropodidae				
Polycentropus spp.			17	
Total Density for Year	**6,338**	**3,125**	**5,468**	**1,130**
Total Taxa for Year	**29**	**28**	**31**	**21**

Table 3-5. Macroinvertebrate taxa and densities (No./m^2) at each Lake Norman sampling location during summer sampling in 2011.

2011	**Locations**			
Taxa	**A**	**B**	**F**	**E**
Diptera				
Ceratopogonidae				
Palpomyia-Bezzia complex	26	9	26	34
Chironomidae-Chironominae				
Chironomus spp.		9		
Cladopelma spp.	9	26		
Cladotanytarsus spp.	164	17	319	26
Cryptochironomus spp.		9	69	26
Cryptotendipes spp.	9	551	121	26
Dicrotendipes spp.	9	95		
Nilothauma spp.	9			
Pagastiella spp.	9	26		
Paralauterborniella nigrohalteralis			26	
Polypedilum halterale gr.	17	164	34	9
Polypedilum scalaenum gr.			43	
Stempellina spp.	9		9	26
Stictochironomus spp.	146			
Stictochironomus spp.		9	646	
Stictochironomus caffranius				103
Tanytarsus spp.	112	77	43	17
Chironomidae-Orthocladiinae				
Parakiefferiella spp.		17		
Chironomidae-Tanypodinae				
Ablabesmyia annulata		34		17
Ablabesmyia mallochi				9
Ablabesmyia ramphe gr.		9	9	
Coelotanypus spp.	405	232	26	284
Procladius spp.	250	284		77
Ephemeroptera				
Baetidae				
Pseudocloeon spp.	9	276	387	
Caenidae				
Caenis spp.	34			
Ephemeridae				
Hexagenia spp.	34	43		43
Megaloptera				
Sialidae				
Sialis spp.	9			
Oligochaeta				
Naididae		26	17	
Arcteonais lomondi			9	
Dero spp.		9		
Dero digitata		267		
Dero trifida		26	474	

Table 3-5. (Continued).

2011	Locatins			
Taxa	**A**	**B**	**F**	**E**
Oligochaeta				
Tubificidae	835	112	740	129
Aulodrilus limnobius	52	60	86	
Aulodrilus pigueti		491		
Limnodrilus hoffmeisterei		9	9	
Other				
Glossiphoniidae				
Helobdella stagnalis	77	77	370	17
Planariidae				
Cura formanii		9	34	
Nematoda	95	129	293	9
Pelecypoda				
Corbiculidae				
Corbicula fluminea	138		422	465
Trichoptera				
Hydroptilidae				
Hydroptila spp.	17			
Leptoceridae				
Oecetis spp.	43	17	26	
Polycentropodidae				
Polycentropus spp.				9
Total Density for Year	**2,517**	**3,119**	**4,238**	**1,326**
Total Taxa for Year	**24**	**30**	**24**	**18**

Table 3-6. Macroinvertebrate taxa and densities (No./m^2) at each Lake Norman sampling location in during summer sampling in 2012.

2012	Locations			
Taxa	**A**	**B**	**F**	**E**
Diptera				
Ceratopogonidae				
Palpomyia-Bezzia complex		9	60	
Chaoboridae				
Chaoborus spp.		26		
Chironomidae-Chironominae				
Chironomus spp.		9		17
Cladopelma spp.				9
Cladotanytarsus spp.	103		577	9
Cryptochironomus spp.	43		164	52
Cryptotendipes spp.	17	9	215	103
Dicrotendipes neomodestus		34		
Pagastiella spp.		9	9	17
Paralauterborniella nigrohalteralis			26	
Polypedilum halterale gr.			121	26
Polypedilum scalaenum gr.	69		52	
Stempellina spp.				17
Stictochironomus spp.	379		189	172
Tanytarsus spp.		17	293	52
Chironomidae-Orthocladiinae				
Parakiefferiella spp.			9	
Chironomidae-Tanypodinae				
Ablabesmyia annulata		9		9
Ablabesmyia mallochi			9	34
Coelotanypus spp.		112	9	138
Djalmabatista pulchra			17	
Procladius spp.		577	26	103
Ephemeroptera				
Baetidae				
Pseudocloeon spp.			26	
Caenidae				
Caenis spp.	77			
Ephemeridae				
Hexagenia spp.		9	9	181
Megaloptera				
Sialidae				
Sialis spp.				34
Oligochaeta				
Naididae	86			
Arcteonais lomondi	9		250	69
Bratislavia unidentata				
Dero spp.			34	9
Dero digitata		1,825		

Table 3-6. (Continued).

2012	Locations			
Taxa	**A**	**B**	**F**	**E**
Oligochaeta				
Naididae				
Dero trifida	95		121	17
Nais spp.	43			
Nais pardalis	17			
Pristinella jenkinae			52	
Uncinais uncinata	456		990	
Tubificidae	964	611	1,558	26
Aulodrilus limnobius	34	43		
Aulodrilus pigueti	9	1,171		
Aulodrilus pluriseta	9	43		
Branchirua sowerbyi	86	482	207	26
Other				
Glossiphoniidae				
Helobdella stagnalis		17		26
Glossiphoniidae				
Helobdella stagnalis			241	
Planariidae				
Cura formanii			34	
Tetrastemmatidae				
Prostoma graecens	9			
Nematoda	26	52	293	26
Pelecypoda				
Corbiculidae				
Corbicula fluminea	69	52	86	34
Sphaeriidae			17	121
Trichoptera				
Leptoceridae				
Oecetis spp.	34			17
Polycentropodidae				
Polycentropus spp.			9	9
Total Density for Year	**2,634**	**5,116**	**5,703**	**1,353**
Total Taxa for Year	**21**	**20**	**30**	**27**

Table 3-7. Macroinvertebrate taxa and densities (No./m^2) at each sampling location in Lake Norman during summer sampling in 2013.

2013	Locations			
Taxa	**A**	**B**	**F**	**E**
Diptera				
Ceratopogonidae				
Palpomyia-Bezzia complex	9	164	52	17
Chaoboridae				
Chaoborus spp.	9			9
Chironomidae-Chironominae				
Chironomus spp.	26			86
Cladopelma spp.		9		17
Cladotanytarsus spp.	689		207	69
Cryptochironomus spp.	52	34	43	26
Cryptotendipes spp.	103	250	86	34
Harnischia spp.				17
Microchironomus spp.				9
Nilothauma spp.		9		
Pagastiella spp.	9	52		17
Paralauterborniella nigrohalteralis	112	17	95	9
Polypedilum halterale gr.	129	198	52	
Polypedilum scalaenum gr.			43	
Stempellina spp.	9	17	9	9
Stictochironomus spp.	697		534	86
Tanytarsus spp.	362	215	77	224
Chironomidae-Orthocladiinae				
Nanocladius spp.			9	
Chironomidae-Tanypodinae				
Ablabesmyia annulata	34	43		17
Ablabesmyia mallochi		26		
Coelotanypus spp.	284	112	52	86
Djalmabatista pulchra			9	
Procladius spp.	396	525	52	267
Ephemeroptera				
Baetidae				
Pseudocloeon spp.	26	17	138	9
Caenidae				
Caenis spp.	26			
Ephemeridae				
Hexagenia spp.	34	17	9	43
Megaloptera				
Sialidae				
Sialis spp.	17			9
Oligochaeta				
Naididae				86
Arcteonais lomondi	103		9	95
Dero spp.	17			
Dero digitata		52		17
Dero trifida	69		224	17
Uncinais uncinata	69		413	34

Table 3-7. (Continued).

2013	Locations			
Taxa	**A**	**B**	**F**	**E**
Oligochaeta				
Tubificidae	1,576	947	1,395	603
Aulodrilus limnobius	77	319		542
Aulodrilus pigueti	34	3,384		
Aulodrilus pluriseta	34			
Branchirua sowerbyi	387	1,128		620
Branchirua sowerbyi			60	
Illyodrilus templetoni	129		69	
Limnodrilus hoffmeisterei	34			
Other				
Glossiphoniidae				
Helobdella stagnalis	232	1,240	465	52
Placobdella spp.		9		
Planariidae				
Cura formanii		17		
Sabellidae				
Manayunkia speciosa	26			43
Talitridae				
Hyalella azteca			43	
Nematoda	284	456	482	121
Pelecypoda				
Corbiculidae				
Corbicula fluminea	112	9	758	26
Sphaeriidae				
Sphaerium spp.	43		26	353
Trichoptera				
Hydroptilidae				
Hydroptila spp.			9	
Leptoceridae				
Oecetis spp.	69	34	95	17
Total Density for Year	**6,318**	**9,300**	**5,515**	**3,686**
Total Taxa for Year	**36**	**27**	**29**	**34**

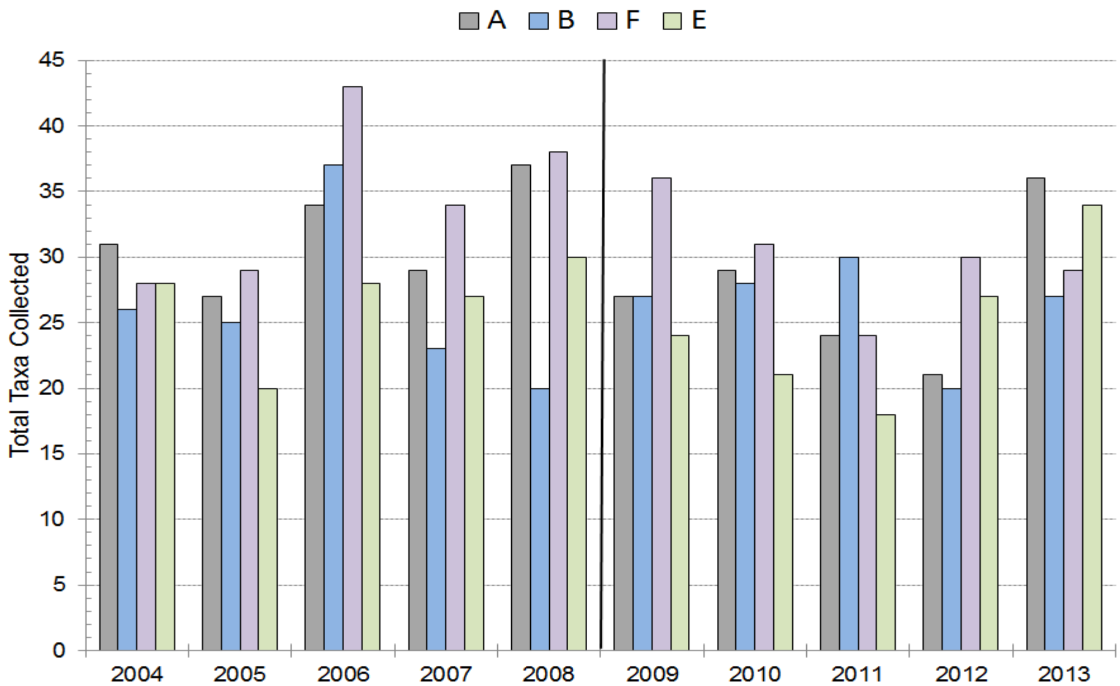

Figure 3-1. Total number of taxa collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

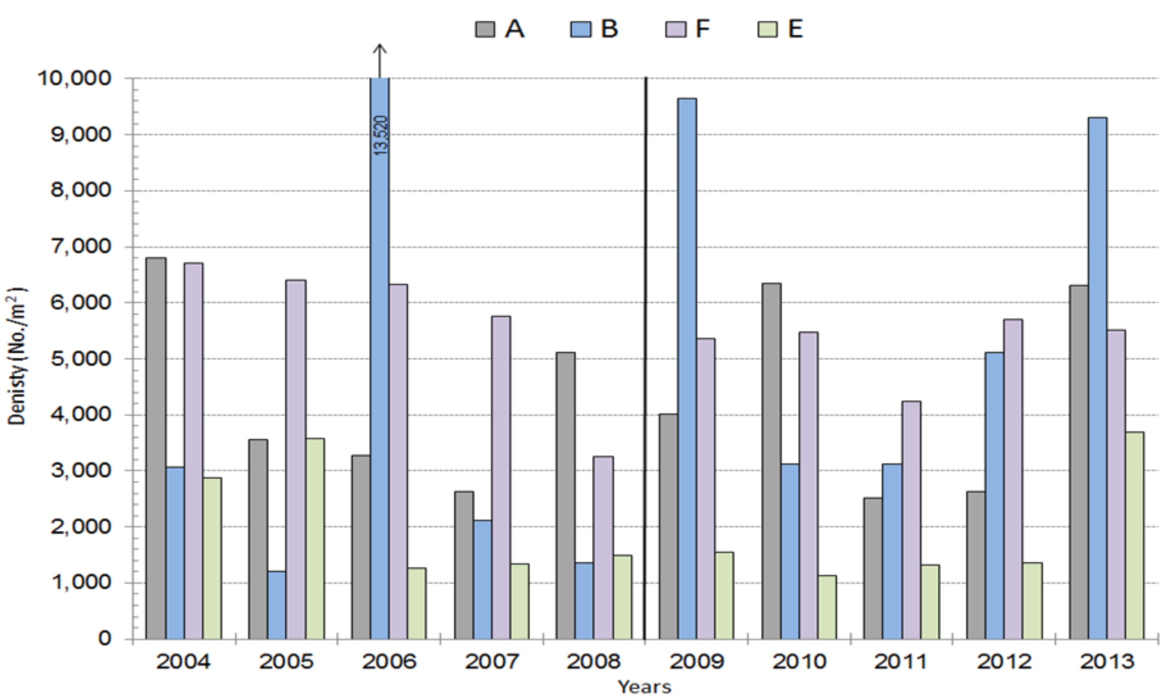

Figure 3-2. Densities (No./m^2) of macroinvertebrates collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

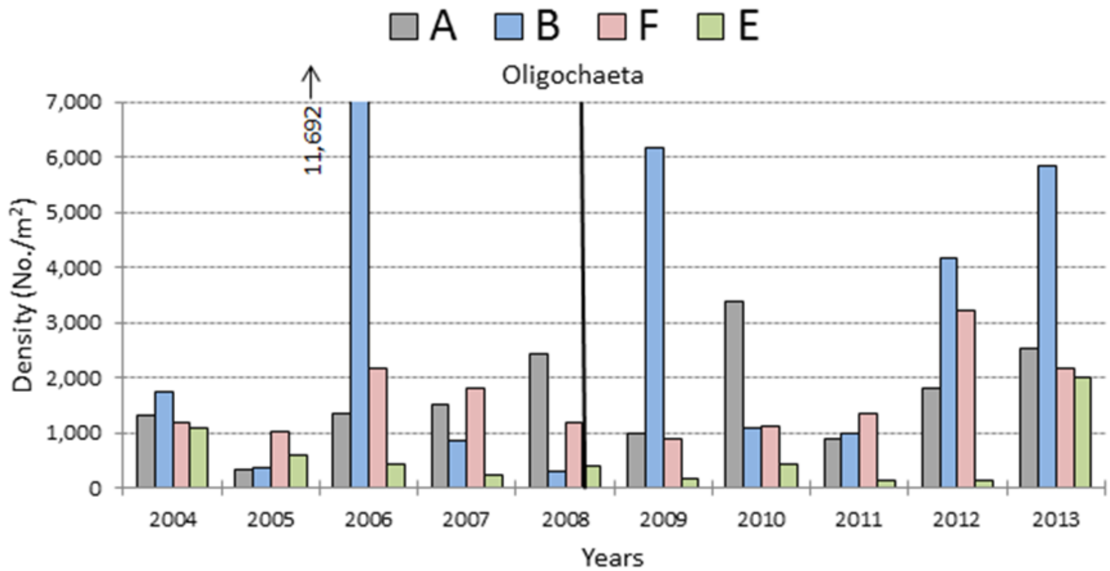

Figure 3-3. Densities (No./m^2) of Oligochaeta collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

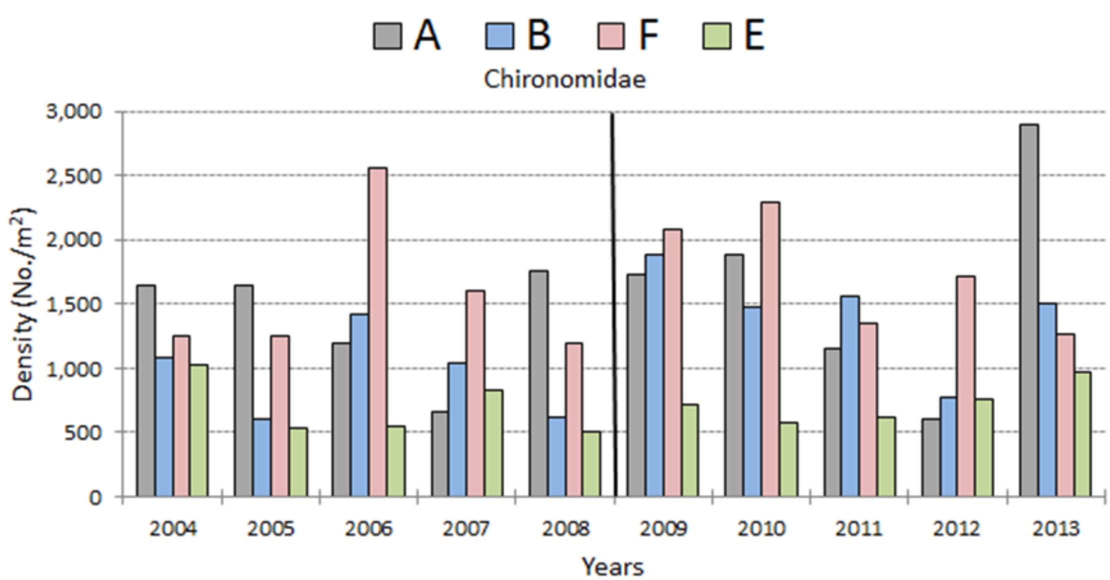

Figure 3-4. Densities (No./m^2) of Chironomidae collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

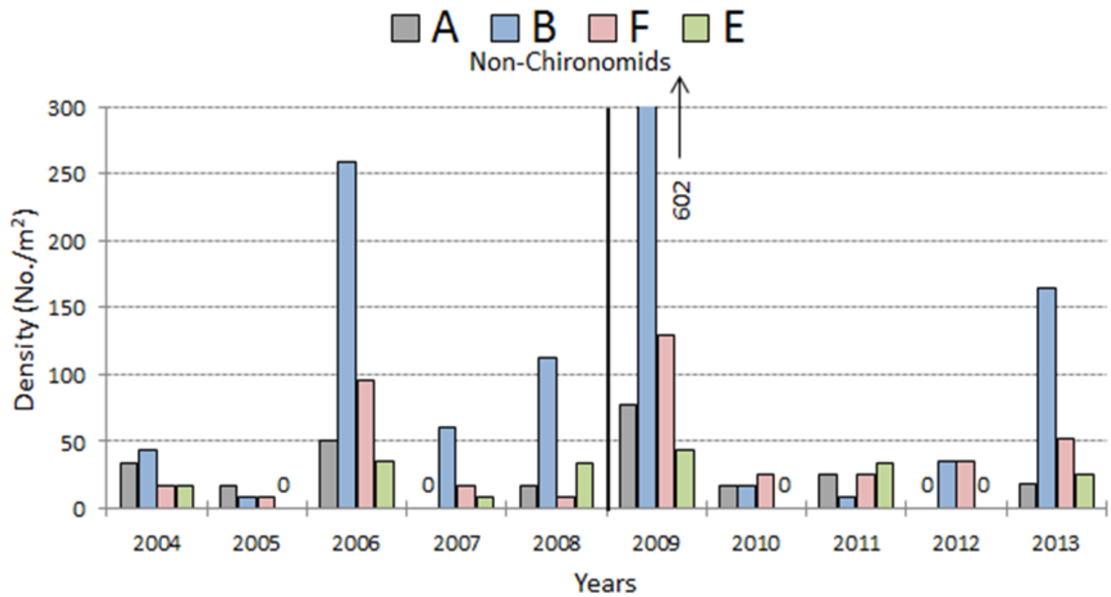

Figure 3-5. Densities (No./m^2) of non-chironomid taxa from Lake Norman in the vicinity MSS, 2004 – 2008 and 2009 – 2013.

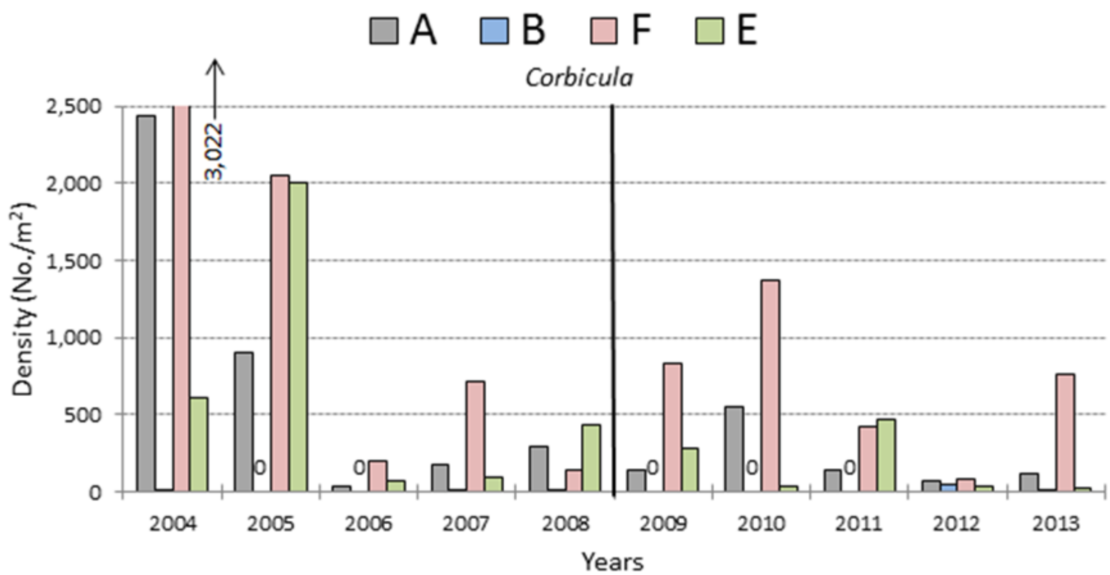

Figure 3-6. Densities (No./m^2) of *Corbicula* collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

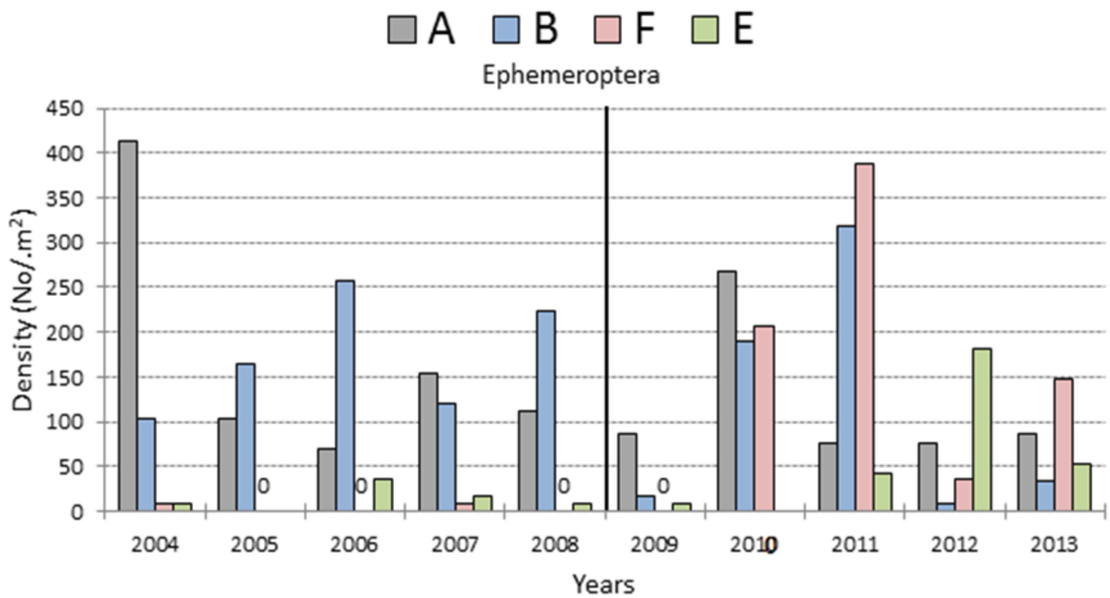

Figure 3-7. Densities (No./m^2) of Ephemeroptera collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

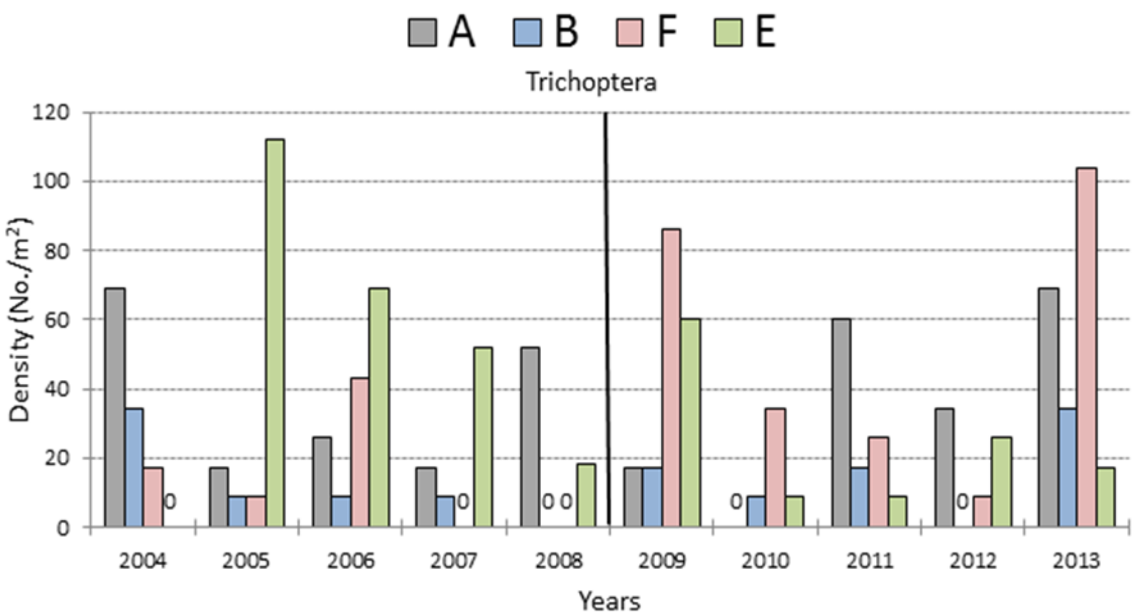

Figure 3-8. Densities (No./m^2) of Trichoptera collected annually from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

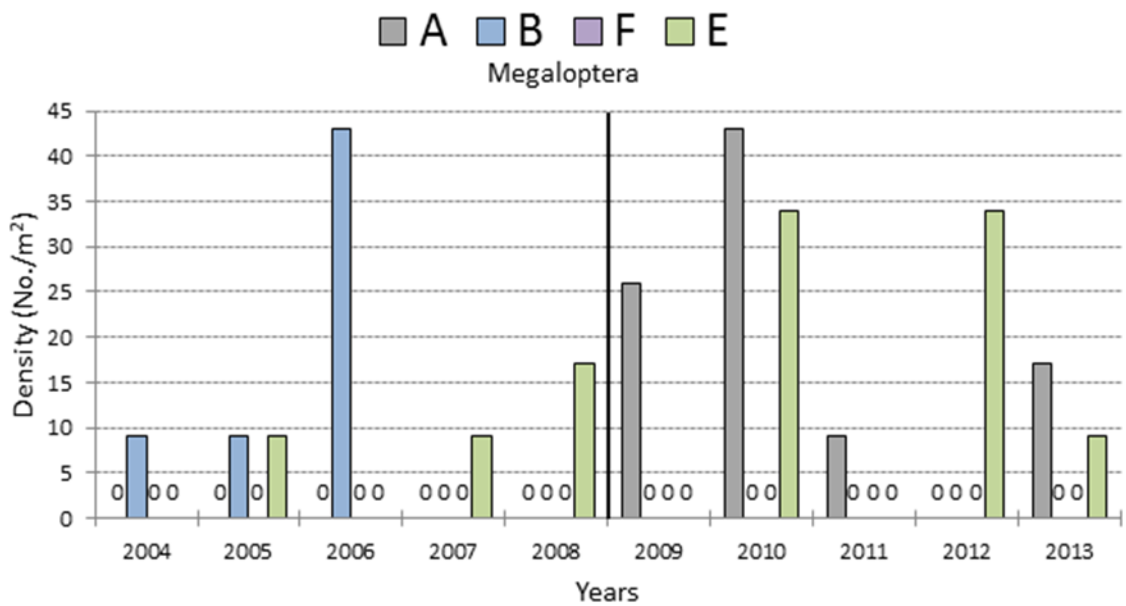

Figure 3-9. Densities (No./m^2) of Megaloptera from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

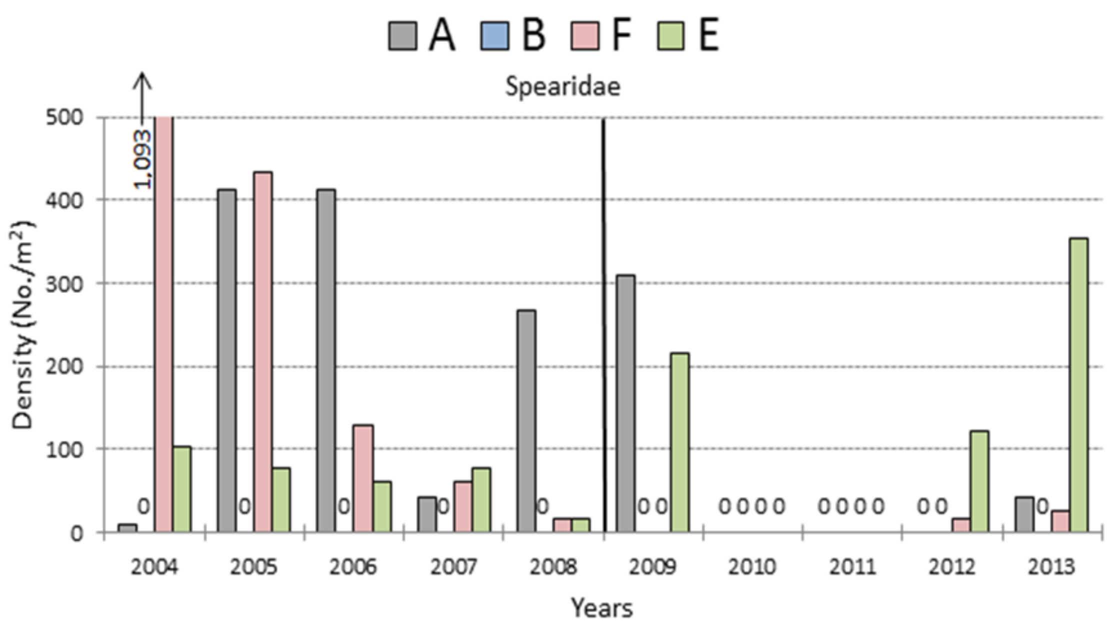

Figure 3-10. Annual densities (No./m^2) of *Sphaeriidae* from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

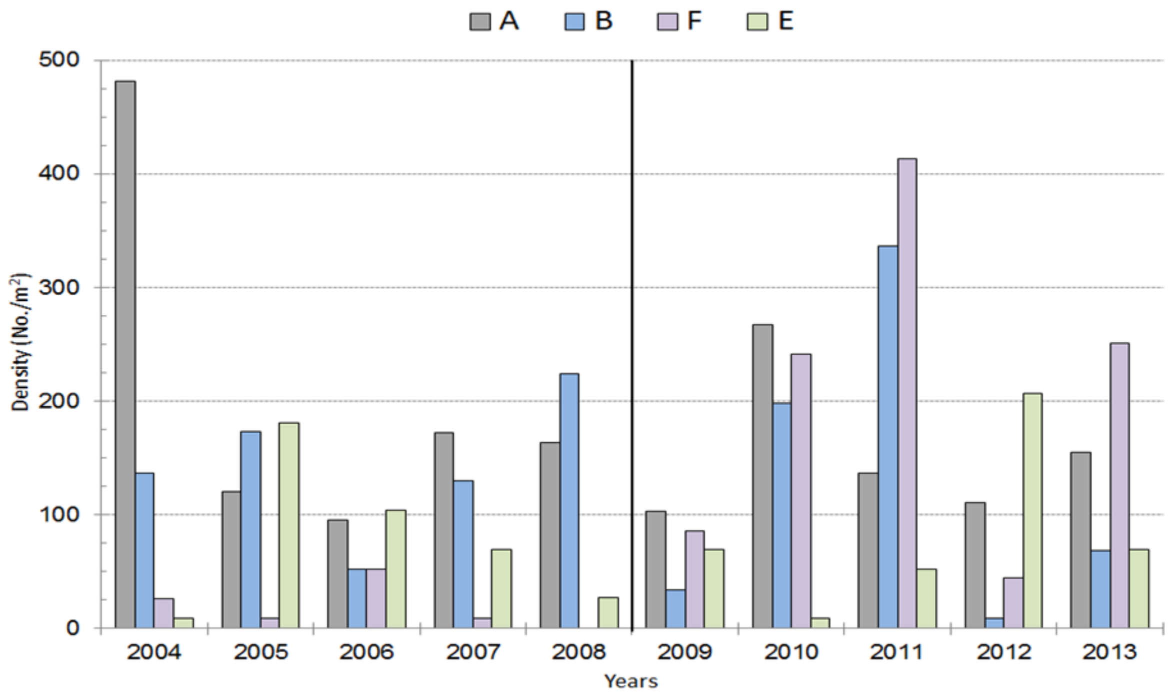

Figure 3-11. Densities (No./m^2) of EPT from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

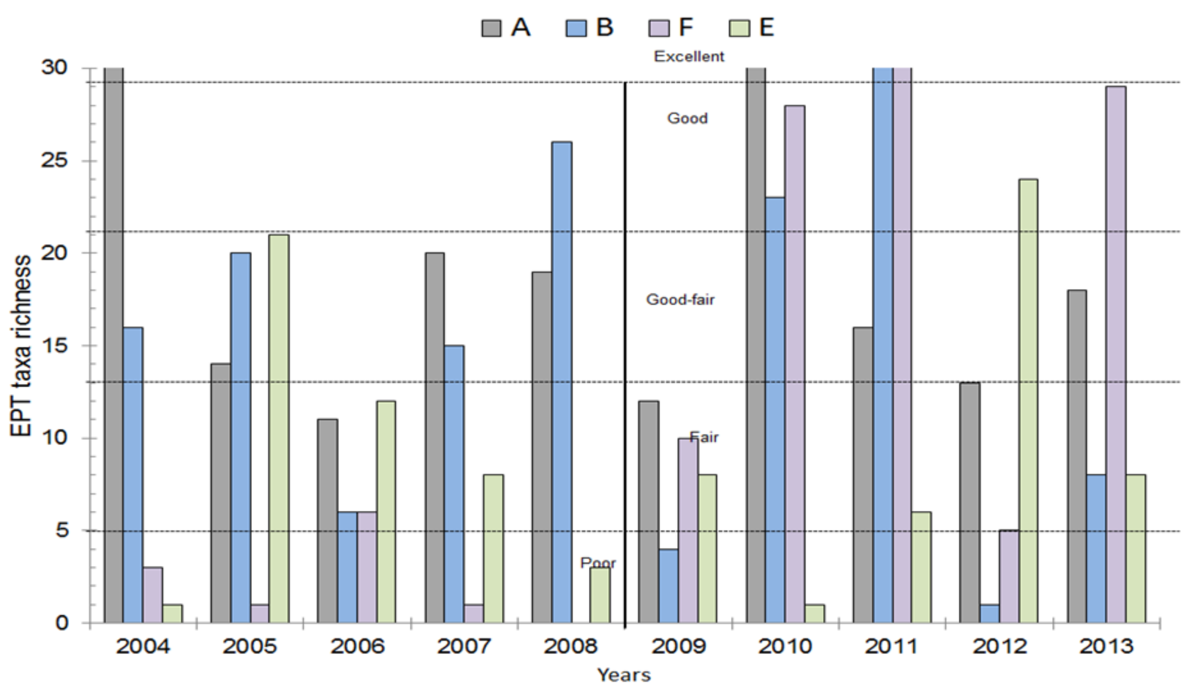

Figure 3-12. EPT taxa richness from Lake Norman in the vicinity of MSS, 2004 – 2008 and 2009 – 2013.

CHAPTER 4

FISH

MATERIALS AND METHODS

Spring Electrofishing Surveys

Annual (2009 – 2013; current National Pollution Discharge Elimination System permit cycle) boat electrofishing surveys were continued in Lake Norman in March or April near the thermal influence of Marshall Steam Station (MSS; Zone 4 in Figure 4-1) and at a reference area (REF, Zone 3) located between MSS and McGuire Nuclear Station. Ten 300-m shoreline transects were surveyed in each area and were identical to historical locations surveyed since 1993. Transects included littoral habitats representative of those found in Lake Norman. All sampling was conducted when surface water temperatures were expected to be 15 – 20 °C.

Stunned fish were collected by two netters and identified to species. Fish were enumerated and weighed in aggregate by taxon, except for spotted bass (*Micropterus punctulatus*) and largemouth bass (*M. salmoides*), where total length (TL, mm) and weight (g) were obtained for each individual collected. Surface water temperature (°C) was measured with a calibrated thermistor at each transect. Annual catch per unit effort (CPUE per 100 m) was determined by area for number of individuals, biomass, and number of species collected. Condition (Wr) based on relative weight was calculated for spotted bass and largemouth bass ≥ 150 mm TL, using the formula $Wr = (W/Ws) \times 100$, where W = weight of the individual fish and Ws = length-specific mean weight for a fish as predicted by a weight-length equation for each species (Neumann et al. 2012). Resulting metrics were compared between areas using a t-test ($P < 0.05$).

Summer Electrofishing Surveys

Annual (2009 – 2013) boat electrofishing surveys were continued in Lake Norman in July near the thermal influence of MSS. Ten 100-m shoreline transects were surveyed to represent three areas (Figure 1-1): two transects above the MSS discharge canal (Location

A), four in the vicinity of the discharge canal (Locations B and C), and four below the discharge canal (Locations D and E). Transects were identical to historical locations surveyed since 1991 and independent of spring transects. Surface water temperature and dissolved oxygen (DO, mg/L) were measured with a calibrated thermistor and DO probe, respectively, at each location. Stunned fish were collected by two netters, identified to species, and measured for TL. Representative and Important Species (RIS) were selected based upon abundance, distribution, and ecological significance as a prey (bluegill [*Lepomis macrochirus*] and redbreast sunfish [*L. auritus*]) or predator (spotted bass) species.

Fall Hydroacoustic and Purse Seine Surveys

Density and distribution of pelagic forage fish in Lake Norman were determined using mobile hydroacoustic (Rudstam et al. 2012) and purse seine (Hayes et al. 2012) techniques. The lake was divided into zones (Figure 4-1) due to its large size and habitat spatial heterogeneity. An annual mobile hydroacoustic survey was conducted in mid-September with multiplexing, side- and down-looking transducers to detect surface-oriented fish and deeper fish (from 2.0-m depth to the bottom), respectively.

Annual purse seine samples were also collected in mid-September from the epilimnion of downlake (Zone 1), midlake (Zone 2), and uplake (Zone 5) areas in water deep enough for unhindered net deployment. The purse seine measured 122.0 x 9.1 m, with a mesh size of 4.8 mm. A subsample of forage fish collected from each area was used to estimate taxa composition and TL size distribution.

Balanced and Indigenous Assessment

Annual surveys are used to assess the balanced and indigenous nature of the Lake Norman fish community and provide information relative to the potential thermal influence of MSS. The assessment includes comparisons of spring electrofishing CPUE (spatially and temporally) and of summer electrofishing RIS length distributions. Results from both seasonal surveys were examined according to species pollution tolerance and trophic guild. Hydroacoustic and purse seine surveys of pelagic forage fish were examined for trends.

RESULTS AND DISCUSSION

Spring Electrofishing Surveys

Spring electrofishing surveys from 2009 to 2013 were conducted at average water temperatures ranging from 15.9 to 21.1 °C. Surveys resulted in the collection of 11,682 individuals comprising 26 species at the MSS area and 10,251 individuals comprising 21 species at the REF area (Table 4-1). The number of individuals per 100 m ranged from 47.3 to 143.3 at the MSS area and from 59.2 to 77.2 at the REF area (Table 4-1 and Figure 4-2). Fish biomass per 100 m ranged from 3.5 to 7.1 kg at the MSS area and from 2.0 to 3.9 kg at the REF area (Figure 4-3). The number of species per 100 m ranged from 14 to 20 at the MSS area and from 14 to 19 at the REF area (Figure 4-4). Since 1993, both biomass and number of species collected from the MSS area were significantly greater than those from the REF area. When limited to the current permit cycle, the biomass collected from the MSS area was significantly greater than from the REF area.

The number of individuals in spring electrofishing surveys from 2009 to 2013 was dominated by centrarchids (MSS-95.9%, REF-93.7%), with clupeids (MSS-1.5%, REF-3.3%) and cyprinids (MSS-1.4%, REF-2.3%) greater than 1.0% each, and the remaining families representing less than 1.0% of individuals combined (Table 4-1). Green sunfish (*Lepomis cyanellus*) exhibited a considerable (and similar) increase in relative abundance at both areas compared to the 2004 – 2008 study period. Overall, current species composition data are similar to previously reported spring electrofishing data near MSS (Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a) and from other Catawba River reservoirs (Duke Power 2004b, 2004c; Duke Energy 2009b, 2009c).

Species considered pollution tolerant for wadeable stream assessments (e.g., longnose gar [*Lepisosteus osseus*], goldfish [*Carassius auratus*], common carp [*Cyprinus carpio*], golden shiner [*Notemigonus crysoleucas*], white catfish [*Ameiurus catus*], redbreast sunfish, green sunfish, and hybrid sunfish; NCDENR 2013) represented 19.7% of MSS and 27.5% of REF individuals during spring 2009 – 2013, similar to spring 2004 – 2008 (MSS-18.1%, REF-24.2%) and spring 2000 – 2003 (MSS-15.4%, REF-17.0%).

Species considered insectivorous for wadeable stream assessments (NCDENR 2013) represented 86.0% of MSS and 86.3% of REF from 2009 to 2013. Species considered piscivorous (MSS-11.2%, REF-8.8%) and omnivorous (MSS-2.8%, REF-4.9%) also reflected similar guild contributions when comparing areas from 2009 to 2013.

No significant difference existed between areas for spotted bass mean Wr (MSS-77.2, REF-77.1). Largemouth bass from MSS (84.5) had a higher mean Wr than from REF (82.8); however, the continued downward trend in the number of largemouth bass collected from Lake Norman in recent years diminishes the significance of a statistical comparison.

Summer Electrofishing Surveys

Summer electrofishing surveys from 2009 to 2013 resulted in the collection of 2,967 individuals comprising six families, 19 species, and two hybrid centrarchid combinations (Table 4-2). The species composition for the combined summer electrofishing surveys was dominated by centrarchids (93.2%), followed by clupeids (4.9%), and cyprinids (1.2%). The remaining families represented less than 1.0% of individuals combined. Previously reported summer data also documented dominance by centrarchids during 2004 – 2008 (90.4%) and 2000 – 2003 (77.0%). Spotted bass have steadily increased in percent composition from being absent prior to 2005 to approximately 9.5% of individuals collected during summer 2009 – 2013. Overall, current CPUE and species composition data are similar to previously reported summer electrofishing data near MSS (Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a) and from other Catawba River reservoirs (Duke Power 2001a, 2001b, 2004b, 2004c; Duke Energy 2009b, 2009c).

Pollution-tolerant species represented 16.6% of the collected fish during summer 2009 – 2013 surveys, similar to summer 2004 – 2008 (12.2%) and summer 2000 – 2003 (18.2%). Insectivorous (78.2%), piscivorous (15.8%), and omnivorous (6.0%) species from 2009 to 2013 surveys had guild contributions similar to summer 2004 – 2008 (79.4%, 12.3%, 8.3%) and summer 2000 – 2003 (81.6%, 12.9%, 5.6%), respectively.

The TL distributions of RIS (i.e., bluegill, redbreast sunfish, and spotted bass) during summer 2009 – 2013 surveys (Figures 4-5 to 4-7) indicated successful reproduction and multiple age groups from above, in the vicinity of, and below the MSS discharge canal. Although the discharge canal consistently had the highest temperature (as high as 36.8 °C) and lowest DO (as low as 0.5 mg/L), it maintained RIS TL size class distributions similar to areas above and below the discharge canal.

Fall Hydroacoustic and Purse Seine Surveys

Annual hydroacoustic estimates near MSS (Zone 4) from 2009 to 2013 indicated the regular availability of pelagic forage fish with no temporal trend in density (range = 1,564 – 11,551 fish/ha; Figure 4-8). Threadfin shad (*Dorosoma petenense*) continued to dominate annual purse seine surveys of the Lake Norman forage fish community from 2009 to 2013, comprising 88.4 – 98.3% of fish collected (Table 4-3). Alewife (*Alosa pseudoharengus*), first detected in low numbers in 1999 (Duke Power 2000), have comprised as much as 25.0% (2002) of mid-September pelagic forage fish surveys, but percent contribution has remained relatively low since 2005 (range = 1.5 – 11.6%).

CONCLUSIONS

A diverse fish community was present in the littoral surveys of Lake Norman near MSS from 2009 to 2013. Spring and summer electrofishing documented 28 and 19 species, respectively, both numerically dominated by centrarchids, especially bluegill. Pollution-tolerant species comprised less of the spring MSS fish population (19.7%) relative to the REF area (27.5%), and comprised only 16.6% of individuals collected during summer surveys. The assorted fish species typically found in Lake Norman near MSS encompass multiple trophic guilds (i.e., insectivores, omnivores, and piscivores) supporting a balanced fish community. Non-indigenous species such as spotted bass and green sunfish are abundant near MSS, but are also prevalent throughout Lake Norman.

Annual hydroacoustic estimates from 2009 to 2013 showed the regular availability of pelagic forage fish near MSS. Purse seine surveys indicate that threadfin shad continue to dominate the Lake Norman forage fish community with a consistent alewife composition of approximately 5% after 2004. The introduction of alewife and inherent, temporal fluctuations in clupeid densities contribute to the variable nature of forage fish populations.

Past studies have indicated that a balanced indigenous fish community exists near MSS (Duke Power Company 1994; Duke Power 1999, 2004a; Duke Energy 2009a). The present study adds more years of comparable data, reinforcing that conclusion. Based on the CPUE of littoral fish during spring, TL distributions of RIS during summer, and the regular availability of forage fish, it is concluded that the thermal discharge of MSS has not impaired the Lake Norman fish community.

Table 4-1. Total number of individuals, percent composition, and total number of species in spring electrofishing surveys from two areas (MSS and REF) in Lake Norman, 1993 – 1997 and 1999, 2000 – 2003, 2004 – 2008, and 2009 – 2013.

		Spring 1993 - 1997, 1999				Spring 2000 - 2003				Spring 2004 - 2008				Spring 2009 - 2013			
		MSS		REF		MSS		REF		MSS		REF		MSS		REF	
Scientific name	Common name	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lepisosteidae																	
Lepisosteus osseus	Longnose gar			2	0.03%	1	0.01%	1	0.01%			1	0.01%			5	0.05%
Clupeidae																	
Alosa pseudoharengus	Alewife					45	0.51%	57	0.77%	1	0.01%	51	0.53%	2	0.02%	1	0.01%
Dorosoma cepedianum	Gizzard shad	81	0.94%	50	0.72%	30	0.34%	94	1.27%	27	0.32%	38	0.39%	84	0.72%	60	0.59%
Dorosoma petenense	Threadfin shad	944	10.98%	1,515	21.72%	840	9.46%	58	0.78%	127	1.51%	523	5.43%	86	0.74%	276	2.69%
Cyprinidae																	
Cyprinella chloristia	Greenfin shiner	22	0.26%	12	0.17%	50	0.56%	153	2.07%	43	0.51%	38	0.39%	18	0.15%	49	0.48%
Cyprinella nivea	Whitefin shiner	734	8.54%	586	8.40%	1,257	14.16%	1,470	19.89%	228	2.72%	353	3.67%	26	0.22%	44	0.43%
Cyprinus carpio	Common carp	157	1.83%	168	2.41%	190	2.14%	51	0.69%	58	0.69%	48	0.50%	99	0.85%	20	0.20%
Hybognathus regius	Eastern silvery minnow									2	0.02%						
Nocomis leptocephalus	Bluehead chub									1	0.01%						
Notemigonus crysoleucas	Golden shiner	8	0.09%	5	0.07%	4	0.05%	2	0.03%	7	0.08%	1	0.01%	1	0.01%		
Notropis hudsonius	Spottail shiner	414	4.81%	67	0.96%	472	5.32%	561	7.59%	240	2.86%	184	1.91%	21	0.18%	119	1.16%
Notropis procne	Swallowtail shiner			1	0.01%			1	0.01%								
Pimephales promelas	Fathead minnow									1	0.01%						
Catostomidae																	
Carpiodes cyprinus	Quillback	5	0.06%	6	0.09%	3	0.03%	3	0.04%	2	0.02%	4	0.04%	3	0.03%		
Moxostoma macrolepidotum	Shorthead redhorse	2	0.02%			4	0.05%			4	0.05%			1	0.01%		
Moxostoma rupiscartes	Striped jumprock													1	0.01%		
Ictaluridae																	
Ameiurus catus	White catfish									1	0.01%						
Ameiurus nebulosus	Brown bullhead															1	0.01%
Ictalurus furcatus	Blue catfish					2	0.02%	8	0.11%			1	0.01%	3	0.03%	1	0.01%
Ictalurus punctatus	Channel catfish	22	0.26%	14	0.20%	37	0.42%	40	0.54%	16	0.19%	24	0.25%	35	0.30%	27	0.26%
Pylodictis olivaris	Flathead catfish	7	0.08%	4	0.06%	14	0.16%	6	0.08%	9	0.11%	14	0.15%	21	0.18%	40	0.39%
Salmonidae																	
Oncorhynchus mykiss	Rainbow trout					2	0.02%	1	0.01%								
Moronidae																	
Morone americana	White perch	8	0.09%			103	1.16%	4	0.05%	8	0.10%	17	0.18%	66	0.56%		
Morone chrysops	White bass	6	0.07%	4	0.06%	2	0.02%	3	0.04%								
Morone saxatilis	Striped bass	6	0.07%			3	0.03%	2	0.03%	1	0.01%	1	0.01%	10	0.09%	3	0.03%
Centrarchidae																	
Lepomis auritus	Redbreast sunfish	1,398	16.26%	1,017	14.58%	957	10.78%	1,004	13.59%	1,110	13.24%	1,925	19.99%	587	5.02%	1,408	13.74%
Lepomis cyanellus	Green sunfish									129	1.54%	12	0.12%	1,373	11.75%	1,084	10.57%
Lepomis gibbosus	Pumpkinseed					4	0.05%										
Lepomis gulosus	Warmouth	63	0.73%	95	1.36%	150	1.69%	118	1.60%	111	1.32%	225	2.34%	69	0.59%	125	1.22%
Lepomis hybrid	Hybrid sunfish	219	2.55%	207	2.97%	213	2.40%	197	2.67%	340	4.05%	360	3.74%	245	2.10%	306	2.99%
Lepomis macrochirus	Bluegill	2,731	31.76%	1,939	27.80%	3,418	38.51%	2,622	35.48%	4,600	54.85%	4,735	49.16%	7,424	63.55%	5,634	54.96%
Lepomis microlophus	Redear sunfish	111	1.29%	174	2.49%	468	5.27%	477	6.45%	559	6.67%	558	5.79%	300	2.57%	199	1.94%
Micropterus punctulatus	Spotted bass					15	0.17%	12	0.16%	304	3.63%	198	2.06%	929	7.95%	750	7.32%
Micropterus salmoides	Largemouth bass	1,349	15.69%	911	13.06%	573	6.46%	420	5.68%	408	4.87%	270	2.80%	221	1.89%	73	0.71%
Micropterus hybrid	Hybrid black bass									19	0.23%	11	0.11%	43	0.37%	18	0.18%
Pomoxis annularis	White crappie	3	0.03%														
Pomoxis nigromaculatus	Black crappie	51	0.59%	118	1.69%	1	0.01%	19	0.26%	19	0.23%	22	0.23%	12	0.10%	8	0.08%
Percidae																	
Etheostoma fusiforme	Swamp darter	1	0.01%														
Etheostoma olmstedi	Tessellated darter	1	0.01%	1	0.01%	1	0.01%	3	0.04%	3	0.04%	4	0.04%	1	0.01%		
Perca flavescens	Yellow perch	256	2.98%	80	1.15%	17	0.19%	3	0.04%	8	0.10%	13	0.13%	1	0.01%		
Total		**8,599**	**100.00%**	**6,976**	**100.00%**	**8,876**	**100.00%**	**7,390**	**100.00%**	**8,386**	**100.00%**	**9,631**	**100.00%**	**11,682**	**100.00%**	**10,251**	**100.00%**
Total no. species		**24**		**21**		**28**		**27**		**28**		**25**		**26**		**21**	

Table 4-2. Total number of individuals, percent composition, and total number of species in summer electrofishing surveys from three areas near MSS (above, in the vicinity of, and below the discharge canal) in Lake Norman, 1991 – 1993, 1994 – 1999, 2000 – 2003, 2004 – 2008, and 2009 – 2013.

		Summer 1991 - 1993[a]		Summer 1994 - 1999[b]		Summer 2000 - 2003		Summer 2004 - 2008		Summer 2009 - 2013	
Scientific name	Common name	No.	%	No.	%	No.	%	No.	%	No.	%
Lepisosteidae											
Lepisosteus osseus	Longnose gar			11	0.26%			3	0.09%	3	0.10%
Clupeidae											
Alosa pseudoharengus	Alewife							5	0.16%	2	0.07%
Dorosoma cepedianum	Gizzard shad	11	0.72%	38	0.91%	4	0.19%	6	0.19%	12	0.40%
Dorosoma petenense	Threadfin shad	5	0.33%	355	8.54%			60	1.88%	130	4.38%
Cyprinidae											
Carassius auratus	Goldfish							1	0.03%	1	0.03%
Cyprinella chloristia	Greenfin shiner	15	0.98%	54	1.30%	28	1.32%	53	1.66%	7	0.24%
Cyprinella nivea	Whitefin shiner	170	11.10%	469	11.28%	257	12.09%	58	1.82%	1	0.03%
Cyprinus carpio	Common carp	53	3.46%	94	2.26%	11	0.52%	3	0.09%	7	0.24%
Notemigonus crysoleucas	Golden shiner			5	0.12%						
Notropis hudsonius	Spottail shiner			29	0.70%	157	7.39%	100	3.14%	20	0.67%
Catostomidae											
Carpiodes cyprinus	Quillback			5	0.12%						
Moxostoma macrolepidotum	Shorthead redhorse					7	0.33%	5	0.16%		
Moxostoma sp.	Brassy jumprock			6	0.14%						
Ictaluridae											
Ictalurus punctatus	Channel catfish	11	0.72%	10	0.24%	4	0.19%	7	0.22%	8	0.27%
Pylodictis olivaris	Flathead catfish			16	0.38%	2	0.09%	3	0.09%	7	0.24%
Poeciliidae											
Gambusia holbrooki	Eastern mosquitofish	5	0.33%							3	0.10%
Moronidae											
Morone americana	White perch					8	0.38%				
Morone chrysops	White bass			5	0.12%						
Centrarchidae											
Lepomis auritus	Redbreast sunfish	119	7.77%	261	6.28%	317	14.92%	272	8.53%	155	5.22%
Lepomis cyanellus	Green sunfish	5	0.33%			1	0.05%	58	1.82%	286	9.64%
Lepomis gibbosus	Pumpkinseed	5	0.33%								
Lepomis gulosus	Warmouth	26	1.70%	91	2.19%	42	1.98%	74	2.32%	88	2.97%
Lepomis hybrid	Hybrid sunfish	5	0.33%	99	2.38%	58	2.73%	53	1.66%	37	1.25%
Lepomis macrochirus	Bluegill	926	60.44%	1,829	43.98%	900	42.35%	1,957	61.41%	1,703	57.40%
Lepomis microlophus	Redear sunfish	5	0.33%	71	1.71%	78	3.67%	65	2.04%	38	1.28%
Micropterus punctulatus	Spotted bass							86	2.70%	282	9.50%
Micropterus salmoides	Largemouth bass	133	8.68%	422	10.15%	240	11.29%	313	9.82%	170	5.73%
Micropterus hybrid	Hybrid black bass							2	0.06%	7	0.24%
Pomoxis nigromaculatus	Black crappie			6	0.14%	1	0.05%				
Percidae											
Etheostoma olmstedi	Tessellated darter	20	1.31%	26	0.63%						
Perca flavescens	Yellow perch	18	1.17%	257	6.18%	10	0.47%	3	0.09%		
Total		1,532	100.00%	4,159	100.00%	2,125	100.00%	3,187	100.00%	2,967	100.00%
Total no. species		16		21		17		20		19	

[a] locations B and E were not sampled in 1992, location B was not sampled in 1993

[b] location B was not sampled in 1994, locations A and B were not sampled in 1995

Table 4-3. Pelagic forage fish species composition from purse seine surveys in Lake Norman, 1993 – 2013.

Year	Species composition		
	Threadfin shad	Gizzard shad	Alewife
1993	100.00%		
1994	99.94%	0.06%	
1995	99.95%	0.05%	
1996	100.00%		
1997	99.99%	0.01%	
1998	99.95%	0.05%	
1999	99.26%	0.26%	0.48%
2000	87.40%	0.22%	12.37%
2001	76.47%	0.01%	23.52%
2002	74.96%		25.04%
2003	82.59%	0.14%	17.27%
2004	86.55%	0.24%	13.20%
2005	98.10%		1.90%
2006	94.87%		5.13%
2007	98.34%		1.66%
2008	95.58%		4.42%
2009	88.40%		11.60%
2010	95.38%	0.36%	4.26%
2011	98.32%	0.15%	1.52%
2012	93.60%		6.40%
2013	93.50%		6.50%

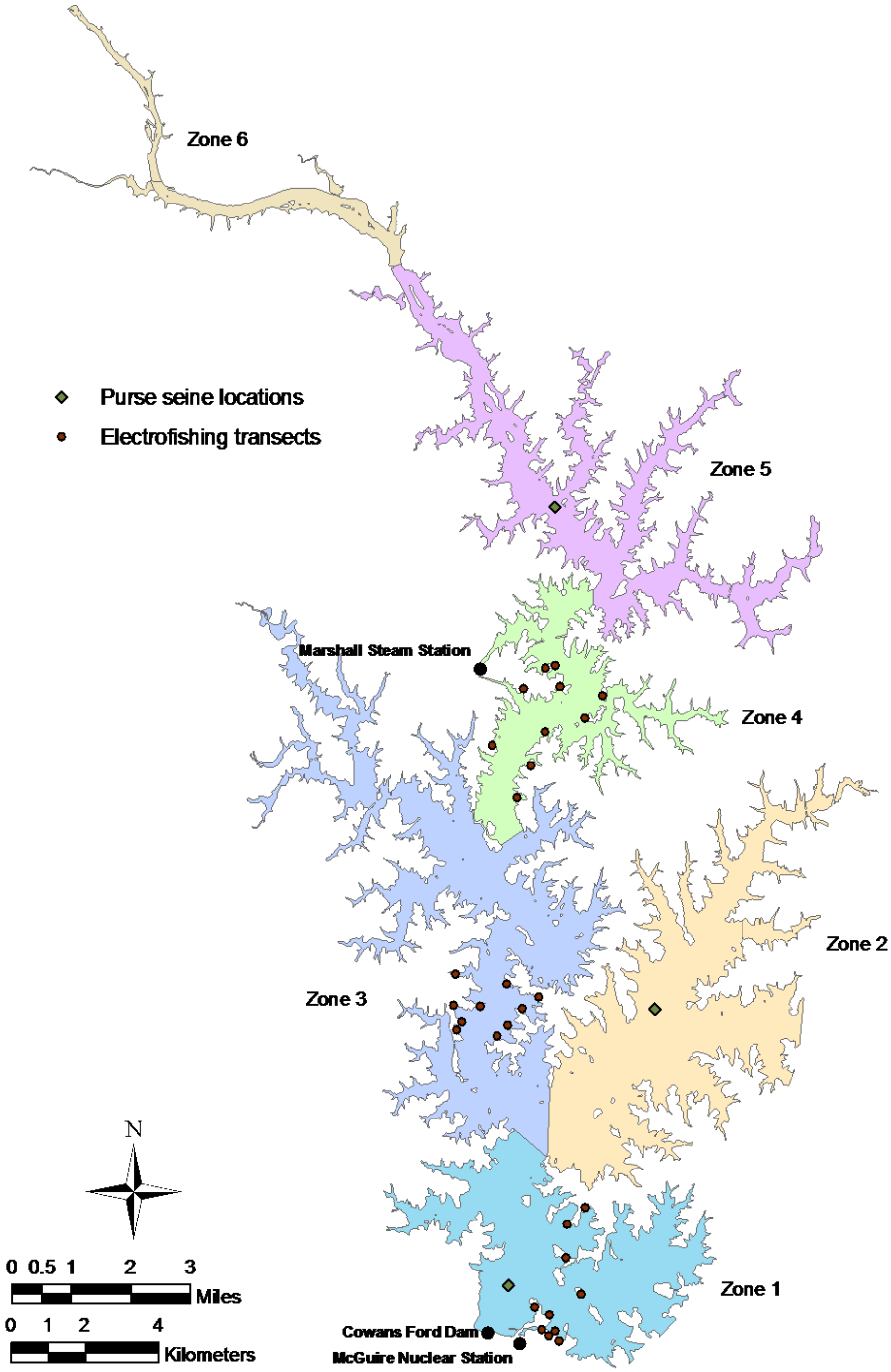

Figure 4-1. Locations associated with spring electrofishing and fall purse seine surveys, and zones associated with fall hydroacoustic survey of Lake Norman.

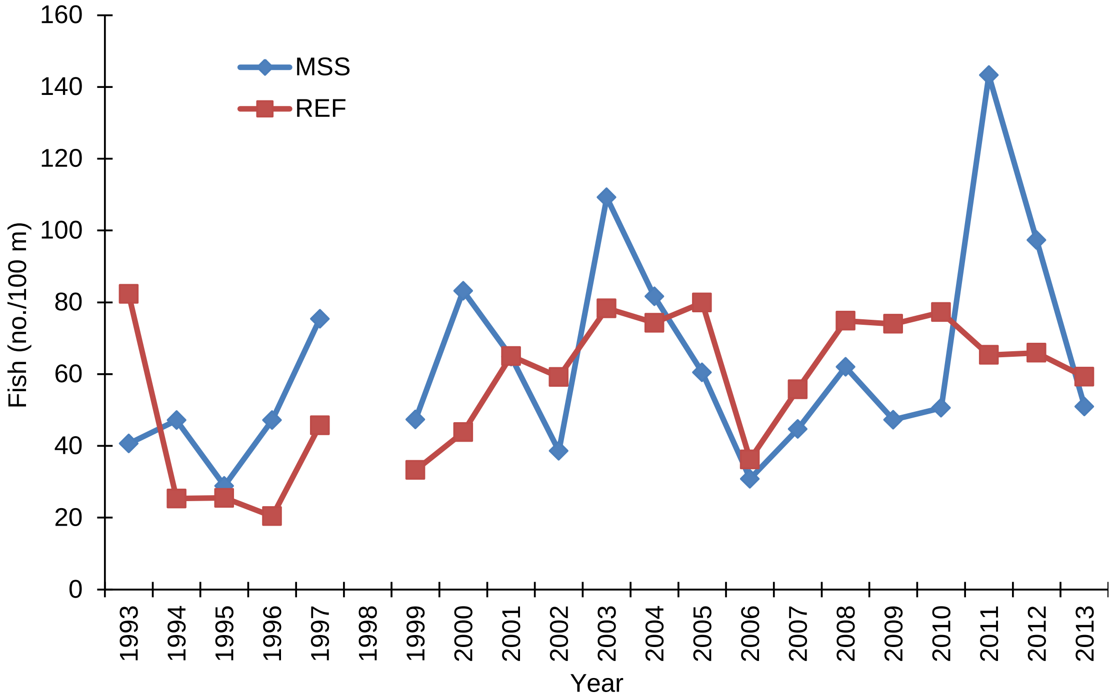

Figure 4-2. Total number of fish collected in spring electrofishing surveys from two areas (MSS and REF) in Lake Norman, 1993 – 1997 and 1999 – 2013.

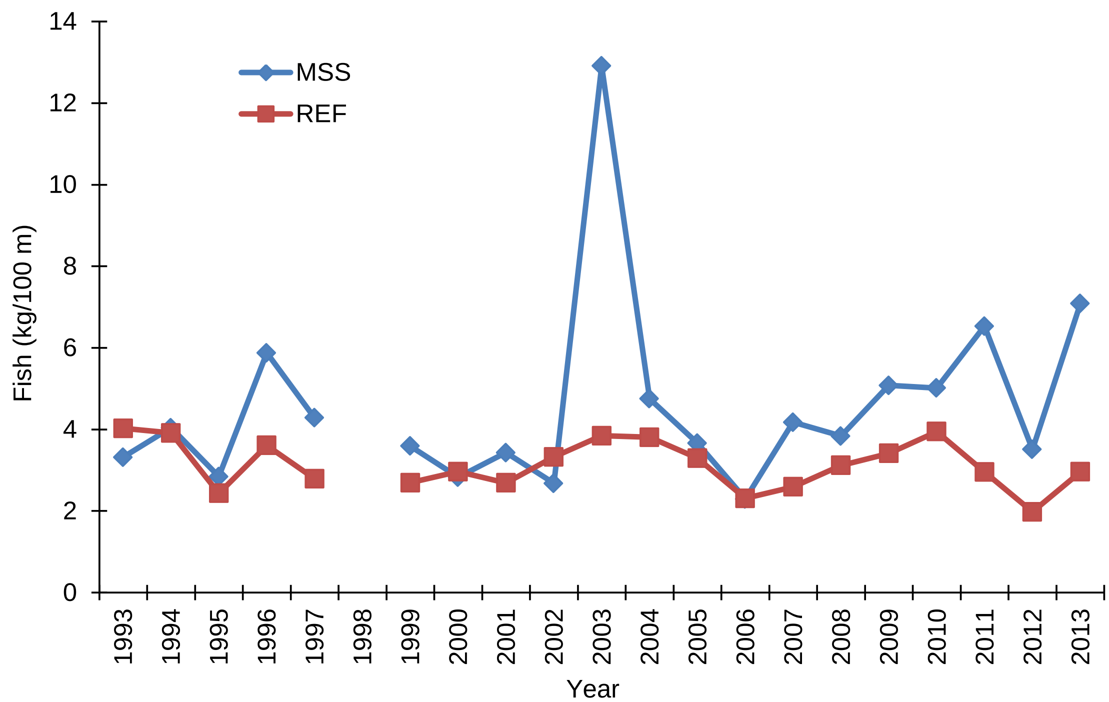

Figure 4-3. Biomass of fish collected in spring electrofishing surveys from two areas (MSS and REF) in Lake Norman, 1993 – 1997 and 1999 – 2013.

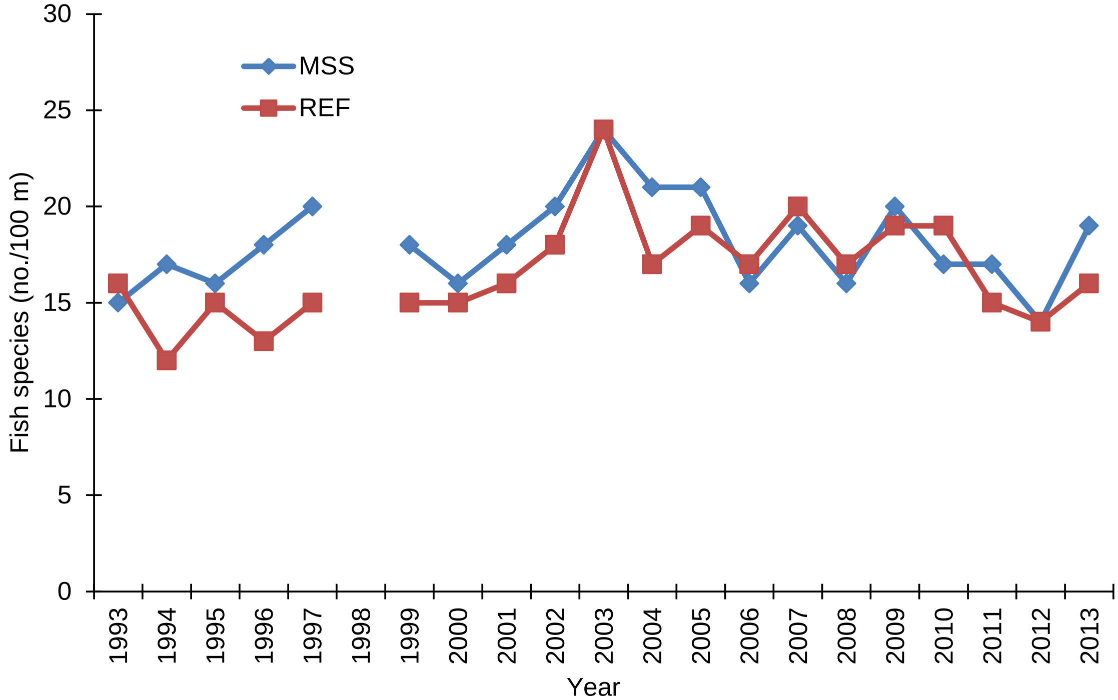

Figure 4-4. Total number of fish species collected in spring electrofishing surveys from two areas (MSS and REF) in Lake Norman, 1993 – 1997 and 1999 – 2013.

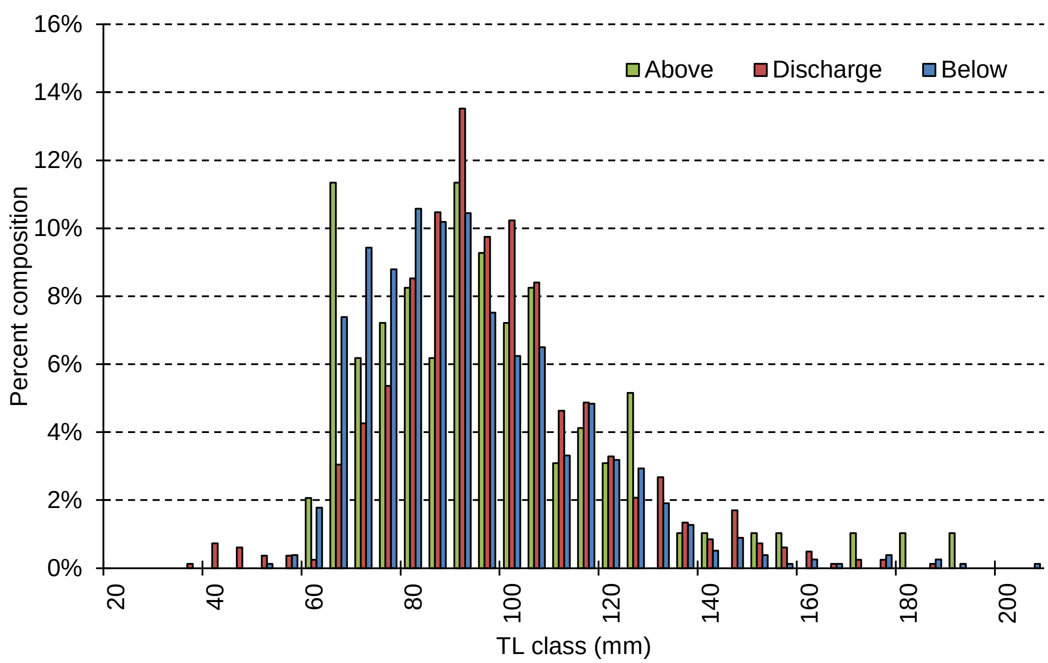

Figure 4-5. Length distribution of bluegill among survey locations in summer electrofishing surveys near MSS in Lake Norman, 2009 – 2013.

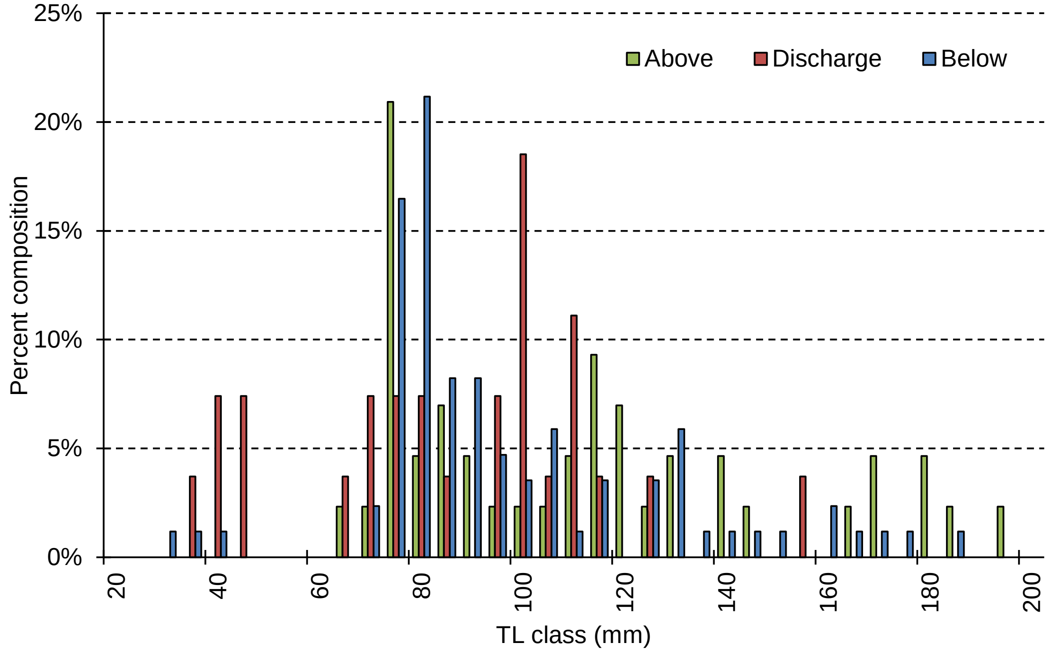

Figure 4-6. Length distribution of redbreast sunfish among survey locations in summer electrofishing surveys near MSS in Lake Norman, 2009 – 2013.

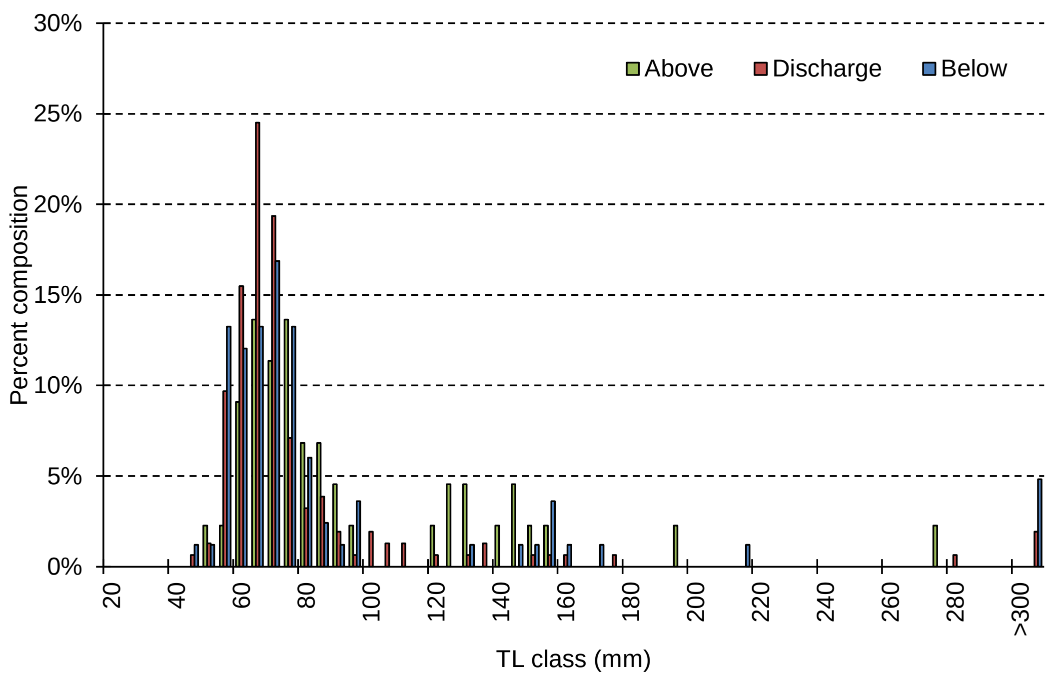

Figure 4-7. Length distribution of spotted bass among survey locations in summer electrofishing surveys near MSS in Lake Norman, 2009 – 2013.

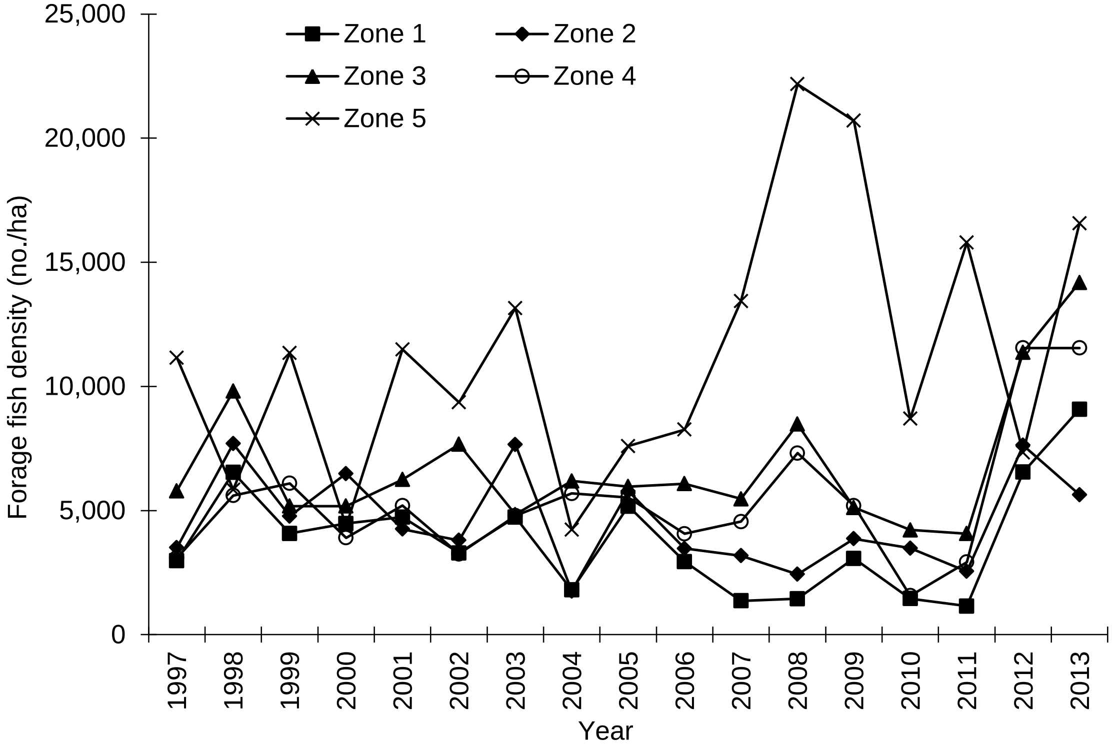

Figure 4-8. Pelagic forage fish density estimates by zone in Lake Norman, late summer/early fall 1997 – 2013.

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