Environmental Assessment of the Lower Cape Fear River System, 2013

By

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Executive Summary

Multiparameter water sampling for the Lower Cape Fear River Program (LCFRP) has been ongoing since June 1995. Scientists from the University of North Carolina Wilmington's (UNCW) Aquatic Ecology Laboratory perform the sampling effort. The LCFRP currently encompasses 33 water sampling stations throughout the lower Cape Fear, Black, and Northeast Cape Fear River watersheds. The LCFRP sampling program includes physical, chemical, and biological water quality measurements and analyses of the benthic and epibenthic macroinvertebrate communities, and has in the past included assessment of the fish communities. Principal conclusions of the UNCW researchers conducting these analyses are presented below, with emphasis on water quality of the period January - December 2013. The opinions expressed are those of UNCW scientists and do not necessarily reflect viewpoints of individual contributors to the Lower Cape Fear River Program.

The mainstem lower Cape Fear River is a 6th order stream characterized by periodically turbid water containing moderate to high levels of inorganic nutrients. It is fed by two large 5th order blackwater rivers (the Black and Northeast Cape Fear Rivers) that have low levels of turbidity, but highly colored water with less inorganic nutrient content than the mainstem. While nutrients are reasonably high in the river channels, major algal blooms have until recently been rare because light is attenuated by water color or turbidity, and flushing is usually high (Ensign et al. 2004). During periods of low flow (as in 2008-2012) algal biomass as chlorophyll *a* increases in the river because lower flow causes settling of more solids and improves light conditions for algal growth. Periodically major algal blooms are seen in the tributary stream stations, some of which are impacted by point source discharges. Below some point sources, nutrient loading can be high and fecal coliform contamination occurs. Other stream stations drain blackwater swamps or agricultural areas, some of which periodically show elevated pollutant loads or effects (Mallin et al. 2001).

Average annual dissolved oxygen (DO) levels at the river channel stations for 2012 were slightly lower than the average for 1995-2011. Dissolved oxygen levels were lowest during the summer and early fall, often falling below the state standard of 5.0 mg/L at several river and upper estuary stations. There is a dissolved oxygen sag in the main river channel that begins at Station DP below a paper mill discharge and near the Black River input, and persists into the mesohaline portion of the estuary. Mean oxygen levels were highest at the upper river stations NC11 and AC and in the middle to lower estuary at stations M35 to M18. Lowest mainstem average 2013 DO levels occurred at the lower river and upper estuary stations DP, IC, NAV, HB, BRR and M61 (6.7-6.8 mg/L). As the water reaches the lower estuary higher algal productivity, mixing and ocean dilution help alleviate oxygen problems.

The Northeast Cape Fear and Black Rivers generally have lower DO levels than the mainstem Cape Fear River. These rivers are classified as blackwater systems because of their tea colored water. The Northeast Cape Fear River generally has lower dissolved oxygen than the Black River; as such, in 2013 Stations NCF117 and B210,

representing those rivers, had average DO concentrations of 6.1 and 6.4 mg/L, respectively. Several stream stations were severely stressed in terms of low dissolved oxygen during the year 2013. Stations NAV, HB, BRR, and M61 were all below 5.0 mg/L on 33% or more of occasions sampled, and IC, DP and M54 were below on 25% of occasions sampled. Considering all sites sampled in 2013, we rated 25% as poor for dissolved oxygen, 19% as fair, and 59% as good, an improvement from 2012

Annual mean turbidity levels for 2013 were lower than the long-term average in all estuary stations. Highest mean turbidities were at NC11-DP, plus NAV (11-12 NTU) with turbidities generally low in the middle to lower estuary. The estuarine stations did not exceed the estuarine turbidity standard on our 2013 sampling trips. Turbidity was considerably lower in the blackwater tributaries (Northeast Cape Fear River and Black River) than in the mainstem river. Average turbidity levels were low in the freshwater streams, with the exception of one excursion to 90 NTU in December at LRC.

Regarding stream stations, chronic or periodic high nitrate levels were found at a number of sites, including ROC (Rockfish Creek), 6RC (Six Runs Creek), PB (panther Branch), NC403 and GCO (Great Coharie Creek). Average chlorophyll *a* concentrations across all sites were low in 2013. We note the highest levels in the river and estuary typically occur in mid-summer; during the growing season May-September river flow as measured by USGS at Lock and Dam #1 was much higher for 2013 compared with the 1995-2012 long-term average (6,975 CFS compared with 3,361 CFS). Higher flows restrict algal bloom formation by maintaining relatively high turbidity; thus troublesome cyanobacteria (i.e. blue-green algal blooms) did not occur in the Cape Fear River during 2013. Stream algal blooms exceeding 20 µg/L in 2012 occurred at ANC, NC403, PB and LRC. A few minor algal blooms occurred at stream stations PB and ANC. Several stream stations, particularly PB, BRN, HAM (Hammond Creek), GS, N403, ROC, LRC and ANC showed high fecal coliform bacteria counts on a number of occasions.

For the 2013 period UNCW rated 100% of the stations as good in terms of chlorophyll *a* and turbidity. Fecal coliform bacteria counts were high in the system in 2013 and the lower estuary had high enterococcus on some occasions. For bacterial water quality overall, 34% of the sites rated as poor, 28% as fair, and 38% as good in 2013. Using the 5.0 mg/L DO standard for the mainstem river stations, and the 4.0 mg/L “swamp water” DO standard for the stream stations and blackwater river stations, 44% of the sites were rated poor or fair for dissolved oxygen. In addition, by our UNCW standards excessive nitrate and phosphorus concentrations were problematic at a number of stations (Chapter 3).

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1.0 Introduction

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The Lower Cape Fear River Program is a unique science and education program that has a mission to develop an understanding of processes that control and influence the ecology of the Cape Fear River, and to provide a mechanism for information exchange and public education. This program provides a forum for dialogue among the various Cape Fear River user groups and encourages interaction among them. Overall policy is set by an Advisory Board consisting of representatives from citizen's groups, local government, industries, academia, the business community, and regulatory agencies. This report represents the scientific conclusions of the UNCW researchers participating in this program and does not necessarily reflect opinions of all other program participants. This report focuses on the period January through December 2013.

The scientific basis of the LCFRP consists of the implementation of an ongoing comprehensive physical, chemical, and biological monitoring program. Another part of the mission is to develop and maintain a data base on the Cape Fear basin and make use of this data to develop management plans. Presently the program has amassed an 18-year (1995-2013) data base that is available to the public, and is used as a teaching tool for programs like UNCW's River Run. Using this monitoring data as a framework the program goals also include focused scientific projects and investigation of pollution episodes. The scientific aspects of the program are carried out by investigators from the University of North Carolina Wilmington Center for Marine Science. The monitoring program was developed by the Lower Cape Fear River Program Technical Committee, which consists of representatives from UNCW, the North Carolina Division of Water Quality, The NC Division of Marine Fisheries, the US Army Corps of Engineers, technical representatives from streamside industries, the Cape Fear Public Utility Authority, Cape Fear Community College, Cape Fear River Watch, the North Carolina Cooperative Extension Service, the US Geological Survey, forestry and agriculture organizations, and others. This integrated and cooperative program was the first of its kind in North Carolina.

Broad-scale monthly water quality sampling at 16 stations in the estuary and lower river system began in June 1995 (UNCW Aquatic Ecology Laboratory, directed by Dr. Michael Mallin). Sampling was increased to 34 stations in February of 1996, 35 stations in February 1998, and 36 stations in 2005, then lowered to 33 in 2011. The Lower Cape Fear River Program added another component concerned with studying the benthic macrofauna of the system in 1996. This component is directed by Dr. Martin Posey and Mr. Troy Alphin of the UNCW Biology Department and includes the benefit of additional data collected by the Benthic Ecology Laboratory under Sea Grant and NSF sponsored projects in the Cape Fear Estuary. These data are collected and analyzed depending upon the availability of funding. The third major biotic component (added in

January 1996) was an extensive fisheries program directed by Dr. Mary Moser of the UNCW Center for Marine Science Research, with subsequent (1999) overseeing by Mr. Michael Williams and Dr. Thomas Lankford of UNCW-CMS. This program involved cooperative sampling with the North Carolina Division of Marine Fisheries and the North Carolina Wildlife Resources Commission. The fisheries program ended in December 1999, but was renewed with additional funds from the Z. Smith Reynolds Foundation from spring – winter 2000. The regular sampling that was conducted by UNCW biologists was assumed by the North Carolina Division of Marine Fisheries.

1.1. Site Description

The mainstem of the Cape Fear River is formed by the merging of the Haw and the Deep Rivers in Chatham County in the North Carolina Piedmont. However, its drainage basin reaches as far upstream as the Greensboro area (Fig. 1.1). The mainstem of the river has been altered by the construction of several dams and water control structures. In the coastal plain, the river is joined by two major tributaries, the Black and the Northeast Cape Fear Rivers (Fig. 1.1). These 5th order blackwater streams drain extensive riverine swamp forests and add organic color to the mainstem. The watershed (about 9,164 square miles) is the most heavily industrialized in North Carolina with 203 permitted wastewater discharges with a permitted flow of approximately 429 million gallons per day, and (as of 2010) over 2.07 million people residing in the basin (NCDENR Basinwide Information Management System (BIMS) & 2010 Census). Approximately 23% of the land use in the watershed is devoted to agriculture and livestock production (2006 National Land Cover Dataset), with livestock production dominated by swine and poultry operations. Thus, the watershed receives considerable point and non-point source loading of pollutants. However, the estuary is a well-flushed system, with flushing time ranging from 1 to 22 days with a median flushing time of about seven days, much shorter than the other large N.C. estuaries to the north (Ensign et al. 2004).

Water quality is monitored by boat at eight stations in the Cape Fear Estuary (from Navassa to Southport) and one station in the Northeast Cape Fear Estuary (Table 1.1; Fig. 1.1). We note that after July 2011 sampling was discontinued at stations M42 and SPD, per agreement with the North Carolina Division of Water Quality; and in 2012 sampling was expanded at Smith Creek at the Castle Hayne Road bridge (Table 1.1) and initiated at a new site along the South River (SR-WC). Riverine stations sampled by boat include NC11, AC, DP, IC, and BBT (Table 1.1; Fig. 1.1). NC11 is located upstream of any major point source discharges in the lower river and estuary system, and is considered to be representative of water quality entering the lower system (we note that the City of Wilmington and portions of Brunswick County get their drinking water from the river just upstream of Lock and Dan #1). Station BBT is located on the Black River between Thoroughfare (a stream connecting the Cape Fear and Black Rivers) and the mainstem Cape Fear, and is influenced by both rivers. We consider B210 and NCF117 to represent water quality entering the lower Black and Northeast Cape Fear Rivers, respectively. Data has also been collected at stream and river stations throughout the Cape Fear, Northeast Cape Fear, and Black River watersheds (Table 1.1; Fig. 1.1; Mallin et al. 2001).

1.2. Report Organization

This report contains two sections assessing LCFRP data. Section 2 presents an overview of physical, chemical, and biological water quality data from the 33 individual stations, and provides tables of raw data as well as figures showing spatial or temporal trends.

The LCFRP has a website that contains maps and an extensive amount of past water quality, benthos, and fisheries data gathered by the Program available at: www.uncw.edu/cms/aelab/LCFRP/.

References Cited

Ensign, S.H., J.N. Halls and M.A. Mallin. 2004. Application of digital bathymetry data in an analysis of flushing times of two North Carolina estuaries. *Computers and Geosciences* 30:501-511.

Mallin, M.A., S.H. Ensign, M.R. McIver, G.C. Shank and P.K. Fowler. 2001. Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters. *Hydrobiologia* 460:185-193.

NCDENR. 2005. Cape Fear River Basinwide Water Quality Plan. North Carolina Department of Environment and Natural Resources, Division of Water Quality/Planning, Raleigh, NC, 27699-1617.

Table 1.1 Description of sampling locations in Lower Cape Fear River Watershed, 2013

Collected by Boat

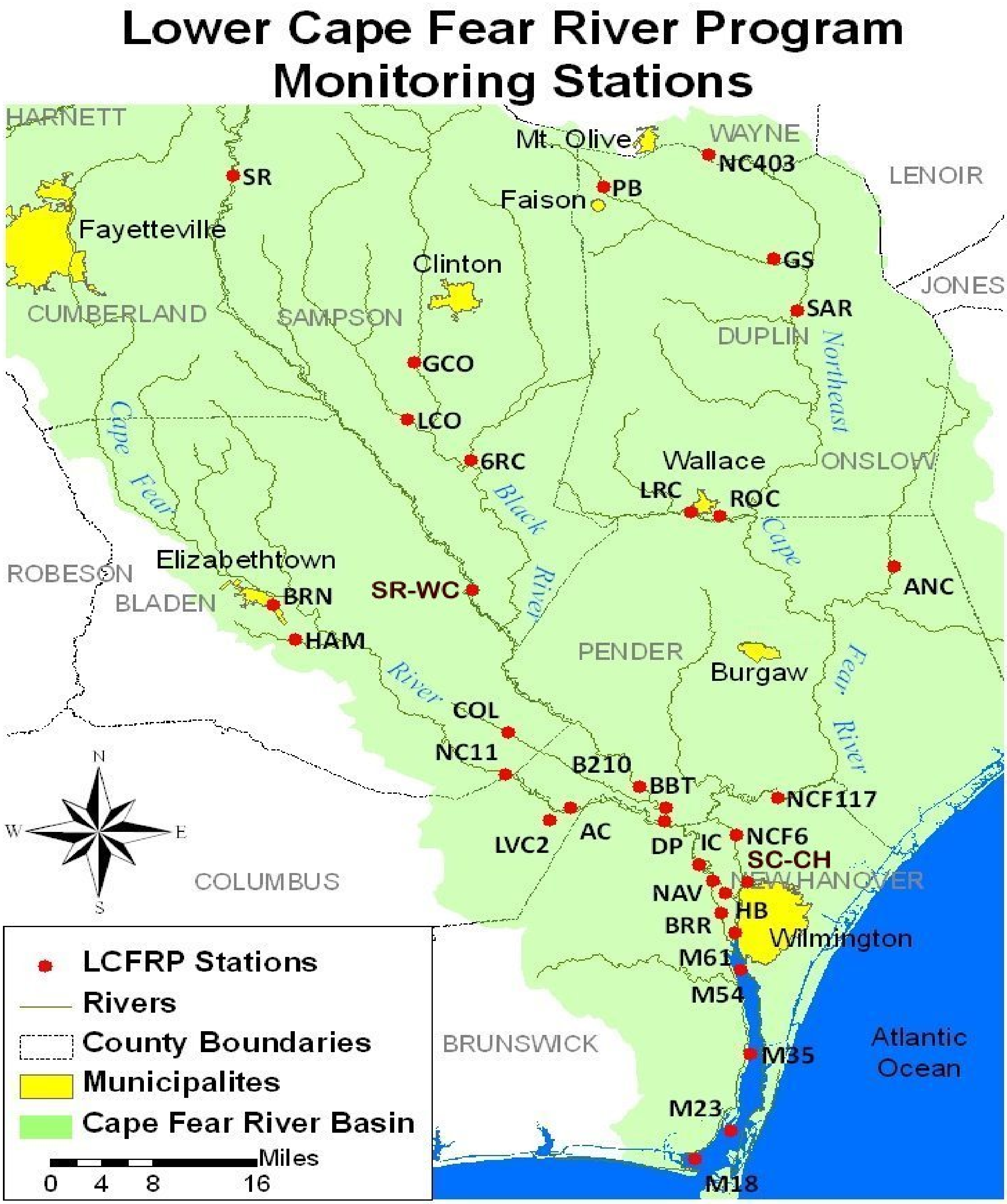
AEL Station	DWR Station #	Description	Comments	County	Lat	Lon	Stream Class.	HUC
NC11	B8360000	Cape Fear River at NC 11 nr East Arcadia	Below Lock and Dam 1, Represents water entering lower basin	Bladen	34.3969	-78.2675	WS-IV Sw	03030005
LVC2	B8441000	Livingston Creek at Momentive Walkway nr Acme	DWR ambient station, Downstream of Momentive	Columbus	34.3353	-78.2011	C Sw	03030005
AC	B8450000	Cape Fear River at Neils Eddy Landing nr Acme	1 mile below IP, DWR ambient station	Columbus	34.3555	-78.1794	C Sw	03030005
DP	B8465000	Cape Fear River at Intake nr Hooper Hill	AT DAK intake, just above confluence with Black R.	Brunswick	34.3358	-78.0534	C Sw	03030005
BBT		Black River below Lyons Thorofare	UNCW AEL station	Pender	34.3513	-78.0490	C Sw ORW+	0303005
IC	B9030000	Cape Fear River ups Indian Creek nr Phoenix	Downstream of several point source discharges	Brunswick	34.3021	-78.0137	C Sw	0303005
NAV	B9050025	Cape Fear River dns of RR bridge at Navassa	Downstream of several point source discharges	Brunswick	34.2594	-77.9877	SC	0303005
HB	B9050100	Cape Fear River at S. end of Horseshoe Bend nr Wilmington	Upstream of confluence with NE Cape Fear River	Brunswick	34.2437	-77.9698	SC	0303005
BRR	B9790000	Brunswick River dns NC 17 at park nr Belville	Near Belville discharge	Brunswick	34.2214	-77.9787	SC	03030005
M61	B9800000	Cape Fear River at Channel Marker 61 at Wilmington	Downstream of several point source discharges	New Hanover	34.1938	-77.9573	SC	03030005
M54	B9795000	Cape Fear River at Channel Marker 54	Downstream of several point source discharges	New Hanover	34.1393	-77.946	SC	03030005
M35	B9850100	Cape Fear River at Channel Marker 35	Upstream of Carolina Beach discharge	Brunswick	34.0335	-77.937	SC	03030005
M23	B9910000	Cape Fear River at Channel Marker 23	Downstream of Carolina Beach discharge	Brunswick	33.9456	-77.9696	SA HQW	03030005
M18	B9921000	Cape Fear River at Channel Marker 18	Near mouth of Cape Fear River	Brunswick	33.913	-78.017	SC	03030005
NCF6	B9670000	NE Cape Fear nr Wrightsboro	Downstream of several point source discharges	New Hanover	34.3171	-77.9538	C Sw	0303007

Collected by Land

AEL Station	DWR Station #	Description	Comments	County	Lat	Lon	Stream Class.	HUC
6RC	B8740000	Six Runs Creek at SR 1003 nr Ingold	Upstream of Black River, CAFOs in watershed	Sampson	34.7933	-78.3113	C Sw ORW+	03030006
LCO	B8610001	Little Coharie Creek at SR 1207 nr Ingold	Upstream of Great Coharie, CAFOs in watershed	Sampson	34.8347	-78.3709	C Sw	03030006
GCO	B8604000	Great Coharie Creek at SR 1214 nr Butler Crossroads	Downstream of Clinton, CAFOs in watershed	Sampson	34.9186	-78.3887	C Sw	03030006
SR	B8470000	South River at US 13 nr Cooper	Downstream of Dunn	Sampson	35.156	-78.6401	C Sw	03030006
BRN	B8340050	Browns Creek at NC87 nr Elizabethtown	CAFOs in watershed	Bladen	34.6136	-78.5848	C	03030005
HAM	B8340200	Hammond Creek at SR 1704 nr Mt. Olive	CAFOs in watershed	Bladen	34.5685	-78.5515	C	03030005

Collected by Land							
6RC	Six Runs Creek at SR 1003 nr Ingold	B8740000	Sampson	34.7933	-78.3113	C Sw ORW+	03030006
LCO	Little Coharie Creek at SR 1207 nr Ingold	B8610001	Sampson	34.8347	-78.3709	C Sw	03030006
GCO	Great Coharie Creek at SR 1214 nr Butler Crossroads	B8604000	Sampson	34.9186	-78.3887	C Sw	03030006
SR	South River at US 13 nr Cooper	B8470000	Sampson	35.156	-78.6401	C Sw	03030006
BRN	Browns Creek at NC87 nr Elizabethtown	B8340050	Bladen	34.6136	-78.5848	C	03030005
HAM	Hammond Creek at SR 1704 nr Mt. Olive	B8340200	Bladen	34.5685	-78.5515	C	03030005
COL	Colly Creek at NC 53 at Colly	B8981000	Bladen	34.4641	-78.2569	C Sw	03030006
B210	Black River at NC 210 at Still Bluff	B9000000	Pender	34.4312	-78.1441	C Sw ORW+	03030006
NC403	NE Cape Fear River at NC 403 nr Williams	B9090000	Duplin	35.1784	-77.9807	C Sw	0303007
PB	Panther Branch (Creek) nr Faison	B9130000	Duplin	35.1345	-78.1363	C Sw	0303007
GS	Goshen Swamp at NC 11 and NC 903 nr Kornegay	B9191000	Duplin	35.0281	-77.8516	C Sw	0303007
SAR	NE Cape Fear River SR 1700 nr Sarecta	B9191500	Duplin	34.9801	-77.8622	C Sw	0303007
ROC	Rockfish Creek at US 117 nr Wallace	B9430000	Duplin	34.7168	-77.9795	C Sw	0303007
LRC	Little Rockfish Creek at NC 11 nr Wallace	B9460000	Duplin	34.7224	-77.9814	C Sw	0303007
ANC	Angola Creek at NC 53 nr Maple Hill	B9490000	Pender	34.6562	-77.7351	C Sw	0303007
SR WC	South River at SR 1007 (Wildcat/Ennis Bridge Road)	B8920000	Sampson	34.6402	-78.3116	C Sw ORW+	03030006
NCF117	NE Cape Fear River at US 117 at Castle Hayne	B9580000	New Hanover	34.3637	-77.8965	B Sw	0303007
SC-CH	Smith Creek at US 117 and NC 133 at Wilmington	B9720000	New Hanover	34.2586	-77.9391	C Sw	0303007

Figure 1.1. Map of the Lower Cape Fear River system and the LCFRP sampling stations.



2.0 Physical, Chemical, and Biological Characteristics of the Lower Cape Fear River and Estuary

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2.1 - Introduction

This section of the report includes a discussion of the physical, chemical, and biological water quality parameters, concentrating on the January-December 2013 Lower Cape Fear River Program monitoring period. These parameters are interdependent and define the overall condition of the river. Physical parameters measured during this study included water temperature, dissolved oxygen, field turbidity and laboratory turbidity, total suspended solids (TSS), salinity, conductivity, pH and light attenuation. The chemical makeup of the Cape Fear River was investigated by measuring the magnitude and composition of nitrogen and phosphorus in the water. Three biological parameters including fecal coliform bacteria or enterococcus bacteria, chlorophyll *a* and biochemical oxygen demand were examined.

2.2 - Materials and Methods

All samples and field parameters collected for the estuarine stations of the Cape Fear River (NAV down through M18) were gathered on an ebb tide. This was done so that the data better represented the river water flowing downstream through the system rather than the tidal influx of coastal ocean water. Sample collection and analyses were conducted according to the procedures in the Lower Cape Fear River Program Quality Assurance/Quality Control (QA/QC) manual. Technical Representatives from the LCFRP Technical Committee and representatives from the NC Division of Water Quality inspect UNCW laboratory procedures and periodically accompany field teams to verify proper procedures are followed. By agreement with N.C. Division of Water Quality, after June 2011 sampling was discontinued at stations M42 and SPD, but full sampling was added at SC-CH and SR-WC in 2012. We note the Town of Burgaw left the program as of 2013 and Stations BCRR and BC117 are no longer being sampled.

<u>Physical Parameters</u>

Water Temperature, pH, Dissolved Oxygen, Turbidity, Light, Salinity, Conductivity

Field parameters other than light attenuation were measured at each site using a YSI 6920 (or 6820) multi-parameter water quality sonde displayed on a YSI 650 MDS. Each parameter is measured with individual probes on the sonde. At stations sampled by boat (see Table 1.1) physical parameters were measured at 0.1 m and at the bottom (up to 12 m). Occasionally, high flow prohibited the sonde from reaching the actual bottom and measurements were taken as deep as possible. At the terrestrially sampled stations (i.e. from bridges or docks) the physical parameters were measured at a depth of 0.1 m. The Aquatic Ecology Laboratory at the UNCW CMS is State-certified by the N.C. Division of Water Quality to perform field parameter measurements. The light attenuation coefficient *k* was determined from data collected on-site using vertical profiles obtained by a Li-Cor LI-1000 integrator interfaced with a Li-Cor LI-193S spherical quantum sensor.

<u>Chemical Parameters</u>

Nutrients

A local State-certified analytical laboratory was contracted to conduct all chemical analyses except for orthophosphate, which is performed at CMS. The following methods detail the techniques used by CMS personnel for orthophosphate analysis.

Orthophosphate (PO_4^{-3})

Water samples were collected ca. 0.1 m below the surface in triplicate in amber 125 mL Nalgene plastic bottles and placed on ice. In the laboratory 50 mL of each triplicate was filtered through separate1.0 micron pre-combusted glass fiber filters, which were frozen and later analyzed for chlorophyll *a*. The triplicate filtrates were pooled in a glass flask, mixed thoroughly, and approximately 100 mL was poured into a 125 mL plastic bottle to be analyzed for orthophosphate. Samples were frozen until analysis.

Orthophosphate analyses were performed in duplicate using an approved US EPA method for the Bran-Lubbe AutoAnalyzer (Method 365.5). In this technique the orthophosphate in each sample reacts with ammonium molybdate and anitmony potassium tartrate in an acidic medium (sulfuric acid) to form an anitmony-phospho-molybdate complex. The complex is then reacted with ascorbic acid and forms a deep blue color. The intensity of the color is measured at a wavelength of 880 nm by a colorimeter and displayed on a chart recorder. Standards and spiked samples were analyzed for quality assurance.

<u>Biological Parameters</u>

Fecal Coliform Bacteria / Enterococcus

Fecal coliform bacteria were analyzed by a State-certified laboratory contracted by the LCFRP. Samples were collected approximately 0.1 m below the surface in sterile plastic bottles provided by the contract laboratory and placed on ice for no more than six hours before analysis. After August 2011 the fecal coliform analysis was changed to *Enterococcus* in the estuarine stations downstream of NAV and HB (Stations BRR, M61, M35, M23 and M18).

Chlorophyll a

The analytical method used to measure chlorophyll *a* is described in Welschmeyer (1994) and was performed by CMS personnel. Chlorophyll *a* concentrations were determined utilizing the 1.0 micron filters used for filtering samples for orthophosphate analysis. All filters were wrapped individually in foil, placed in airtight containers and stored in the freezer. During analysis each filter was immersed in 10 mL of 90% acetone for 24 hours, which extracts the chlorophyll *a* into solution. Chlorophyll *a* concentration of each solution was measured on a Turner 10-AU fluorometer. The fluorometer uses an optimal combination of excitation and emission bandwidth filters which reduces the errors inherent in the acidification technique.

Biochemical Oxygen Demand (BOD)

Five sites were originally chosen for BOD analysis. One site was located at NC11, upstream of International Paper, and a second site was at AC, about 3 miles downstream of International Paper (Fig.1.1). Two sites were located in blackwater rivers (NCF117 and B210) and one site (BBT) was situated in an area influenced by both the mainstem Cape Fear River and the Black River. For the sampling period May 2000-April 2004 additional BOD data were collected at stream stations 6RC, LCO, GCO, BRN, HAM and COL in the Cape Fear and Black River watersheds. In May 2004 those stations were dropped and sampling commenced at ANC, SAR, GS, N403, ROC and BC117 in the Northeast Cape Fear River watershed for several years. The procedure used for BOD analysis is Method 5210 in Standard Methods (APHA 1995). Samples were analyzed for both 5-day and 20-day BOD. During the analytical period, samples were kept in airtight bottles and placed in an incubator at 20^{o} C. All experiments were initiated within 6 hours of sample collection. Samples were analyzed in duplicate. Dissolved oxygen measurements were made using a YSI Model 5000 meter that was air-calibrated. No adjustments were made for pH since most samples exhibited pH values within or very close to the desired 6.5-7.5 range (pH is monitored during the analysis as well); a few sites have naturally low pH and there was no adjustment for these samples because it would alter the natural water chemistry and affect true BOD. Data are presented within for the five original sites.

Parameter	***Method***	***NC DWR Certified***
Water Temperature	SM 2550B-2000	Yes
Dissolved Oxygen	SM 4500O G-2001	Yes
pH	SM 4500 H B-2000	Yes
Specific Conductivity	SM 2510 B-1997	Yes
Lab Turbidity	SM 2130 B-2001	Yes
Field Turbidity	SM 2130 B-2001	No
Chlorophyll *a*	Welschmeyer 1994	No

Biochemical Oxygen Demand	SM 5210 B-2001	No
Parameter	***Method***	***NC DWR Certified***
Total Nitrogen	By addition	
Nitrate + Nitrite	EPA 353.2 Rev 2.0 1993	Yes
Total Kjeldahl Nitrogen	EPA 351.2 Rev 2.0 1993	Yes
Ammonia Nitrogen	EPA 350.1 Rev 2.0 1993	Yes
Total Phosphorus	SM 4500 P E-1999	Yes
Orthophosphate	EPA 365.5	No
Fecal Coliform	SM 9222 D-1997	Yes
Enterococcus	Enterolert IDEXX	Yes

2.3 - Results and Discussion

This section includes results from monitoring of the physical, biological, and chemical parameters at all stations for the time period January-December 2013. Discussion of the data focuses both on the river channel stations and stream stations, which sometimes reflect poorer water quality than mainstem stations. The contributions of the two large blackwater tributaries, the Northeast Cape Fear River and the Black River, are represented by conditions at NCF117 and B210, respectively. The Cape Fear Region did not experience any significant hurricane activity during this monitoring period (after major hurricanes in 1996, 1998, and 1999). Therefore this report reflects low to medium to somewhat elevated flow conditions for the Cape Fear River and Estuary.

<u>Physical Parameters</u>

Water temperature

Water temperatures at all stations ranged from 3.5 to 28.9^{o}C, and individual station annual averages ranged from 15.4 to 19.5^{o}C (Table 2.1). Highest temperatures occurred during July and August and lowest temperatures during January. Stream stations were generally cooler than river stations, most likely because of shading and lower nighttime air temperatures affecting the shallower waters.

Salinity

Salinity at the estuarine stations (NAV through M18; also NCF6 in the Northeast Cape Fear River) ranged from 0.1 to 34.5 practical salinity units (psu) and station annual means ranged from 1.7 to 25.5 psu (Table 2.2). Lowest salinities occurred in mid-summer and highest salinities occurred in late fall and winter. The annual mean salinity for 2013 was similar to that of the seventeen-year average for 1995-2012 for all of the estuarine stations (Figure 2.1). Two stream stations, NC403 and PB, had occasional oligohaline conditions due to discharges from pickle production facilities. SC-CH is a tidal creek that enters the Northeast Cape Fear River upstream of Wilmington and salinity there ranged widely, from 0.1 to 15.9 psu.

Conductivity

Conductivity at the estuarine stations ranged from 0.07 to 52.4 mS/cm and from 0.07 to 6.93 mS/cm at the freshwater stations (Table 2.3). Temporal conductivity patterns followed those of salinity. Dissolved ionic compounds increase the conductance of water, therefore, conductance increases and decreases with salinity, often reflecting river flow conditions due to rainfall. Stations PB and NC403 are below industrial discharges, and often have elevated conductivity. Smith Creek (SC-CH) is an estuarine tidal creek and the conductivity values reflect this (Table 2.3).

pH

pH values ranged from 3.6 to 8.2 and station annual means ranged from 4.0 to 8.0 (Table 2.4). pH was typically lowest upstream due to acidic swamp water inputs and highest downstream as alkaline seawater mixes with the river water. Low pH values at COL predominate because of naturally acidic blackwater inputs at this near-pristine stream station. We also note that LRC had an unusually high pH level (8.1) in April 2013 (Table 2.4).

Dissolved Oxygen

Dissolved oxygen (DO) problems have been a major water quality concern in the lower Cape Fear River and its estuary, and several of the tributary streams (Mallin et al. 1999; 2000; 2001a; 2001b; 2002a; 2002b; 2003; 2004; 2005a; 2006a; 2006b; 2007; 2008; 2009; 2010; 2011; 2012; 2013). Surface concentrations for all sites in 2013 ranged from 0.4 to 12.5 mg/L and station annual means ranged from 5.0 to 9.9 mg/L (Table 2.5). Average annual DO levels at the river channel and estuarine stations for 2013 were similar to the average for 1995-2012 (Figure 2.2). River dissolved oxygen levels were lowest during the summer and early fall (Table 2.5), often falling below the state standard of 5.0 mg/L at several river and upper estuary stations. Working synergistically to lower oxygen levels are two factors: lower oxygen carrying capacity in warmer water and increased bacterial respiration (or biochemical oxygen demand, BOD), due to higher temperatures in summer. Unlike other large North Carolina estuaries (the Neuse, Pamlico and New River) the Cape Fear estuary rarely suffers from dissolved oxygen stratification. This is because, despite salinity stratification the oxygen remains well mixed due to strong estuarine gravitational circulation and high freshwater inputs (Lin et al. 2006). Thus, hypoxia in the Cape Fear is present throughout the water column.

There is a dissolved oxygen sag in the main river channel that begins at DP below a paper mill discharge and persists into the mesohaline portion of the estuary (Fig. 2.2). Mean oxygen levels were highest at the upper river stations NC11 and AC and in the low-to-middle estuary at stations M35 to M18. Lowest mainstem mean 2013 DO levels occurred at the river and upper estuary stations IC, NAV, HB, BRR and M61 (6.7-6.8 mg/L). Stations NAV, HB, BRR, and M61 were all below 5.0 mg/L on 33% or more of occasions sampled, and IC, DP and M54 were below on 25% of occasions sampled, an improvement from 2012. Based on number of occasions the river stations were below 5 mg/L UNCW rated NAV, HB, BRR, and M61 as poor for 2013; the mid to lower estuary stations were rated as fair to good. Discharge of high BOD waste from the paper/pulp mill just above the AC station (Mallin et al. 2003), as well as inflow of blackwater from the Northeast Cape Fear and Black Rivers, helps to diminish oxygen in the lower river and upper estuary. Additionally, algal blooms periodically form behind Lock and Dam #1 (including the blue-green algal blooms in recent years), and the chlorophyll *a* they produce is strongly correlated with BOD at Station NC11 (Mallin et al. 2006b); thus the blooms do contribute to lower DO in the river. As the water reaches the lower estuary higher algal productivity, mixing and ocean dilution help alleviate oxygen problems.

The Northeast Cape Fear and Black Rivers generally have lower DO levels than the mainstem Cape Fear River (NCF117 2013 mean = 6.1, NCF6 = 6.5, B210 2013 mean = 6.4) . These rivers are classified as blackwater systems because of their tea colored water. As the water passes through swamps en route to the river channel, tannins from decaying vegetation leach into the water, resulting in the observed color. Decaying vegetation on the swamp floor has an elevated biochemical oxygen demand and usurps oxygen from the water, leading to naturally low dissolved oxygen levels. Runoff from concentrated animal feeding operations (CAFOs) may also contribute to chronic low dissolved oxygen levels in these blackwater rivers (Mallin et al. 1998; 1999; 2006; Mallin 2000). We note that phosphorus and nitrogen (components of animal manure) levels have been positively correlated with BOD in the blackwater rivers and their major tributaries (Mallin et al. 2006b).

Several stream stations were severely stressed in terms of low dissolved oxygen during the year 2013. Station GS had DO levels below 4.0 mg/L 42% of the occasions sampled, with NC403, SR and LVC2 at 33% (Table 2.5). Some of this can be attributed to low summer water conditions and some potentially to CAFO runoff; however point-source discharges also likely contribute to low dissolved oxygen levels at NC403 and possibly SR, especially via nutrient loading (Mallin et al. 2001a; 2002a; 2004). Hypoxia is thus a continuing and widespread problem, with 44% of the sites impacted in 2013 (an improvement from 2012 however).

Field Turbidity

Field turbidity levels ranged from 0 to 90 Nephelometric turbidity units (NTU) and station annual means ranged from 1 to 13 NTU (Table 2.6). The State standard for estuarine turbidity is 25 NTU. Highest mean turbidities were at NC11-DP, plus NAV (11-12 NTU) with turbidities generally low in the middle to lower estuary (Figure 2.3). The estuarine stations did not exceed the estuarine turbidity standard on our 2013 sampling trips. Annual mean turbidity levels for 2013 were well below the long-term average at all estuary sites (Fig. 2.3). Turbidity was considerably lower in the blackwater tributaries (Northeast Cape Fear River and Black River) than in the mainstem river. Average turbidity levels were low in the freshwater streams, with the exception of one excursion to 90 NTU in December at LRC. The State standard for freshwater turbidity is 50 NTU.

Note: In addition to the laboratory-analyzed turbidity that are required my NCDWQ for seven locations, the LCFRP uses nephelometers designed for field use, which allows us to acquire in situ turbidity from a natural situation. North Carolina regulatory agencies are required to use turbidity values from water samples removed from the natural system, put on ice until arrival at a State-certified laboratory, and analyzed using laboratory nephelometers. Standard Methods notes that transport of samples and temperature change alters true turbidity readings. Our analysis of samples using both methods shows that lab turbidity is nearly always lower than field turbidity; thus we do not discuss lab turbidity in this report.

Total Suspended Solids

A new monitoring plan was developed for the LCFRP in September 2011. These changes were suggested by the NC Division of Water Resources (then DWQ). NCDWR suggested the LCFRP stop monitoring TSS at Stations ANC, GS, 6RC, LCO, SR, BRN, HAM, COL, SR-WC and monitor turbidity instead. DWQ believed turbidity would be more useful than TSS in evaluating water quality at these stations because there are water quality standards for turbidity. TSS is used by the DWQ NPDES Unit to evaluate discharges. No LCFRP subscribers discharge in these areas.

Total suspended solid (TSS) values system wide ranged from 1 to 151 mg/L with station annual means from 2 to 19 mg/L (Table 2.7). The overall highest river values were at NAV, M23 and M18. In the stream stations TSS was generally considerably lower than the river and estuary, except for a few incidents at Station LRC and Station ROC. Although total suspended solids (TSS) and turbidity both quantify suspended material in the water column, they do not always go hand in hand. High TSS does not mean high turbidity and vice versa. This anomaly may be explained by the fact that fine clay particles are effective at dispersing light and causing high turbidity readings, while not resulting in high TSS. On the other hand, large organic or inorganic particles may be less effective at dispersing light, yet their greater mass results in high TSS levels. While there is no NC ambient standard for TSS, many years of data from the lower Cape Fear watershed indicates that 25 mg/L can be considered elevated. The fine silt and clay in the upper to middle estuary sediments are most likely derived from the Piedmont and carried downstream to the estuary, while the sediments in the lowest portion of the estuary are marine-derived sands (Benedetti et al. 2006).

Light Attenuation

The attenuation of solar irradiance through the water column is measured by a logarithmic function (k) per meter. The higher this light attenuation coefficient is the more strongly light is attenuated (through absorbance or reflection) in the water column. River and estuary light attenuation coefficients ranged from 0.89 to 6.40/m and station annual means ranged from 1.65 at M18 to 4.35 /m at NCF6 (Table 2.8). Elevated mean and median light attenuation occurred from DP in the lower river downstream to M54 in the estuary (Table 2.8). In the Cape Fear system, light is attenuated by both turbidity and water color.

High light attenuation did not always coincide with high turbidity. Blackwater, though low in turbidity, will attenuate light through absorption of solar irradiance. At NCF6 and BBT, blackwater stations with moderate turbidity levels, light attenuation was high. Compared to other North Carolina estuaries the Cape Fear has high average light attenuation. The high average light attenuation is a major reason why phytoplankton production in the major rivers and the estuary of the LCFR is generally low. Whether caused by turbidity or water color this attenuation tends to limit light availability to the phytoplankton (Mallin et al. 1997; 1999; 2004; Dubbs and Whalen 2008).

Chemical Parameters – Nutrients

Total Nitrogen

Total nitrogen (TN) is calculated from TKN (see below) plus nitrate; it is not analyzed in the laboratory. TN ranged from 50 (detection limit) to 5,150 μg/L and station annual means ranged from 237 to 1,978 μg/L (Table 2.9). Mean total nitrogen in 2013 was considerably lower than the seventeen-year mean at the river and estuary stations (Figure 2.4). Previous research (Mallin et al. 1999) has shown a positive correlation between river flow and TN in the Cape Fear system. In the main river total nitrogen concentrations were highest between NC11 and DP, entering the system then declined into the lower estuary, most likely reflecting uptake of nitrogen into the food chain through algal productivity and subsequent grazing by planktivores as well as through dilution and marsh denitrification. The highest median TN value at the stream stations was at ROC, with 1,945 μg/L; other elevated TN values were seen at ANC, NC403 and 6RC.

Nitrate+Nitrite

Nitrate+nitrite (henceforth referred to as nitrate) is the main species of inorganic nitrogen in the Lower Cape Fear River. Concentrations system wide ranged from 10 (detection limit) to 4,850 μg/L and station annual means ranged from 19 to 1,561 μg/L (Table 2.10). The highest average riverine nitrate levels were at NC11 and AC (555 and 557 μg/L, respectively) indicating that much of this nutrient is imported from upstream. Moving downstream, nitrate levels decrease most likely as a result of uptake by primary producers, microbial denitrification in riparian marshes and tidal dilution. Despite this, the rapid flushing of the estuary (Ensign et al. 2004) permits sufficient nitrate to enter the coastal ocean in the plume and contribute to offshore productivity (Mallin et al. 2005b). Nitrate can limit phytoplankton production in the lower estuary in summer (Mallin et al. 1999). The blackwater rivers carried lower concentrations of nitrate compared to the mainstem Cape Fear stations; i.e. the Northeast Cape Fear River (NCF117 mean = 240 μg/L) and the Black River (B210 = 184 μg/L). Lowest river nitrate occurred during early summer and early fall.

Several stream stations showed high levels of nitrate on occasion including ROC, 6RC, GCO, NC403, and PB. 6RC, ROC and GCO primarily receive non-point agricultural or animal waste drainage, while point sources contribute to NC403 and PB. Over the past several years a considerable number of experiments have been carried out by UNCW researchers to assess the effects of nutrient additions to water collected from blackwater streams and rivers (i.e. the Black and Northeast Cape Fear Rivers, and Colly and Great Coharie Creeks). These experiments have collectively found that additions of nitrogen (as either nitrate, ammonium, or urea) significantly stimulate phytoplankton production and BOD increases. Critical levels of these nutrients were in the range of 0.2 to 0.5 mg/L as N (Mallin et al. 1998; Mallin et al. 2001a; Mallin et al. 2002a, Mallin et al. 2004). Thus, we conservatively consider nitrate concentrations exceeding 0.5 mg/L as N in Cape Fear watershed streams to be potentially problematic to the stream's environmental health.

Ammonium/ammonia

Ammonium concentrations ranged from 5 (detection limit) to 1,070 μg/L and station annual means ranged from 10 to 238 μg/L (Table 2.11). River areas with the highest mean ammonium levels this monitoring period included AC and DP, which are downstream of a pulp mill discharge, and NAV and HB in the upper estuary. Notable for 2013 were elevated ammonium concentrations at the most saline station M18 (the highest average in the system – Table 2.11). There is a major point source discharger (ADM) just upstream of that site that may have accounted for the high ammonium. At the stream stations, areas with highest levels of ammonium were PB, LVC2, NC403, ANC and HAM (Table 2.11). ANC had the highest peak concentration of 1,070 μg/L in July for unknown reasons; LVC2 had the second highest peak of 1,060 μg/L in August.

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is a measure of the total concentration of organic nitrogen plus ammonium. TKN ranged from 50 (detection limit) to 1,400 μg/L and station annual means ranged from 104 to 808 μg/L (Table 2.12). TKN concentration decreases ocean-ward through the estuary, likely due to ocean dilution and food chain uptake of nitrogen. Several minor peals in the 1,000 μg/L range occurred in stations ANC, NC403 and COL; ANC also had the highest median concentrations.

Total Phosphorus

Total phosphorus (TP) concentrations ranged from 10 (detection limit) to 1,250 μg/L and station annual means ranged from 33 to 398 μg/L (Table 2.13). Mean TP for 2013 was higher than the seventeen-year mean in the estuary and river stations (Figure 2.5). In the river TP was highest at the upper riverine channel stations NC11, AC and DP and declined downstream into the estuary. Some of this decline is attributable to the settling of phosphorus-bearing suspended sediments, yet incorporation of phosphorus into bacteria and algae is also responsible.

The experiments discussed above in the nitrate subsection also involved additions of phosphorus, either as inorganic orthophosphate or a combination of inorganic plus organic P. The experiments showed that additions of P exceeding 0.5 mg/L led to significant increases in bacterial counts, as well as significant increases in BOD over control. Thus, we consider concentrations of phosphorus above 0.5 mg/L (500 μg/L) to be potentially problematic to blackwater streams (Mallin et al. 1998; 2004). Streams periodically exceeding this critical concentration included GCO, LCO, ROC and NC403. Station NC403 is downstream of industrial or wastewater discharges, while GCO, LCO and ROC are in non-point agricultural areas.

Orthophosphate

Orthophosphate ranged from undetectable to 730 μg/L and station annual means ranged from undetectable to 222 μg/L (Table 2.14). Much of the orthophosphate load is imported into the Lower Cape Fear system from upstream areas, as NC11 or AC typically have high levels; there are also inputs of orthophosphate from the paper mill above AC (Table 2.14). The Northeast Cape Fear River had higher orthophosphate levels than the Black River. Orthophosphate can bind to suspended materials and is transported downstream via particle attachment; thus high levels of turbidity at the uppermost river stations may be an important factor in the high orthophosphate levels. Turbidity declines toward the lower estuary because of settling, and orthophosphate concentration also declines. In the estuary, primary productivity helps reduce orthophosphate concentrations by assimilation into biomass. Orthophosphate levels typically reach maximum concentrations during summertime, when anoxic sediment releases bound phosphorus. Also, in the Cape Fear Estuary, summer algal productivity is limited by nitrogen, thereby allowing the accumulation of orthophosphate (Mallin et al. 1997; 1999). In spring, productivity in the estuary is usually limited by phosphorus (Mallin et al. 1997; 1999).

ROC, ANC and GCO had the highest stream station concentrations. All of those sites are in non-point source areas.

<u>Chemical Parameters - EPA Priority Pollutant Metals</u>

The LCFRP had previously sampled for water column metals (EPA Priority Pollutant Metals) on a bimonthly basis. However, as of 2007 this requirement was suspended by the NC Division of Water Quality and these data are no longer collected by the LCFRP.

Biological Parameters

Chlorophyll a

During this monitoring period in most locations chlorophyll *a* was low, except for elevated concentrations in summer and early fall at the lower estuary stations (Table 2.15). The state standard was not exceeded in our samples in 2013. We note that at the upper site NC11 it has been demonstrated that chlorophyll *a* biomass is significantly correlated with biochemical oxygen demand (BOD5 – Mallin et al. 2006b). System wide, chlorophyll *a* ranged from undetectable to 28 μg/L and station annual means ranged from 2-10 μg/L, lower than in 2012. Production of chlorophyll *a* biomass is usually low to moderate in the rivers and estuary primarily because of light limitation by turbidity in the mainstem (Dubbs and Whalen 2008) and high organic color and low inorganic nutrients in the blackwater rivers.

Spatially, besides Station NC11 along the mainstem high values are normally found in the mid-to-lower estuary stations because light becomes more available downstream of the estuarine turbidity maximum (Fig. 2.6). On average, flushing time of the Cape Fear estuary is rapid, ranging from 1-22 days with a median of 6.7 days (Ensign et al. 2004). This does not allow for much settling of suspended materials, leading to light limitation of phytoplankton production. However, under lower-than-average flows there is generally clearer water through less suspended material and less blackwater swamp inputs. For the growing season May-September, long-term (1995-2012) average monthly flow at Lock and Dam #1 was approximately 3,361 CFS (USGS data; (http://nc.water.usgs.gov/realtime/real_time_cape_fear.html), whereas for 2013 discharge in May-September was well above the average at 6,975 CFS. Thus, chlorophyll *a* concentrations in the river and upper estuary were suppressed by increased flow; however the lowest stations in the estuary, M35-M18 showed chlorophyll *a* increases (Figure 2.6).

As noted in earlier reports, blooms of cyanobacteria (blue-green algae) called *Microcystis aeruginosa* began occurring in 2009 and continued to occur in summer 2010, 2011 and 2012. This species contains many strains long known to produce toxins, both as a threat to aquatic life and to humans as well (Burkholder 2002). At least some of the blooms in the main stem of the Cape Fear have produced toxins (Isaacs 2013). River discharge appears to be a major factor controlling formation and persistence of these blooms. The blooms in 2009-2012 all occurred when average river discharge for May-September was below 1,900 CFS. The cyanobacterial blooms were suppressed by elevated river flow in 2013.

Phytoplankton blooms occasionally occur at the stream stations, with a few occurring at various months in 2013 (Table 2.15). These streams are generally shallow, so vertical mixing does not carry phytoplankton cells down below the critical depth where respiration exceeds photosynthesis. In areas where the forest canopy opens up large blooms can occur. When blooms occur in blackwater streams they can become sources of BOD upon death and decay, reducing further the low summer dissolved oxygen conditions common to these waters (Mallin et al. 2001a; 2002a; 2004; 2006b). Stations PB and ANC had minor algal blooms in 2013, although not exceeding the state standard of 40 µg/L (Table 2.15).

Biochemical Oxygen Demand

For the mainstem river, median annual five-day biochemical oxygen demand (BOD5) concentrations were approximately equivalent between NC11 and AC, suggesting that in 2013 (as was the case with 2007 through 2012) there was little discernable effect of BOD loading from the nearby pulp/paper mill inputs (Table 2.16). BOD5 values between 1.0 and 2.0 mg/L are typical for the rivers in the Cape Fear system (Mallin et al. 2006b) and in 2013 BOD5 values ranged from 0.6 – 2.5 mg/L. There were no major differences among sites for BOD5 or BOD20 in 2013. BOD20 values showed similar patterns to BOD5 in 2013.

Fecal Coliform Bacteria/ Enterococcus bacteria

Fecal coliform (FC) bacterial counts ranged from 5 to 11,000 CFU/100 mL and station annual geometric means ranged from 33 to 436 CFU/100 mL (Table 2.17). The state human contact standard (200 CFU/100 mL) was exceeded in the mainstem three times at NAV and once each at AC, DP and IC in 2013. During 2013 the stream stations showed high fecal coliform pollution levels. BRN exceeded 200 CFU/100 mL 100% of the time sampled; HAM, PB and SAR 75%, LRC and ROC 58%, NC403 and ANC 50%, LVC2 42%, and SC-CH 33% and SR-WC 30% of the time sampled. NC403 and PB are located below point source discharges and the other sites are primarily influenced by non-point source pollution.

Enterococcus counts were initiated in the estuary in mid-2011, as this test is now the standard used by North Carolina regulators for swimming in salt waters. Sites covered by this test include BRR, M61, M54, M35, M23 and M18. The State has a single-sample level for Tier II swimming areas in which the enterococci level in a Tier II swimming area shall not exceed a single sample of 276 enterococci per 100 milliliter of water (15A NCAC 18A .3402); the LCFRP is using this standard for the Cape Fear estuary samples in our rating system. As such, in 2013 station BRR exceeded the standard on two occasions, and M61 and M35 exceeded the standard on one occasion each. Overall, elevated fecal coliform and enterococcus counts are problematic in this system, with 62% of the stations rated as Fair or Poor in 2013, slightly lower than the previous year 2012.

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Table 2.1 Water temperature (°C) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	8.1	8.3	9.0	9.3	9.4	10.1	10.5	10.6
FEB	8.8	8.9	10.1	10.3	10.2	10.1	10.4	10.3
MAR	13.9	13.8	14.0	14.0	13.8	14.1	14.3	14.1
APR	15.6	17.5	16.3	16.9	17.0	16.9	16.8	15.6
MAY	20.1	20.2	20.7	20.1	19.8	19.3	18.7	18.7
JUN	24.3	24.4	24.5	25.0	25.1	27.7	27.7	27.2
JUL	25.2	25.7	25.3	26.3	26.2	26.7	27.1	27.7
AUG	27.8	27.9	27.8	28.7	28.0	28.2	27.7	27.4
SEP	26.3	26.5	26.9	27.2	27.4	27.6	27.8	27.8
OCT	22.9	23.0	22.7	23.2	23.0	23.0	22.5	22.2
NOV	14.7	14.7	14.0	14.8	14.3	13.5	13.6	13.6
DEC	12.1	12.5	12.7	12.7	13.0	13.0	13.6	13.7
mean	**18.3**	**18.6**	**18.7**	**19.0**	**18.9**	**19.2**	**19.2**	**19.1**
std dev	7.0	7.0	6.8	6.9	6.8	7.2	7.0	7.0
median	17.9	18.9	18.5	18.5	18.4	18.1	17.8	17.2
max	27.8	27.9	27.8	28.7	28.0	28.2	27.8	27.8
min	8.1	8.3	9.0	9.3	9.4	10.1	10.4	10.3

	NC11	AC	DP	BBT	IC	NCF6
JAN	8.8	8.8	9.0	8.8	8.6	8.7
FEB	9.1	9.1	8.9	8.7	8.7	10.2
MAR	12.7	12.6	13.1	14.4	14.1	14.1
APR	19.6	20.0	19.7	19.4	19.7	19.4
MAY	18.3	18.4	18.5	19.6	18.9	20.4
JUN	25.0	24.4	24.3	24.5	24.4	25.7
JUL	26.0	26.1	26.0	25.5	25.5	26.8
AUG	27.5	28.4	28.5	27.3	28.2	28.3
SEP	27.5	27.8	26.7	28.5	26.5	26.9
OCT	23.4	22.8	22.5	22.5	22.7	23.6
NOV	16.9	17.0	17.3	17.3	17.5	18.2
DEC	10.1	10.7	10.9	11.1	11.3	11.8
mean	**18.7**	**18.8**	**18.8**	**19.0**	**18.8**	**19.5**
std dev	7.2	7.2	7.0	7.0	6.9	7.0
median	19.0	19.2	19.1	19.5	19.3	19.9
max	27.5	28.4	28.5	28.5	28.2	28.3
min	8.8	8.8	8.9	8.7	8.6	8.7

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	5.5	4.3	3.5	5.4	5.4	8.9	6.8
FEB	10.6	10.7	11.0	10.0	10.9	12.9	11.7
MAR	13.7	13.6	14.1	13.0	14.9	17.8	15.1
APR	13.3	15.5	14.7	15.1	16.6	19.5	15.4
MAY	16.4	18.0	17.0	17.8	20.8	21.9	18.6
JUN	22.3	23.1	22.5	23.3	27.7	28.0	22.8
JUL	23.6	25.3	26.7	26.8	28.7	28.9	26.3
AUG	23.9	23.2	24.5	23.9	25.5	26.6	24.6
SEP	22.3	22.6	23.9	24.8	28.0	26.6	23.3
OCT	16.7	16.7	16.0	16.5	16.4	17.3	16.7
NOV	8.4	8.5	6.3	8.4	8.3	8.2	8.8
DEC	12.9	11.0	12.6	11.7	11.9	14.5	12.1
mean	**15.8**	**16.0**	**16.1**	**16.4**	**17.9**	**19.3**	**16.9**
std dev	6.2	6.7	7.3	7.0	8.1	7.3	6.4
median	15.1	16.1	15.4	15.8	16.5	18.7	16.1
max	23.9	25.3	26.7	26.8	28.7	28.9	26.3
min	5.5	4.3	3.5	5.4	5.4	8.2	6.8

	6RC	LCO	GCO	SR	BRN	HAM
JAN	8.7	8.3	7.5	7.2	8.8	8.4
FEB	6.3	5.9	6.0	5.7	7.3	6.8
MAR	7.7	7.2	6.8	7.1	9.0	8.3
APR	14.5	14.6	15.7	14.4	15.6	15.9
MAY	17.1	16.9	17.0	16.9	16.7	16.8
JUN	23.2	23.6	24.0	23.8	23.8	23.7
JUL	25.0	25.4	26.1	25.8	24.2	24.3
AUG	26.8	26.8	28.0	26.4	26.2	25.7
SEP	21.8	22.0	22.7	22.0	20.9	20.8
OCT	16.0	16.0	16.1	15.1	15.7	15.1
NOV	13.5	12.9	13.7	13.0	12.8	12.4
DEC	9.4	9.0	8.2	7.2	9.0	9.5
mean	**15.8**	**15.7**	**16.0**	**15.4**	**15.8**	**15.6**
std dev	7.1	7.4	7.9	7.7	6.7	6.8
median	15.3	15.3	15.9	14.8	15.7	15.5
max	26.8	26.8	28.0	26.4	26.2	25.7
min	6.3	5.9	6.0	5.7	7.3	6.8

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	7.9	6.7	5.0		4.8	9.0
FEB	10.8	11.3	11.1		11.2	11.3
MAR	12.0	9.0	8.1	8.5	8.8	11.6
APR	19.2	18.9	15.7	16.8	15.9	19.3
MAY	24.7	20.3	19.4	20.3	22.1	24.1
JUN	25.6	23.9	21.9	22.9	23.6	26.1
JUL	26.6	25.5	23.9	25.0	24.8	28.0
AUG	27.1	24.5	21.7	24.5	24.9	27.6
SEP	26.3	24.2	21.2	23.3	23.8	27.5
OCT	20.4	19.6	18.6	18.9	19.3	20.6
NOV	18.1	16.5	13.0	14.4	15.6	18.6
DEC	9.3	8.4	8.1	7.8	8.9	10.8
mean	**19.0**	**17.4**	**15.6**	**18.2**	**17.0**	**19.5**
std dev	7.3	6.9	6.4	6.3	7.2	7.3
median	19.8	19.3	17.2	19.6	17.6	20.0
max	27.1	25.5	23.9	25.0	24.9	28.0
min	7.9	6.7	5.0	7.8	4.8	9.0

Table 2.2 Salinity (psu) at the Lower Cape Fear River Program estuarine stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18	NCF6	SC-CH
JAN	0.1	0.2	2.8	7.0	8.0	13.4	22.1	25.2	0.1	0.7
FEB	0.1	0.3	3.0	6.0	8.3	14.0	21.4	24.3	0.1	0.2
MAR	0.1	0.1	0.6	3.7	4.8	8.2	15.1	19.0	0.1	2.4
APR	0.1	0.4	0.3	2.0	4.3	16.7	25.3	31.4	4.2	3.8
MAY	0.1	0.2	1.5	5.1	10.0	18.3	28.0	29.4	0.3	0.1
JUN	0.1	0.1	0.1	0.1	0.3	3.6	11.6	24.4	0.5	0.2
JUL	0.1	0.1	0.1	0.1	0.1	0.3	5.0	7.9	0.1	0.1
AUG	0.1	1.2	1.2	4.9	6.5	11.0	20.5	25.0	1.9	0.5
SEP	0.1	1.1	1.5	6.3	7.3	11.1	17.8	24.2	0.5	3.0
OCT	6.0	11.1	12.6	17.8	19.1	21.8	27.1	29.1	5.6	15.9
NOV	5.4	9.2	12.9	16.9	18.0	23.9	29.7	31.4	13.0	11.6
DEC	8.3	8.6	6.9	12.3	17.7	26.2	33.6	34.5	0.1	0.5
mean	**1.7**	**2.7**	**3.6**	**6.9**	**8.7**	**14.0**	**21.4**	**25.5**	**2.2**	**3.3**
std dev	3.0	4.2	4.7	5.9	6.5	7.9	8.1	7.0	3.9	5.1
median	0.1	0.4	1.5	5.6	7.7	13.7	21.8	25.1	0.4	0.6
max	8.3	11.1	12.9	17.8	19.1	26.2	33.6	34.5	13.0	15.9
min	0.1	0.1	0.1	0.1	0.1	0.3	5.0	7.9	0.1	0.1

Table 2.3 Conductivity (mS/cm) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	0.20	0.33	5.20	12.29	13.86	22.78	35.12	39.66
FEB	0.20	0.64	5.43	10.50	14.30	23.13	34.17	38.32
MAR	0.17	0.20	1.28	6.80	8.57	14.15	24.77	30.49
APR	0.16	0.76	0.59	3.75	7.67	27.01	39.51	48.11
MAY	0.21	0.46	2.92	9.04	16.99	29.57	43.59	45.44
JUN	0.10	0.11	0.11	0.12	0.68	6.61	19.33	38.48
JUL	0.07	0.08	0.07	0.08	0.09	0.54	9.05	13.79
AUG	0.13	2.38	2.26	8.82	11.31	18.63	32.84	39.21
SEP	0.13	2.20	2.84	11.08	12.75	18.79	28.92	38.20
OCT	10.59	18.60	21.08	28.79	30.67	34.60	42.13	44.94
NOV	9.52	15.69	21.40	27.41	28.78	37.72	45.86	48.14
DEC	14.51	14.70	12.05	20.57	28.56	40.92	51.09	52.37
mean	**3.00**	**4.68**	**6.27**	**11.60**	**14.52**	**22.87**	**33.86**	**39.76**
std dev	5.27	7.12	7.72	9.49	10.28	12.13	11.96	10.11
median	0.18	0.70	2.88	9.77	13.30	22.95	34.64	39.43
max	14.51	18.60	21.40	28.79	30.67	40.92	51.09	52.37
min	0.07	0.08	0.07	0.08	0.09	0.54	9.05	13.79

	NC11	AC	DP	BBT	IC	NCF6
JAN	0.15	0.17	0.17	0.16	0.18	0.17
FEB	0.14	0.23	0.20	0.16	0.19	0.20
MAR	0.14	0.14	0.20	0.13	0.17	0.15
APR	0.12	0.13	0.19	0.17	0.19	7.51
MAY	0.13	0.12	0.13	0.12	0.13	0.52
JUN	0.14	0.14	0.19	0.16	0.17	0.95
JUL	0.09	0.10	0.09	0.07	0.08	0.08
AUG	0.12	0.11	0.13	0.12	0.13	3.64
SEP	0.12	0.13	0.15	0.13	0.13	1.01
OCT	0.15	0.20	0.21	0.20	0.20	9.84
NOV	0.15	0.21	0.26	0.26	0.58	19.17
DEC	0.12	0.21	0.22	0.14	0.19	0.20
mean	**0.13**	**0.16**	**0.18**	**0.15**	**0.19**	**3.62**
std dev	0.02	0.04	0.05	0.05	0.13	5.87
median	0.13	0.14	0.19	0.15	0.17	0.74
max	0.15	0.23	0.26	0.26	0.58	19.17
min	0.09	0.10	0.09	0.07	0.08	0.08

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	0.13	0.19	0.18	0.54	1.33	0.14	0.16
FEB	0.10	0.13	0.13	0.30	0.31	0.09	0.09
MAR	0.09	0.17	0.16	0.68	1.29	0.12	0.15
APR	0.09	0.18	0.17	0.71	0.73	0.12	0.16
MAY	0.12	0.20	0.18	0.71	2.95	0.14	0.16
JUN	0.11	0.22	0.20	0.99	6.93	0.12	0.10
JUL	0.12	0.13	0.13	0.23	0.51	0.09	0.10
AUG	0.08	0.17	0.17	0.31	0.56	0.11	0.13
SEP	0.09	0.17	0.16	0.64	2.23	0.15	0.21
OCT	0.08	0.21	0.20	0.44	1.94	0.12	0.38
NOV	0.16	0.21	0.20	0.62	1.89	0.16	0.19
DEC	0.16	0.20	0.20	0.48	1.09	0.14	0.17
mean	**0.11**	**0.18**	**0.17**	**0.55**	**1.81**	**0.12**	**0.17**
std dev	0.03	0.03	0.03	0.22	1.79	0.02	0.08
median	0.10	0.18	0.18	0.58	1.31	0.12	0.16
max	0.16	0.22	0.20	0.99	6.93	0.16	0.38
min	0.08	0.13	0.13	0.23	0.31	0.09	0.09

	6RC	LCO	GCO	SR	BRN	HAM
JAN	0.14	0.10	0.14	0.10	0.13	0.15
FEB	0.15	0.10	0.14	0.09	0.14	0.15
MAR	0.14	0.10	0.13	0.09	0.15	0.13
APR	0.14	0.10	0.17	0.10	0.14	0.17
MAY	0.13	0.09	0.14	0.08	0.09	0.17
JUN	0.14	0.10	0.15	0.08	0.10	0.13
JUL	0.14	0.10	0.15	0.08	0.11	0.16
AUG	0.15	0.09	0.19	0.10	0.12	0.20
SEP	0.15	0.10	0.24	0.10	0.13	0.22
OCT	0.16	0.10	0.26	0.09	0.10	0.24
NOV	0.16	0.11	0.30	0.10	0.08	0.25
DEC	0.15	0.11	0.18	0.09	0.13	0.22
mean	**0.15**	**0.10**	**0.18**	**0.09**	**0.12**	**0.18**
std dev	0.01	0.01	0.06	0.01	0.02	0.04
median	0.14	0.10	0.16	0.09	0.12	0.17
max	0.16	0.11	0.30	0.10	0.15	0.25
min	0.13	0.09	0.13	0.08	0.08	0.13

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	0.15	0.10	0.07		0.12	1.33
FEB	0.12	0.09	0.07		0.10	0.34
MAR	0.14	0.10	0.07	0.08	0.10	4.44
APR	0.15	0.10	0.07	0.08	0.11	6.95
MAY	5.22	0.14	0.07	0.07	0.10	0.17
JUN	0.11	0.08	0.07	0.06	0.07	0.45
JUL	0.18	0.07	0.06	0.07	0.07	0.11
AUG	0.13	0.07	0.07	0.07	0.13	1.00
SEP	0.16	0.09	0.08	0.07	0.10	5.22
OCT	0.21	0.11	0.07	0.08	0.16	26.00
NOV	0.22	0.12	0.06	0.09	1.81	19.44
DEC	0.15	0.10	0.07	0.08	0.10	0.99
mean	**0.58**	**0.10**	**0.07**	**0.08**	**0.25**	**5.54**
std dev	1.46	0.02	0.00	0.01	0.49	8.45
median	0.15	0.10	0.07	0.08	0.10	1.17
max	5.22	0.14	0.08	0.09	1.81	26.00
min	0.11	0.07	0.06	0.06	0.07	0.11

Table 2.4 pH at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	6.8	6.7	7.2	7.4	7.4	7.8	8.0	8.1
FEB	7.1	7.3	7.3	7.4	7.6	7.9	8.1	8.2
MAR	7.1	7.3	7.2	7.3	7.4	7.8	8.2	8.2
APR	7.1	7.1	7.1	7.3	7.4	8.2	8.2	8.2
MAY	7.0	7.5	7.1	7.2	7.5	8.0	8.0	8.0
JUN	6.4	6.4	6.4	6.5	6.5	7.3	8.0	8.1
JUL	6.1	6.2	6.2	6.2	6.3	6.6	6.9	7.2
AUG	6.7	6.7	6.7	7.0	7.1	7.5	8.0	8.1
SEP	6.5	6.6	6.7	6.9	7.1	7.5	8.0	8.1
OCT	7.2	7.3	7.3	7.5	7.6	7.0	8.0	8.0
NOV	7.5	7.6	7.7	7.8	7.9	8.0	8.0	8.1
DEC	7.4	7.5	7.6	7.6	7.9	8.0	8.1	8.1
mean	**6.9**	**7.0**	**7.0**	**7.2**	**7.3**	**7.6**	**8.0**	**8.0**
std dev	0.4	0.5	0.5	0.5	0.5	0.5	0.3	0.3
median	7.1	7.2	7.2	7.3	7.4	7.8	8.0	8.1
max	7.5	7.6	7.7	7.8	7.9	8.2	8.2	8.2
min	6.1	6.2	6.2	6.2	6.3	6.6	6.9	7.2

	NC11	AC	DP	BBT	IC	NCF6
JAN	7.0	7.1	6.8	6.8	6.8	6.5
FEB	7.1	7.3	7.3	6.9	7.1	6.8
MAR	6.8	7.0	7.2	6.6	7.0	6.6
APR	6.7	6.8	6.9	6.7	6.8	7.0
MAY	6.8	6.9	6.9	6.7	6.7	6.8
JUN	6.9	6.9	6.9	6.8	6.8	6.8
JUL	6.5	6.6	6.5	6.0	6.2	5.9
AUG	6.6	6.6	6.6	6.3	6.4	6.6
SEP	6.7	6.7	6.6	6.4	6.4	6.5
OCT	6.9	7.1	6.9	6.9	6.9	6.9
NOV	7.0	7.0	7.0	7.0	7.0	7.0
DEC	5.9	6.7	6.7	6.3	6.6	6.6
mean	**6.7**	**6.9**	**6.9**	**6.6**	**6.7**	**6.7**
std dev	0.3	0.2	0.2	0.3	0.3	0.3
median	6.8	6.9	6.9	6.7	6.8	6.7
max	7.1	7.3	7.3	7.0	7.1	7.0
min	5.9	6.6	6.5	6.0	6.2	5.9

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	6.0	6.5	6.6	6.5	6.7	7.3	7.0
FEB	5.9	6.6	6.7	6.4	6.8	6.8	6.5
MAR	5.3	6.7	6.7	6.4	6.8	7.6	7.1
APR	5.6	6.8	7.0	6.5	6.8	8.1	7.2
MAY	6.2	7.0	6.7	6.2	6.7	7.6	7.2
JUN	6.3	7.0	6.6	6.4	7.1	7.7	6.8
JUL	6.1	6.5	6.6	6.3	6.6	6.9	6.4
AUG	5.4	6.5	6.5	6.2	6.5	7.2	6.8
SEP	5.4	6.6	6.6	6.6	7.0	7.6	7.0
OCT	4.9	6.5	6.4	6.5	6.5	7.4	7.2
NOV	6.0	6.4	6.4	6.6	6.5	7.6	6.2
DEC	5.3	6.1	6.2	6.1	6.4	7.0	6.5
mean	**5.7**	**6.6**	**6.6**	**6.4**	**6.7**	**7.4**	**6.8**
std dev	0.4	0.3	0.2	0.2	0.2	0.4	0.3
median	5.8	6.6	6.6	6.4	6.7	7.5	6.9
max	6.3	7.0	7.0	6.6	7.1	8.1	7.2
min	4.9	6.1	6.2	6.1	6.4	6.8	6.2

	6RC	LCO	GCO	SR	BRN	HAM
JAN	6.2	5.8	5.8	5.3	6.6	6.6
FEB	6.8	6.4	6.5	6.1	6.8	6.9
MAR	6.5	6.2	6.4	6.1	6.9	6.9
APR	7.1	6.7	6.7	6.1	7.1	7.3
MAY	6.6	6.1	6.0	5.8	6.4	6.5
JUN	6.7	6.6	6.6	6.2	6.5	6.8
JUL	6.7	6.5	6.6	6.1	6.7	6.8
AUG	7.0	6.8	6.9	6.3	6.8	7.1
SEP	7.3	6.9	7.0	6.2	6.9	7.2
OCT	6.4	6.6	6.7	6.3	6.8	7.2
NOV	6.6	6.7	6.9	6.5	7.2	7.4
DEC	5.9	5.8	6.0	5.5	6.1	6.5
mean	**6.7**	**6.4**	**6.5**	**6.0**	**6.7**	**6.9**
std dev	0.4	0.4	0.4	0.3	0.3	0.3
median	6.7	6.6	6.6	6.1	6.8	6.9
max	7.3	6.9	7.0	6.5	7.2	7.4
min	5.9	5.8	5.8	5.3	6.1	6.5

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	6.7	6.2	3.8		6.7	6.9
FEB	6.7	5.9	4.0		6.9	6.9
MAR	6.7	6.4	3.9	5.9	7.0	6.8
APR	6.7	6.4	3.8	6.2	6.5	7.0
MAY	6.8	6.7	4.0	6.4	6.3	6.6
JUN	6.5	5.9	3.9	5.6	6.4	6.9
JUL	6.7	6.0	5.3	3.9	5.8	6.2
AUG	6.5	5.8	3.8	5.9	6.7	7.0
SEP	6.4	6.0	3.9	6.1	6.4	6.8
OCT	6.8	6.3	4.1	6.6	7.0	7.0
NOV	6.7	6.3	3.6	6.1	7.2	7.1
DEC	6.2	5.7	3.8	5.2	7.3	6.6
mean	**6.6**	**6.1**	**4.0**	**5.8**	**6.7**	**6.8**
std dev	0.2	0.3	0.4	0.8	0.4	0.2
median	6.7	6.1	3.9	6.0	6.7	6.9
max	6.8	6.7	5.3	6.6	7.3	7.1
min	6.2	5.7	3.6	3.9	5.8	6.2

Table 2.5 Dissolved Oxygen (mg/l) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	10.1	10.0	9.6	9.4	9.3	9.3	9.2	9.2
FEB	10.7	10.6	10.1	9.9	9.9	9.9	10.1	10.1
MAR	8.8	8.8	8.8	9.0	9.0	10.0	10.8	10.6
APR	8.9	8.8	8.6	8.6	8.6	9.5	9.7	9.2
MAY	6.6	6.0	6.6	6.8	7.5	8.0	7.6	7.8
JUN	3.7	3.5	3.7	3.7	4.2	6.8	7.4	6.9
JUL	3.2	3.2	3.4	3.3	3.3	4.0	4.9	5.7
AUG	4.8	4.4	4.5	4.7	4.7	6.0	6.6	7.0
SEP	4.2	4.3	4.5	4.5	5.2	6.0	7.0	7.0
OCT	5.3	5.4	5.4	5.7	6.2	6.9	6.9	7.0
NOV	7.4	7.5	7.9	7.9	8.3	8.8	8.9	8.6
DEC	8.4	8.2	8.0	8.2	8.0	8.3	8.5	8.7
mean	**6.8**	**6.7**	**6.8**	**6.8**	**7.0**	**7.8**	**8.1**	**8.2**
std dev	2.6	2.6	2.4	2.3	2.2	1.9	1.7	1.5
median	7.0	6.8	7.3	7.4	7.8	8.2	8.1	8.2
max	10.7	10.6	10.1	9.9	9.9	10.0	10.8	10.6
min	3.2	3.2	3.4	3.3	3.3	4.0	4.9	5.7

	NC11	AC	DP	BBT	IC	NCF6
JAN	11.2	10.9	10.2	10.1	10.1	9.6
FEB	11.3	11.1	11.2	10.5	10.8	9.7
MAR	9.8	9.6	9.4	8.2	9.0	8.4
APR	7.2	7.0	6.3	6.1	6.2	6.7
MAY	8.2	8.0	7.8	6.9	6.8	6.3
JUN	6.2	5.3	4.6	4.5	4.4	5.1
JUL	4.9	4.6	4.4	2.7	3.2	2.9
AUG	6.5	6.4	5.6	4.9	5.1	4.2
SEP	6.1	5.4	4.2	4.2	4.0	4.0
OCT	7.3	7.1	5.7	5.7	5.4	5.6
NOV	8.4	7.9	6.7	7.0	6.8	7.1
DEC	10.3	9.9	9.2	7.8	8.4	7.8
mean	**8.1**	**7.8**	**7.1**	**6.6**	**6.7**	**6.5**
std dev	2.1	2.2	2.4	2.4	2.4	2.2
median	7.8	7.5	6.5	6.5	6.5	6.5
max	11.3	11.1	11.2	10.5	10.8	9.7
min	4.9	4.6	4.2	2.7	3.2	2.9

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	9.9	11.0	10.3	8.3	10.2	12.5	11.2
FEB	8.4	9.0	10.3	8.4	10.3	10.3	8.4
MAR	7.0	7.4	6.5	5.4	9.8	11.0	8.7
APR	7.5	7.5	9.0	6.9	8.8	11.8	9.7
MAY	5.7	7.3	4.8	1.7	8.3	10.1	7.5
JUN	1.3	5.7	0.7	0.4	10.4	7.8	5.4
JUL	4.3	4.1	2.8	2.2	4.9	7.7	4.5
AUG	3.3	5.7	2.5	2.9	6.8	7.7	6.3
SEP	5.0	5.4	3.8	4.2	8.8	9.1	6.2
OCT	5.4	7.0	3.2	4.7	6.2	9.1	7.4
NOV	6.4	9.6	7.6	7.6	8.4	12.2	10.0
DEC	6.9	8.5	6.9	6.8	7.7	9.5	9.0
mean	**5.9**	**7.4**	**5.7**	**5.0**	**8.4**	**9.9**	**7.9**
std dev	2.3	2.0	3.2	2.7	1.7	1.7	2.0
median	6.1	7.4	5.7	5.1	8.6	9.8	8.0
max	9.9	11.0	10.3	8.4	10.4	12.5	11.2
min	1.3	4.1	0.7	0.4	4.9	7.7	4.5

	6RC	LCO	GCO	SR	BRN	HAM
JAN	10.6	10.3	9.0	8.4	10.6	10.2
FEB	12.3	12.4	11.5	11.3	12.0	12.0
MAR	10.0	10.2	9.2	9.9	10.0	9.9
APR	9.4	9.1	7.4	5.2	9.9	10.5
MAY	8.5	8.5	7.1	4.6	8.9	7.4
JUN	6.4	6.6	4.7	2.6	6.6	6.5
JUL	6.3	6.6	4.6	2.6	7.1	6.5
AUG	6.2	6.2	5.3	5.8	6.9	5.0
SEP	6.9	7.1	6.3	1.0	8.0	6.4
OCT	8.4	8.6	8.1	3.9	8.6	7.3
NOV	9.3	9.0	8.1	4.0	8.8	7.2
DEC	9.9	10.0	9.2	7.7	10.4	8.4
mean	**8.7**	**8.7**	**7.5**	**5.6**	**9.0**	**8.1**
std dev	1.9	1.9	2.1	3.1	1.7	2.1
median	8.9	8.8	7.8	4.9	8.9	7.4
max	12.3	12.4	11.5	11.3	12.0	12.0
min	6.2	6.2	4.6	1.0	6.6	5.0

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	9.6	11.7	10.4		11.5	9.6
FEB	9.1	9.1	7.5		11.2	9.9
MAR	8.2	10.3	8.8	10.3	9.9	8.8
APR	5.9	6.3	6.2	7.8	6.6	6.2
MAY	5.0	2.9	5.7	7.1	5.4	4.4
JUN	4.0	4.1	3.9	6.0	3.9	4.5
JUL	3.4	3.2	4.1	3.2	3.5	2.0
AUG	4.0	4.1	4.9	5.4	3.5	4.9
SEP	3.7	4.5	5.1	6.4	4.3	4.6
OCT	5.3	4.7	5.7	7.4	3.4	6.0
NOV	5.7	6.3	6.4	7.9	6.5	7.0
DEC	9.0	9.3	8.1	10.3	9.5	8.6
mean	**6.1**	**6.4**	**6.4**	**7.2**	**6.6**	**6.4**
std dev	2.3	3.0	2.0	2.1	3.1	2.5
median	5.5	5.5	6.0	7.3	6.0	6.1
max	9.6	11.7	10.4	10.3	11.5	9.9
min	3.4	2.9	3.9	3.2	3.4	2.0

Table 2.6 Field Turbidity (NTU) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	11	12	10	9	6	3	3	4
FEB	13	12	9	8	6	4	3	3
MAR	8	8	8	5	5	2	2	3
APR	22	17	14	9	17	5	7	1
MAY	7	6	9	7	7	5	7	8
JUN	18	11	8	9	14	9	5	8
JUL	18	21	16	9	22	13	4	2
AUG	11	6	8	3	3	3	3	3
SEP	9	3	4	1	1	3	2	6
OCT	7	5	14	8	4	3	3	4
NOV	12	7	8	6	4	4	2	5
DEC	7	11	4	2	4	5	4	4
mean	**12**	**10**	**9**	**6**	**8**	**5**	**4**	**4**
std dev	5	5	4	3	6	3	2	2
median	11	10	9	8	6	4	3	4
max	22	21	16	9	22	13	7	8
min	7	3	4	1	1	2	2	1

	NC11	AC	DP	BBT	IC	NCF6
JAN	6	5	6	5	7	9
FEB	14	14	16	8	13	10
MAR	19	17	18	4	9	1
APR	16	8	12	9	7	8
MAY	23	23	20	9	13	10
JUN	12	12	27	20	15	20
JUL	23	24	21	5	12	0
AUG	7	5	5	4	4	0
SEP	6	6	5	2	5	13
OCT	3	5	5	5	10	4
NOV	4	4	5	5	15	5
DEC	4	5	8	1	6	7
mean	**11**	**11**	**12**	**6**	**10**	**7**
std dev	7	7	8	5	4	6
median	10	7	10	5	10	8
max	23	24	27	20	15	20
min	3	4	5	1	4	0

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	3	0	0	0	6	2	1
FEB	10	2	1	3	7	12	11
MAR	4	1	0	0	4	1	1
APR	3	1	1	0	10	1	0
MAY	7	2	1	1	7	2	3
JUN	4	4	7	4	24	4	26
JUL	6	1	1	2	6	3	4
AUG	7	4	2	3	24	4	17
SEP	4	3	2	0	11	1	6
OCT	1	1	1	0	6	2	1
NOV	1	0	0	0	4	1	0
DEC	0	0	0	0	5	90	2
mean	**4**	**2**	**1**	**1**	**10**	**10**	**6**
std dev	3	1	2	2	7	25	8
median	4	1	1	0	7	2	3
max	10	4	7	4	24	90	26
min	0	0	0	0	4	1	0

	6RC	LCO	GCO	SR	BRN	HAM
JAN	4	2	0	0	1	6
FEB	1	1	0	0	1	3
MAR	1	1	0	0	1	4
APR	1	1	0	0	0	2
MAY	1	6	0	0	1	4
JUN	4	2	4	0	12	11
JUL	1	0	12	0	6	7
AUG	6	2	10	9	3	3
SEP	3	1	4	9	3	2
OCT	1	0	0	0	1	1
NOV	0	0	0	0	0	0
DEC	0	0	0	0	2	0
mean	**2**	**1**	**3**	**2**	**3**	**4**
std dev	2	2	4	4	3	3
median	1	1	0	0	1	3
max	6	6	12	9	12	11
min	0	0	0	0	0	0

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	0	0	0		0	19
FEB	6	1	0		1	10
MAR	1	0	0	0	2	9
APR	0	0	0	0	2	17
MAY	6	3	0	0	1	1
JUN	3	2	0	25	1	32
JUL	9	1	0	0	0	1
AUG	1	0	0	1	5	6
SEP	1	2	0	0	2	22
OCT	1	0	0	0	2	7
NOV	0	0	0	0	0	12
DEC	1	4	3	2	3	14
mean	**2**	**1**	**0**	**3**	**2**	**13**
std dev	3	1	1	8	1	9
median	1	1	0	0	2	11
max	9	4	3	25	5	32
min	0	0	0	0	0	1

Table 2.7 Total Suspended Solids (mg/L) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	14.5	20.3	13.3	11.5	13.8	11.3	14.7	15.2
FEB	11.3	9.2	10.1	11.9	11.0	11.1	16.7	17.3
MAR	6.4	7.1	7.4	8.0	8.9	8.9	14.4	16.9
APR	27.4	14.9	13.8	12.6	32.5	18.7	23.6	20.5
MAY	9.2	6.9	11.6	12.7	14.9	2.4	22.6	25.6
JUN	27.8	11.6	7.9	9.5	14.5	13.4	13.0	26.6
JUL	18.4	18.2	14.3	9.9	26.9	12.2	10.5	9.1
AUG	13.8	7.7	9.7	6.2	7.1	9.7	14.1	18.1
SEP	9.3	6.9	5.8	6.3	6.7	9.1	12.6	20.3
OCT	12.5	11.6	17.2	12.1	13.8	11.6	17.3	20.0
NOV	20.5	11.5	13.4	16.0	13.0	16.3	19.6	13.4
DEC	8.3	14.6	9.0	10.8	12.9	19.0	17.8	22.4
mean	**15.0**	**11.7**	**11.1**	**10.6**	**14.7**	**12.0**	**16.4**	**18.8**
std dev	7.2	4.5	3.4	2.8	7.6	4.6	4.0	4.9
median	13.2	11.6	10.9	11.2	13.4	11.5	15.7	19.1
max	27.8	20.3	17.2	16.0	32.5	19.0	23.6	26.6
min	6.4	6.9	5.8	6.2	6.7	2.4	10.5	9.1

	NC11	AC	DP	IC	NCF6
JAN	4.4	3.7	5.7	7.8	10.0
FEB	7.7	8.7	13.8	10.3	12.9
MAR	13.5	13.5	18.9	6.6	3.3
APR	14.0	6.8	10.3	7.1	12.0
MAY	25.6	24.9	20.5	12.7	12.1
JUN	8.6	6.7	22.6	15.2	28.1
JUL	29.6	29.5	23.5	9.8	2.7
AUG	7.1	3.3	3.8	3.0	2.9
SEP	3.9	3.8	6.1	6.8	14.7
OCT	3.4	4.9	6.7	10.3	8.8
NOV	3.8	4.7	7.3	16.6	20.1
DEC	5.5	8.7	12.2	11.1	9.5
mean	**11.5**	**10.7**	**13.2**	**9.7**	**11.3**
std dev	9.3	9.3	7.5	4.0	7.7
median	7.9	6.8	11.3	9.8	10.0
max	29.6	29.5	23.5	16.6	28.1
min	3.4	3.3	3.8	3.0	2.7

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN		1.4		1.4	5.8	1.4	1.4
FEB		3.0		1.3	3.0	7.5	5.6
MAR		2.7		1.4	2.9	1.4	1.4
APR		4.0		1.4	5.8	1.5	1.4
MAY		5.1		1.4	6.8	1.8	1.4
JUN		6.5		12.8	15.3	1.4	30.8
JUL		1.3		3.7	6.3	4.3	6.0
AUG		8.2		4.3	4.8	1.4	21.9
SEP		5.6		1.4	16.8	36.7	3.0
OCT		4.9		1.4	6.4	1.4	1.4
NOV		1.4		1.4	3.9	1.5	1.4
DEC		1.4		1.4	7.2	151.0	6.2
mean		**3.8**		**2.8**	**7.2**	**17.6**	**6.8**
std dev		2.3		3.3	4.6	43.2	9.5
median		3.5		1.4	6.3	1.5	2.2
max		8.2		12.8	16.8	151.0	30.8
min		1.3		1.3	2.9	1.4	1.4

	6RC	LCO	GCO	SR	BRN	HAM
JAN			1.4			
FEB			1.5			
MAR			1.4			
APR			3.7			
MAY			7.3			
JUN			6.0			
JUL			9.5			
AUG			4.3			
SEP			1.4			
OCT			1.4			
NOV			1.4			
DEC			1.5			
mean			**3.4**			
std dev			2.8			
median			1.5			
max			9.5			
min			1.4			

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	1.4	1.4			1.4	
FEB	3.4	1.4			1.4	
MAR	1.4	1.4			1.4	14.6
APR	1.4	1.4			3.6	27.7
MAY	2.8	1.6			3.0	10.3
JUN	1.4	1.4			1.5	43.3
JUL	3.7	1.4			1.4	17.8
AUG	4.7	4.4			7.3	12.0
SEP	4.3	3.9			2.7	27.2
OCT	1.4	1.4			1.4	18.6
NOV	6.0	1.4			1.4	26.7
DEC	1.4	3.2			1.4	22.7
mean	**2.8**	**2.0**			**2.3**	**22.1**
std dev	1.6	1.1			1.7	9.8
median	2.1	1.4			1.4	20.7
max	6.0	4.4			7.3	43.3
min	1.4	1.4			1.4	10.3

Table 2.8 Light Attenuation (k) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	3.58	3.62	3.86	3.37	3.04	2.55	1.81	1.57
FEB	2.94	3.01	2.91	2.67	2.44	1.82	1.54	1.49
MAR	2.31	2.31	2.42	2.61	2.29	2.10	1.69	1.96
APR	3.16	3.06	2.82	2.69	3.76	1.85	1.52	0.89
MAY	3.37	3.21	2.94	3.07	2.67	1.93	1.52	1.32
JUN	3.91	3.97	3.60	3.44	3.52		1.86	1.69
JUL	5.28	5.12	5.07	5.31	7.35	3.86	3.30	3.44
AUG	3.35	2.81	2.49	3.33	2.86	2.96	2.14	1.76
SEP					2.71		1.96	1.89
OCT	2.47	2.50	3.30	2.19	2.16	1.62	1.62	1.52
NOV	3.49	2.94	2.87	2.38	1.97	1.64	1.30	1.15
DEC	2.99	3.17	2.51	2.37	2.08	1.45	1.27	1.06
mean	**3.35**	**3.25**	**3.16**	**3.04**	**3.07**	**2.18**	**1.79**	**1.65**
std dev	0.79	0.77	0.78	0.87	1.46	0.75	0.54	0.65
max	5.28	5.12	5.07	5.31	7.35	3.86	3.30	3.44
min	2.31	2.31	2.42	2.19	1.97	1.45	1.27	0.89

	NC11	AC	DP	BBT	IC	NCF6
JAN	2.17	1.98	2.72	2.78	2.81	4.30
FEB	2.27	2.68	2.86	2.62	2.91	4.10
MAR	2.61	2.56	2.55	2.52	2.56	3.21
APR						
MAY	3.18	3.05	2.93	2.69	3.13	4.31
JUN	2.59	2.44	3.96	4.11	3.68	6.40
JUL	3.87	4.08	3.98	4.01	4.16	4.42
AUG	2.26	2.13	2.45	3.48	2.85	3.23
SEP	2.72	2.94	3.60	3.47	3.72	5.83
OCT	1.80	2.14	2.79	2.70	3.04	3.33
NOV	1.96	2.02	2.64	3.09	4.05	3.48
DEC	2.55	2.99	2.87	3.00	3.27	5.25
mean	**2.54**	**2.64**	**3.03**	**3.13**	**3.29**	**4.35**
std dev	0.58	0.62	0.55	0.56	0.53	1.08
max	3.87	4.08	3.98	4.11	4.16	6.40
min	1.80	1.98	2.45	2.52	2.56	3.21

Table 2.9 Total Nitrogen (μg/l) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	1,010	1,040	940	930	750	540	360	320
FEB	1,090	1,260	1,340	840	840	540	210	240
MAR	1,000	1,090	1,130	930	1,730	790	210	120
APR	870	810	960	830	910	390	230	50
MAY	1,310	1,270	1,020	800	780	400	450	50
JUN	450	550	720	640	860	460	500	400
JUL	320	320	310	340	350	450	330	380
AUG	830	860	780	750	720	490	550	530
SEP	200	130	50	170	110	100	50	50
OCT	340	100	280	250	370	260	320	240
NOV	970	960	610	450	460	580	100	260
DEC	790	710	860	450	390	290	240	200
mean	**765**	**758**	**750**	**615**	**689**	**441**	**296**	**237**
std dev	353	407	379	271	415	176	153	154
median	850	835	820	695	735	455	280	240
max	1,310	1,270	1,340	930	1,730	790	550	530
min	200	100	50	170	110	100	50	50

	NC11	AC	DP	IC	NCF6
JAN	1,030	1,010	1,080	920	1,160
FEB	470	530	200	370	400
MAR	1,290	1,380	1,080	1,130	650
APR	530	510	640	1,160	820
MAY	1,250	1,210	1,400	1,070	330
JUN	820	1,230	1,240	860	780
JUL	740	620	410	570	470
AUG	830	800	810	1,000	630
SEP	50	50	50	50	100
OCT	1,370	1,420	1,060	1,110	480
NOV	50	50	50	50	50
DEC	950	770	680	510	240
mean	**782**	**798**	**725**	**733**	**509**
std dev	442	470	466	411	320
median	825	785	745	890	475
max	1,370	1,420	1,400	1,160	1,160
min	50	50	50	50	50

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	1,150	610	200	1,170	210	530	1,550
FEB	1,340	730	940	660	750	560	80
MAR	1,020	790	400	790	460	530	2,030
APR	900	650	300	560	580	340	2,090
MAY	1,400	1,210	830	660	670	740	2,500
JUN	1,260	900	830	1,150	940	610	1,570
JUL	1,300	670	460	1,160	2,200	500	1,090
AUG	920	560	440	1,270	1,040	490	1,910
SEP	470	120	50	980	1,990	230	5,150
OCT	700	200	300	50	200	50	730
NOV	550	460	50	1,780	200	50	3,050
DEC	1,610	400	50	1,100	200	770	1,980
mean	**1,052**	**608**	**404**	**944**	**787**	**450**	**1,978**
std dev	355	297	315	437	678	238	1,272
median	1,085	630	350	1,040	625	515	1,945
max	1,610	1,210	940	1,780	2,200	770	5,150
min	470	120	50	50	200	50	80

	6RC	LCO	GCO	SR	BRN	HAM
JAN	1,530	1,240	550	430	180	640
FEB	1,450	400	240	300	230	380
MAR	760	490	510	300	440	580
APR	940	440	360	470	530	1,090
MAY	1,310	880	480	470	460	550
JUN	1,120	680	700	470	580	720
JUL	1,290	460	510	230	380	490
AUG	1,010	640	450	50	570	120
SEP	880	390	1,660	130	560	50
OCT	50	50	50	50	50	50
NOV	50	180	1,390	50	320	50
DEC	890	360	540	50	240	50
mean	**940**	**518**	**620**	**250**	**378**	**398**
std dev	479	315	457	180	175	339
median	975	450	510	265	410	435
max	1,530	1,240	1,660	470	580	1,090
min	50	50	50	50	50	50

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	780	640	430		410	
FEB	430	1,400	400		200	
MAR	770	480	400	490	330	560
APR	770	750	1,130	750	300	630
MAY	640	1,050	1,300	770	690	850
JUN	840	1,060	720	670	430	450
JUL	500	380	630	180	250	140
AUG	750	510	540	280	1,300	210
SEP	340	230	320	240	140	250
OCT	50	50	300	50	50	400
NOV	50	50	50	50	100	100
DEC	540	480	50	360	160	540
mean	**538**	**590**	**523**	**384**	**363**	**413**
std dev	277	416	381	273	343	240
median	590	495	415	320	275	425
max	840	1,400	1,300	770	1,300	850
min	50	50	50	50	50	100

Table 2.10 Nitrate/Nitrite (μg/l) at the Lower Cape Fear River stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	410	540	440	330	350	240	160	120
FEB	790	660	540	440	440	340	210	140
MAR	700	690	730	530	530	390	210	120
APR	570	610	660	530	510	190	30	10
MAY	710	570	520	300	380	100	50	30
JUN	50	50	320	240	360	60	100	10
JUL	320	320	310	240	250	250	230	180
AUG	630	560	580	450	420	290	150	30
SEP	200	130	10	70	110	100	10	10
OCT	240	100	280	150	370	260	120	40
NOV	870	760	610	450	460	280	100	60
DEC	690	610	660	450	390	190	40	10
mean	**515**	**467**	**472**	**348**	**381**	**224**	**118**	**63**
std dev	263	249	208	150	114	100	76	60
median	600	565	530	385	385	245	110	35
max	870	760	730	530	530	390	230	180
min	50	50	10	70	110	60	10	10

	NC11	AC	DP	IC	NCF6
JAN	630	610	480	520	560
FEB	70	130	100	70	10
MAR	890	880	780	630	250
APR	30	110	640	660	320
MAY	950	810	800	670	30
JUN	420	630	540	360	280
JUL	440	420	410	270	170
AUG	830	800	810	800	330
SEP	10	10	10	10	10
OCT	1,370	1,420	1,060	1,110	280
NOV	70	90	40	30	10
DEC	950	770	680	510	240
mean	**555**	**557**	**529**	**470**	**208**
std dev	452	420	336	336	169
median	535	620	590	515	245
max	1,370	1,420	1,060	1,110	560
min	10	10	10	10	10

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	450	410	10	870	210	330	1,250
FEB	140	230	40	260	550	160	80
MAR	120	290	10	490	60	130	1,330
APR	100	250	10	260	80	40	1,790
MAY	300	510	10	60	70	140	2,000
JUN	60	200	30	50	40	210	770
JUL	300	270	160	760	1,700	200	490
AUG	220	260	40	770	540	90	1,310
SEP	170	120	10	980	1,690	230	4,850
OCT	10	10	10	10	10	10	530
NOV	50	360	10	1,780	10	60	2,750
DEC	1,010	400	10	1,100	10	370	1,580
mean	**244**	**276**	**29**	**616**	**414**	**164**	**1,561**
std dev	272	135	43	531	628	111	1,269
median	155	265	10	625	75	150	1,320
max	1,010	510	160	1,780	1,700	370	4,850
min	10	10	10	10	10	10	80

	6RC	LCO	GCO	SR	BRN	HAM
JAN	1,130	740	250	130	180	540
FEB	1,150	100	40	10	30	80
MAR	360	290	210	10	140	180
APR	740	240	60	10	230	290
MAY	810	280	80	10	260	250
JUN	620	280	100	70	80	320
JUL	1,190	360	210	130	380	290
AUG	1,010	340	450	60	570	120
SEP	880	390	1,460	30	560	50
OCT	30	10	40	10	10	10
NOV	920	180	1,290	30	320	10
DEC	890	360	540	60	240	10
mean	**811**	**298**	**394**	**47**	**250**	**179**
std dev	341	179	486	45	184	164
median	885	285	210	30	235	150
max	1,190	740	1,460	130	570	540
min	30	10	40	10	10	10

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	380	240	30		110	
FEB	30	10	10		10	
MAR	270	180	10	190	130	260
APR	270	250	10	150	10	230
MAY	140	150	10	70	10	150
JUN	240	260	20	170	30	150
JUL	200	180	30	80	50	140
AUG	450	210	40	280	400	110
SEP	340	230	20	240	140	250
OCT	10	10	10	10	10	10
NOV	10	10	10	10	10	10
DEC	540	480	30	360	160	240
mean	**240**	**184**	**19**	**156**	**89**	**155**
std dev	172	133	11	116	114	93
median	255	195	15	160	40	150
max	540	480	40	360	400	260
min	10	10	10	10	10	10

Table 2.11 Ammonium (μg/l) at the Lower Cape Fear River stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	60	60	90	100	140	130	200	230
FEB	190	170	170	160	130	110	130	160
MAR	90	80	90	100	130	100	60	320
APR	150	150	180	130	150	120	210	370
MAY	150	140	120	100	80	180	330	380
JUN	110	110	110	110	110	120	120	210
JUL	110	120	100	90	80	110	140	120
AUG	100	160	120	170	170	100	270	350
SEP	70	70	60	100	70	60	110	270
OCT	50	40	30	20	30	10	10	430
NOV	70	70	40	30	30	20	10	10
DEC	60	50	60	70	50	30	10	10
mean	**101**	**102**	**98**	**98**	**98**	**91**	**133**	**238**
std dev	44	46	47	44	48	51	104	141
median	95	95	95	100	95	105	125	250
max	190	170	180	170	170	180	330	430
min	50	40	30	20	30	10	10	10

	NC11	AC	DP	IC	NCF6
JAN	70	80	80	70	30
FEB	110	170	160	160	70
MAR	90	90	170	110	60
APR	130	120	160	130	120
MAY	120	120	120	110	60
JUN	90	130	160	150	30
JUL	100	90	110	100	130
AUG	80	90	90	110	90
SEP	80	80	100	60	40
OCT	30	50	60	50	10
NOV	60	100	110	80	80
DEC	50	80	80	60	20
mean	**84**	**100**	**117**	**99**	**62**
std dev	29	31	37	36	38
median	85	90	110	105	60
max	130	170	170	160	130
min	30	50	60	50	10

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	90	110	90	120	210	110	80
FEB	310	20	10	20	50	140	60
MAR	150	40	60	70	90	50	90
APR	40	80	50	50	90	80	60
MAY	150	60	60	80	170	110	80
JUN	180	120	180	460	190	150	220
JUL	1,070	50	100	260	410	100	60
AUG	190	90	150	120	230	110	110
SEP	80	50	40	90	110	100	60
OCT	60	50	60	90	130	60	60
NOV	30	30	20	40	70	20	20
DEC	40	30	10	70	80	110	30
mean	**199**	**61**	**69**	**123**	**153**	**95**	**78**
std dev	286	32	53	122	100	37	51
median	120	50	60	85	120	105	60
max	1,070	120	180	460	410	150	220
min	30	20	10	20	50	20	20

	6RC	LCO	GCO	SR	BRN	HAM
JAN	70	20	20	10	10	20
FEB	100	80	40	40	100	50
MAR	60	70	10	10	30	30
APR	70	60	100	100	40	620
MAY	130	50	50	40	60	80
JUN	100	80	130	100	60	130
JUL	70	70	190	60	100	90
AUG	70	80	80	210	70	90
SEP	30	40	50	130	40	40
OCT	10	10	10	10	10	10
NOV	30	30	20	10	10	10
DEC	40	10	20	10	30	10
mean	**65**	**50**	**60**	**61**	**47**	**98**
std dev	34	27	56	63	32	169
median	70	55	45	40	40	45
max	130	80	190	210	100	620
min	10	10	10	10	10	10

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	100	40	40		130	
FEB	130	30	40		90	
MAR	100	60	90	90	90	120
APR	80	70	80	80	100	110
MAY	60	60	220	50	120	110
JUN	180	70	80	90	70	100
JUL	90	50	60	60	80	80
AUG	70	80	120	90	1,060	100
SEP	60	70	70	50	100	90
OCT	30	30	50	30	70	40
NOV	50	40	20	40	300	90
DEC	40	20	20	20	40	40
mean	**83**	**52**	**74**	**60**	**188**	**88**
std dev	42	19	55	26	282	28
median	75	55	65	55	95	95
max	180	80	220	90	1,060	120
min	30	20	20	20	40	40

Table 2.12 Total Kjeldahl Nitrogen (μg/l) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	600	500	500	600	400	300	200	200
FEB	300	600	800	400	400	200	50	100
MAR	300	400	400	400	1200	400	50	50
APR	300	200	300	300	400	200	50	50
MAY	600	700	500	500	400	300	400	50
JUN	400	500	400	400	500	400	400	50
JUL	50	50	50	100	100	200	100	50
AUG	200	300	200	300	300	200	400	50
SEP	50	50	50	100	50	50	50	50
OCT	100	50	50	100	50	50	200	200
NOV	100	200	50	50	50	300	50	200
DEC	100	100	200	50	50	100	200	200
mean	**258**	**304**	**292**	**275**	**325**	**225**	**179**	**104**
std dev	196	231	237	190	326	120	147	72
median	250	250	250	300	350	200	150	50
max	600	700	800	600	1,200	400	400	200
min	50	50	50	50	50	50	50	50

	NC11	AC	DP	IC	NCF6
JAN	400	400	600	400	600
FEB	400	400	100	300	400
MAR	400	500	300	500	400
APR	500	400	50	500	500
MAY	300	400	600	400	300
JUN	400	600	700	500	500
JUL	300	200	50	300	300
AUG	50	50	50	200	300
SEP	50	50	50	50	100
OCT	50	50	50	50	200
NOV	50	50	50	50	50
DEC	50	50	50	50	50
mean	**246**	**263**	**221**	**275**	**308**
std dev	180	208	260	189	182
median	300	300	50	300	300
max	500	600	700	500	600
min	50	50	50	50	50

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	700	200	200	300	50	200	300
FEB	1200	500	900	400	200	400	50
MAR	900	500	400	300	400	400	700
APR	800	400	300	300	500	300	300
MAY	1100	700	700	600	600	600	500
JUN	1200	700	800	1100	900	400	800
JUL	1000	400	300	400	500	300	600
AUG	700	300	400	500	500	400	600
SEP	300	50	50	50	300	50	300
OCT	700	200	300	50	200	50	200
NOV	500	100	50	50	200	50	300
DEC	600	50	50	50	200	400	400
mean	**808**	**342**	**371**	**342**	**379**	**296**	**421**
std dev	281	230	290	304	235	175	221
median	750	350	300	300	350	350	350
max	1,200	700	900	1,100	900	600	800
min	300	50	50	50	50	50	50

	6RC	LCO	GCO	SR	BRN	HAM
JAN	400	500	300	300	50	100
FEB	300	300	200	300	200	300
MAR	400	200	300	300	300	400
APR	200	200	300	400	300	800
MAY	500	600	400	400	200	300
JUN	500	400	600	400	500	400
JUL	100	100	300	100	50	200
AUG	50	300	50	50	50	50
SEP	50	50	200	100	50	50
OCT	50	50	50	50	50	50
NOV	50	50	100	50	50	50
DEC	50	50	50	50	50	50
mean	**221**	**233**	**238**	**208**	**154**	**229**
std dev	188	190	165	153	148	228
median	150	200	250	200	50	150
max	500	600	600	400	500	800
min	50	50	50	50	50	50

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	400	400	400		300	
FEB	400	1400	400		200	
MAR	500	300	400	300	200	300
APR	500	500	1100	600	300	400
MAY	500	900	1300	700	600	700
JUN	600	800	700	500	400	300
JUL	300	200	600	100	200	50
AUG	300	300	500	50	900	100
SEP	50	50	300	50	50	50
OCT	50	50	300	50	50	400
NOV	50	50	50	50	100	100
DEC	50	50	50	50	50	300
mean	**308**	**417**	**508**	**245**	**279**	**270**
std dev	209	423	377	261	254	204
median	350	300	400	75	200	300
max	600	1,400	1,300	700	900	700
min	50	50	50	50	50	50

Table 2.13 Total Phosphorus (μg/l) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	270	390	200	180	160	130	100	110
FEB	160	160	90	110	80	60	60	50
MAR	100	110	100	80	100	80	70	40
APR	160	160	150	120	150	80	30	30
MAY	150	160	140	440	100	60	60	80
JUN	160	130	120	140	150	140	100	70
JUL	290	160	150	430	180	160	340	70
AUG	190	140	190	110	110	80	60	50
SEP	140	110	110	80	80	60	40	30
OCT	140	110	140	80	90	60	50	50
NOV	250	120	90	110	80	60	30	80
DEC	120	110	130	110	60	60	60	30
mean	**178**	**155**	**134**	**166**	**112**	**86**	**83**	**58**
std dev	58	74	34	123	37	35	80	24
median	160	135	135	110	100	70	60	50
max	290	390	200	440	180	160	340	110
min	100	110	90	80	60	60	30	30

	NC11	AC	DP	IC	NCF6
JAN	310	270	290	180	180
FEB	160	170	340	140	70
MAR	140	130	150	110	40
APR	170	210	170	150	120
MAY	190	190	170	150	140
JUN	300	320	300	200	170
JUL	170	160	180	180	180
AUG	200	170	190	190	140
SEP	160	140	130	120	150
OCT	170	180	180	200	120
NOV	230	280	210	200	100
DEC	210	170	150	120	90
mean	**201**	**199**	**205**	**162**	**162**
std dev	52	57	65	33	43
median	180	175	180	165	130
max	310	320	340	200	200
min	140	130	130	110	110

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	120	70	80	80	180	60	130
FEB	190	60	60	80	80	90	110
MAR	120	60	60	80	80	40	170
APR	110	80	70	80	200	40	170
MAY	170	200	120	340	150	80	330
JUN	310	390	820	590	200	80	410
JUL	370	200	220	380	230	130	280
AUG	360	400	220	290	290	80	510
SEP	230	210	170	280	480	160	600
OCT	200	170	150	180	330	70	640
NOV	220	100	50	90	260	40	250
DEC	310	70	70	150	430	300	390
mean	**226**	**168**	**174**	**218**	**243**	**98**	**333**
std dev	88	116	203	155	119	70	173
median	210	135	100	165	215	80	305
max	370	400	820	590	480	300	640
min	110	60	50	80	80	40	110

	6RC	LCO	GCO	SR	BRN	HAM
JAN	130	100	320	70	110	140
FEB	60	40	170	20	60	70
MAR	50	30	80	10	50	60
APR	50	40	220	10	60	70
MAY	170	140	250	70	80	180
JUN	140	70	720	90	150	150
JUL	150	1,250	620	120	200	180
AUG	180	110	600	180	160	200
SEP	130	70	550	50	100	160
OCT	120	50	620	90	80	160
NOV	70	20	370	50	70	130
DEC	70	30	250	20	110	130
mean	**110**	**163**	**398**	**65**	**103**	**136**
std dev	45	330	204	48	44	45
median	125	60	345	60	90	145
max	180	1,250	720	180	200	200
min	50	20	80	10	50	60

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	80	120	50		40	
FEB	110	40	30		60	
MAR	40	40	40	10	10	60
APR	90	110	10	10	10	120
MAY	100	360	50	50	30	110
JUN	220	120	50	120	40	220
JUL	210	120	30	60	40	120
AUG	240	130	40	70	60	100
SEP	140	130	90	70	40	110
OCT	100	110	50	40	30	80
NOV	80	280	40	230	30	100
DEC	70	110	70	30	10	140
mean	**123**	**139**	**46**	**69**	**33**	**116**
std dev	62	88	19	62	16	41
median	100	120	45	55	35	110
max	240	360	90	230	60	220
min	40	40	10	10	10	60

Table 2.14 Orthophosphate (μg/l) at the Lower Cape Fear River Program stations during 2013.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	60	60	40	40	40	30	20	20
FEB	60	50	30	50	40	30	10	10
MAR	50	50	50	30	30	20	10	10
APR	50	50	50	50	50	10	10	0
MAY	60	60	50	40	30	10	10	10
JUN	50	50	50	60	70	60	30	10
JUL	40	40	40	50	50	50	30	30
AUG	50	60	60	50	60	30	10	10
SEP	40	40	40	40	40	0	20	10
OCT	130	70	60	70	80	50	30	20
NOV	70	40	50	40	40	30	20	80
DEC	40	50	60	50	40	20	0	10
mean	**58**	**52**	**48**	**48**	**48**	**28**	**17**	**18**
std dev	24	9	9	11	15	18	10	21
median	50	50	50	50	40	30	15	10
max	130	70	60	70	80	60	30	80
min	40	40	30	30	30	0	0	0

	NC11	AC	DP	BBT	IC	NCF6
JAN	90	70	60	70	50	20
FEB	90	90	60	40	60	20
MAR	60	60	50	20	40	10
APR	70	80	70	60	70	30
MAY	60	50	60	50	50	30
JUN	80	70	80	60	60	50
JUL	40	40	40	40	40	80
AUG	70	70	80	70	70	60
SEP	60	50	40	40	40	60
OCT	170	180	180	20	200	60
NOV	150	180	140	110	80	30
DEC	90	80	60	20	50	30
mean	**86**	**85**	**77**	**50**	**68**	**40**
std dev	38	47	42	26	44	21
median	75	70	60	45	55	30
max	170	180	180	110	200	80
min	40	40	40	20	40	10

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	50	10	10	30	40	10	90
FEB	130	10	10	30	20	20	50
MAR	60	10	10	30	30	10	90
APR	50	10	20	30	40	10	90
MAY	60	30	20	30	20	10	110
JUN	110	80	30	60	10	20	70
JUL	240	60	60	340	70	40	120
AUG	730	50	50	150	80	20	190
SEP	140	60	50	150	100	20	280
OCT	200	170	50	180	200	20	640
NOV	130	30	20	60	90	10	140
DEC	160	20	20	50	80	20	90
mean	**172**	**45**	**29**	**95**	**65**	**18**	**163**
std dev	186	46	18	95	52	9	162
median	130	30	20	55	55	20	100
max	730	170	60	340	200	40	640
min	50	10	10	30	10	10	50

	6RC	LCO	GCO	SR	BRN	HAM
JAN	20	10	90	10	20	10
FEB	20	10	90	0	10	10
MAR	10	10	50	0	10	10
APR	10	10	140	10	20	20
MAY	30	10	120	10	20	40
JUN	50	30	370	20	40	50
JUL	30	20	150	20	30	50
AUG	50	40	240	10	50	70
SEP	40	20	350	10	30	60
OCT	60	30	620	0	50	140
NOV	20	10	280	10	30	70
DEC	30	10	160	0	20	30
mean	**31**	**18**	**222**	**8**	**28**	**47**
std dev	16	11	163	7	14	37
median	30	10	155	10	25	45
max	60	40	620	20	50	140
min	10	10	50	0	10	10

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	30	30	30		20	
FEB	40	20	20		0	
MAR	20	20	40		0	20
APR	40	40	10	10	0	30
MAY	30	30	20	10	10	30
JUN	90	50	30	20	10	40
JUL	90	40	10	10	0	40
AUG	80	40	20	20	20	30
SEP	60	40	10	20	0	40
OCT	60	50	40	10	0	70
NOV	40	30	10	10	10	40
DEC	30	20	10	10	0	30
mean	**51**	**34**	**21**	**13**	**6**	**37**
std dev	25	11	12	5	8	13
median	40	35	20	10	0	35
max	90	50	40	20	20	70
min	20	20	10	10	0	20

Table 2.15 Chlorophyll *a* (μg/l) at the Lower Cape Fear River Program stations during 2013

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	0	1	1	1	1	1	2	1
FEB	4	5	4	8	4	5	8	11
MAR	8	7	7	4	6	9	10	15
APR	3	2	3	4	6	8	6	4
MAY	1	1	6	7	13	9	5	6
JUN	2	1	1	1	2	7	17	12
JUL	1	1	1	1	2	2	2	7
AUG	1	1	5	10	9	17	21	22
SEP	1	1	5	5	8	17	21	18
OCT	3	4	5	5	5	5	4	5
NOV	3	3	4	5	5	6	6	7
DEC	3	2	2	4	7	4	4	4
mean	**3**	**2**	**4**	**5**	**6**	**8**	**9**	**9**
std dev	2	2	2	3	3	5	7	6
median	3	2	4	5	6	7	6	7
max	8	7	7	10	13	17	21	22
min	0	1	1	1	1	1	2	1

	NC11	AC	DP	BBT	IC	NCF6
JAN	0	0	0	0	0	1
FEB	4	4	4	2	3	1
MAR	4	2	3	1	3	1
APR	1	1	1	1	1	7
MAY	1	1	1	1	1	3
JUN	13	1	1	1	1	3
JUL	1	1	1	1	1	1
AUG	1	1	1	1	1	4
SEP	2	2	1	1	1	1
OCT	4	5	3	2	2	4
NOV	2	1	2	2	3	4
DEC	1	1	1	0	1	1
mean	**3**	**2**	**2**	**1**	**2**	**3**
std dev	3	1	1	1	1	2
median	2	1	1	1	1	2
max	13	5	4	2	3	7
min	0	0	0	0	0	1

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	2	2	2	3	8	16	2
FEB	5	5	6	8	3	4	3
MAR	3	5	3	5	3	4	1
APR	5	2	5	8	5	3	1
MAY	2	1	2	2	5	1	0
JUN	22	2	6	5	28	1	3
JUL	8	1	3	3	2	4	1
AUG	11	3	6	4	9	2	3
SEP	1	1	8	6	10	1	0
OCT	1	2	5	9	14	1	1
NOV	2	1	4	3	4	8	0
DEC	1	2	4	14	23	17	1
mean	**5**	**2**	**5**	**6**	**10**	**5**	**1**
std dev	6	1	2	3	8	6	1
median	3	2	5	5	7	4	1
max	22	5	8	14	28	17	3
min	1	1	2	2	2	1	0

	6RC	LCO	GCO	SR	BRN	HAM
JAN	3	1	2	7	2	1
FEB	1	2	1	4	1	1
MAR	1	2	1	5	1	2
APR	1	2	1	4	1	3
MAY	0	2	1	2	1	0
JUN	1	1	1	3	2	7
JUL	1	1	2	5	3	6
AUG	0	0	1	5	1	1
SEP	0	0	0	1	0	1
OCT	1	0	1	1	1	0
NOV	1	0	1	1	0	2
DEC	2	1	2	3	1	1
mean	**1**	**1**	**1**	**3**	**1**	**2**
std dev	1	1	1	2	1	2
median	1	1	1	4	1	1
max	3	2	2	7	3	7
min	0	0	0	1	0	0

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	0	1	0		1	
FEB	2	2	1		1	
MAR	0	1	1	0	1	1
APR	1	1	1	1	3	6
MAY	1	1	4	0	2	7
JUN	1	1	2	2	1	7
JUL	0	0	0	1	1	5
AUG	1	1	3	1	2	11
SEP	0	0	0	1	0	3
OCT	0	0	1	1	0	2
NOV	0	0	1	2	1	4
DEC	0	1	1	1	1	3
mean	**1**	**1**	**1**	**1**	**1**	**5**
std dev	1	1	1	1	1	3
median	0	1	1	1	1	5
max	2	2	4	2	3	11
min	0	0	0	0	0	1

Table 2.16 Biochemical Oxygen Demand (mg/l) at the Lower Cape Fear River Program stations during 2013.

5-Day Biochemical Oxygen Demand

	NC11	AC	BBT	NCF117	B210	LVC2
JAN	1.3	1.6	1.3	1.2	1.4	1.4
FEB	1.0	1.4	1.1		1.3	1.1
MAR	1.7	1.1	1.0	1.3	1.3	1.7
APR	1.6	1.5	2.1	1.3	1.3	1.7
MAY						
JUN	1.6	1.2	1.4	1.6	1.7	2.5
JUL	1.5		1.2	2.0	1.4	1.2
AUG	0.8	0.6	0.7	1.0	0.9	1.5
SEP	1.3	1.7	2.2			
OCT	1.6	1.1	1.0	0.9	1.7	1.3
NOV	1.1	0.9	1.5	1.2	1.6	1.4
DEC	1.4	2.1		0.7	1.0	0.7
mean	1.4	1.3	1.4	1.2	1.4	1.5
stdev	0.3	0.4	0.5	0.4	0.3	0.5
median	1.4	1.3	1.3	1.2	1.4	1.4
max	1.7	2.1	2.2	2.0	1.7	2.5
min	0.8	0.6	0.7	0.7	0.9	0.7

20-Day Biochemical Oxygen Demand

	NC11	AC	BBT	NCF117	B210	LVC2
JAN	4.0	4.1	3.8	3.0	2.8	3.2
FEB	3.5	4.5	3.4		2.9	2.9
MAR	4.2	3.1	2.9	3.2	2.6	3.6
APR	4.0	3.7	4.8	4.0	3.6	4.4
MAY						
JUN	3.9	3.4	4.4	4.9	4.4	5.4
JUL	3.9		3.8	4.6	4.1	3.3
AUG	2.6	2.3	2.8	2.9	3.1	7.5
SEP	3.6	4.1	4.9			
OCT	3.1	3.2	3.0	3.2	4.7	3.2
NOV	2.8	2.9	4.1	3.1	3.5	3.6
DEC	3.3	4.8		2.7	3.1	2.5
mean	3.5	3.6	3.8	3.5	3.5	4.0
stdev	0.5	0.8	0.8	0.8	0.7	1.5
median	3.6	3.6	3.8	3.2	3.3	3.5
max	4.2	4.8	4.9	4.9	4.7	7.5
min	2.6	2.3	2.8	2.7	2.6	2.5

Table 2.17 Fecal Coliform (cfu/100 mL) and Enterococcus (MPN) at the Lower Cape Fear River Program stations during 2013.

	NC11	AC	DP	IC	NCF6	NAV	HB
JAN	5	5	28	28	82	55	55
FEB	28	19	28	19	5	10	5
MAR	46	28	46	37	28	19	82
APR	89	19	172	100	82	37	37
MAY	19	28	10	37	82	217	37
JUN	55	910	1,270	240	46	37	19
JUL	55	136	82	10	19	1,180	55
AUG	55	55	10	37	46	118	37
SEP	28	55	55	10	46	546	46
OCT	19	37	37	5	64	73	55
NOV	37	19	37	82	270	37	46
DEC	55	46	19	127	136	100	46
mean	**41**	**113**	**150**	**61**	**76**	**202**	**43**
std dev	22	242	340	65	68	327	18
max	89	910	1,270	240	270	1,180	82
min	5	5	10	5	5	10	5
Geomean	33	40	46	35	51	80	37

ENTEROCOCCUS

	BRR	M61	M54	M35	M23	M18
JAN	86	63	41	20	10	20
FEB	98	52	31	52	63	51
MAR	85	75	20	10	10	31
APR	5	74	63	10	10	20
MAY	52	63	41	31	20	10
JUN	295	121	97	20	5	5
JUL	546	295	275	411	146	216
AUG	269	175	121	74	20	108
SEP	41	30	41	20	5	5
OCT	30	31	5	10	5	5
NOV	5	20	5	10	10	10
DEC	41	10	5	5	5	5
mean	**129**	**84**	**62**	**56**	**26**	**41**
std dev	155	77	73	109	39	60
max	546	295	275	411	146	216
min	5	10	5	5	5	5
Geomean	60	58	32	23	13	18

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	100	220	10	55	220	360	240
FEB	637	728	127	37	91	340	1000
MAR	136	64	19	145	163	118	91
APR	82	145	91	73	310	163	55
MAY	154	250	270	210	109	10	370
JUN	470	270	100	370	230	440	3,300
JUL	819	100	400	1,820	5,600	370	154
AUG	1,090	1,000	109	210	728	546	910
SEP	300	250	136	530	570	46	2,200
OCT	250	546	270	490	819	1,820	600
NOV	46	145	200	200	100	82	109
DEC	163	350	118	64	1,460	11,000	200
mean	**354**	**339**	**154**	**350**	**867**	**1,275**	**769**
std dev	319	270	108	471	1,479	2,968	962
max	637	1,000	400	1,820	5,600	11,000	3,300
min	46	64	10	37	91	10	55
Geomean	233	253	107	189	372	271	367

	6RC	LCO	GCO	SR	BRN	HAM
JAN	400	127	100	64	230	145
FEB	82	82	55	73	330	728
MAR	73	64	109	82	145	210
APR	82	46	10	37	210	199
MAY	118	240	82	55	1,000	230
JUN	64	64	46	64	1,270	455
JUL	109	109	55	118	6,000	1,090
AUG	100	220	230	230	360	220
SEP	163	163	82	109	350	420
OCT	82	37	100	91	290	145
NOV	19	172	109	91	230	118
DEC	210	230	440	82	320	240
mean	**125**	**130**	**118**	**91**	**895**	**350**
std dev	95	71	110	47	1,574	278
max	400	240	440	230	6,000	1,090
min	19	37	10	37	145	118
Geomean	99	109	83	83	436	275

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	28	5	55		73	46
FEB	244	64	64		250	73
MAR	10	19	10	19	210	37
APR	136	145	73	55	73	73
MAY	64	28	19	28	100	46
JUN	728	145	109	1,270	64	455
JUL	19	380	37	5,900	364	728
AUG	55	235	280	136	3,000	455
SEP	28	46	82	64	91	73
OCT	64	55	19	154	55	91
NOV	37	19	118	118	109	220
DEC	37	637	340	250	210	181
mean	**121**	**148**	**101**	**799**	**383**	**207**
std dev	193	181	100	1,737	794	213
max	728	637	340	5,900	3,000	728
min	10	5	10	19	55	37
Geomean	57	68	62	156	157	126

Figure 2.1 Salinity at the Lower Cape Fear River Program estuarine stations, 1995-2012 versus 2013.

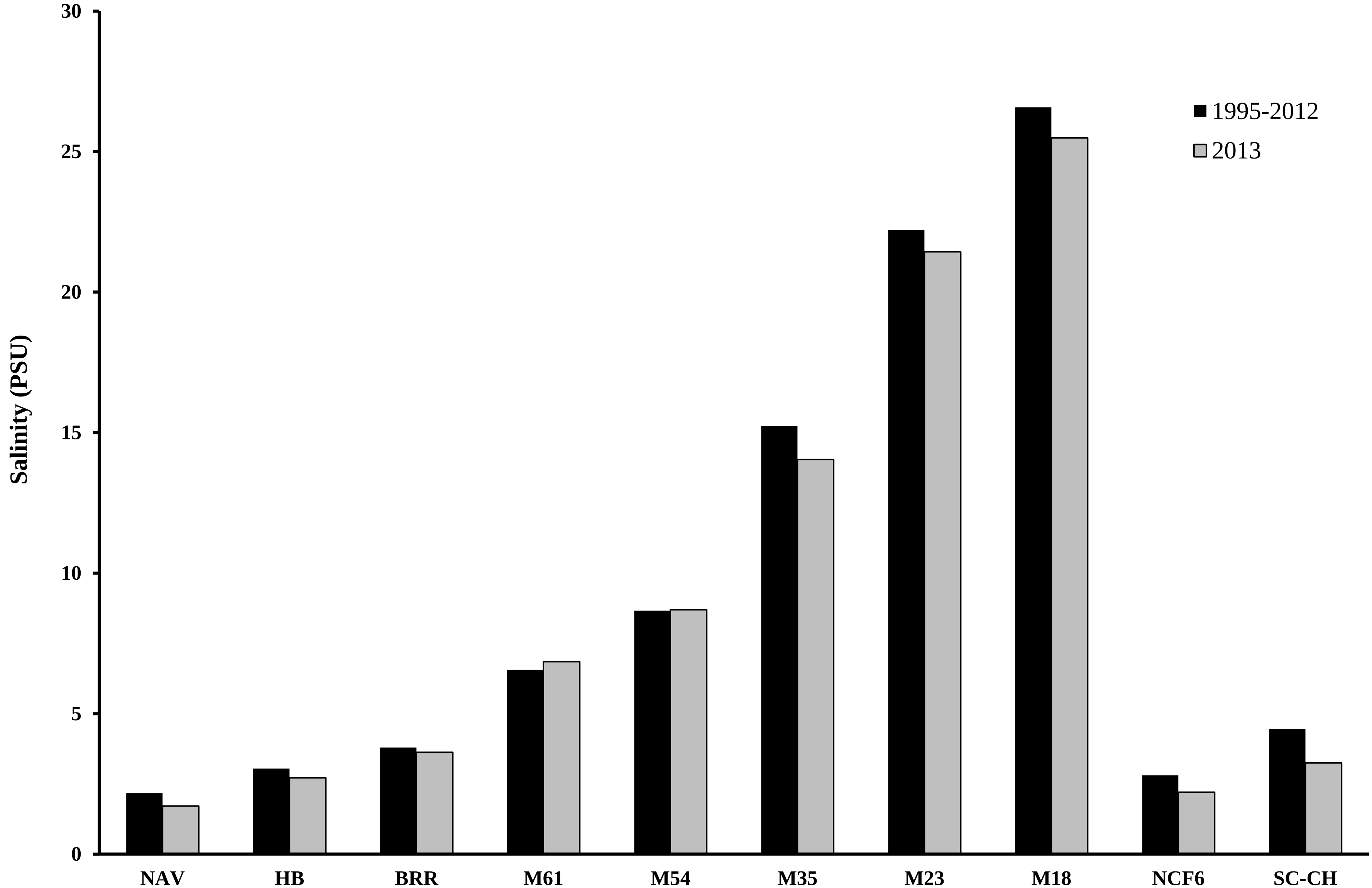


Figure 2.2 Dissolved Oxygen at the Lower Cape Fear River Program mainstem stations, 1995-2012 versus 2013.

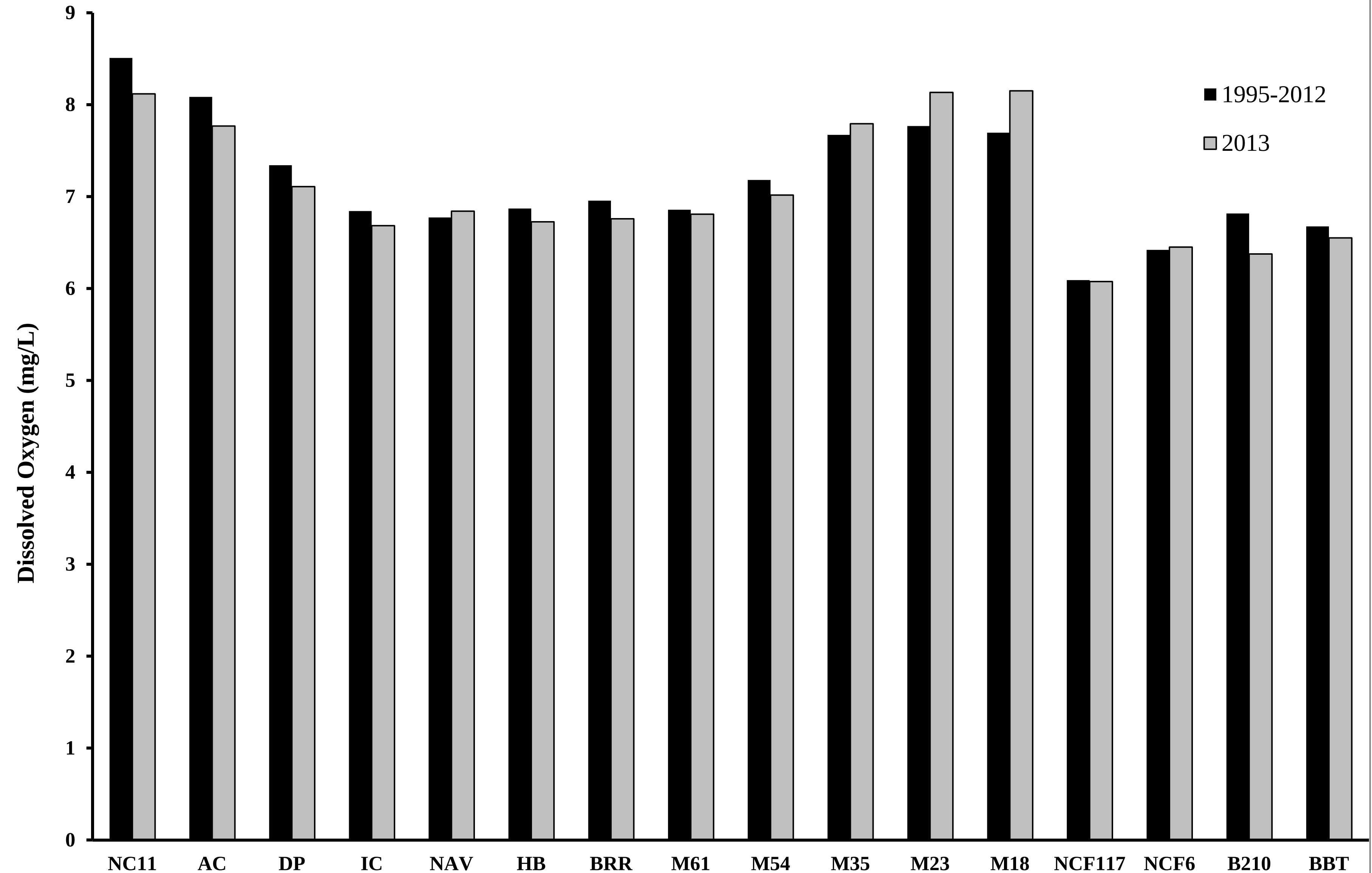
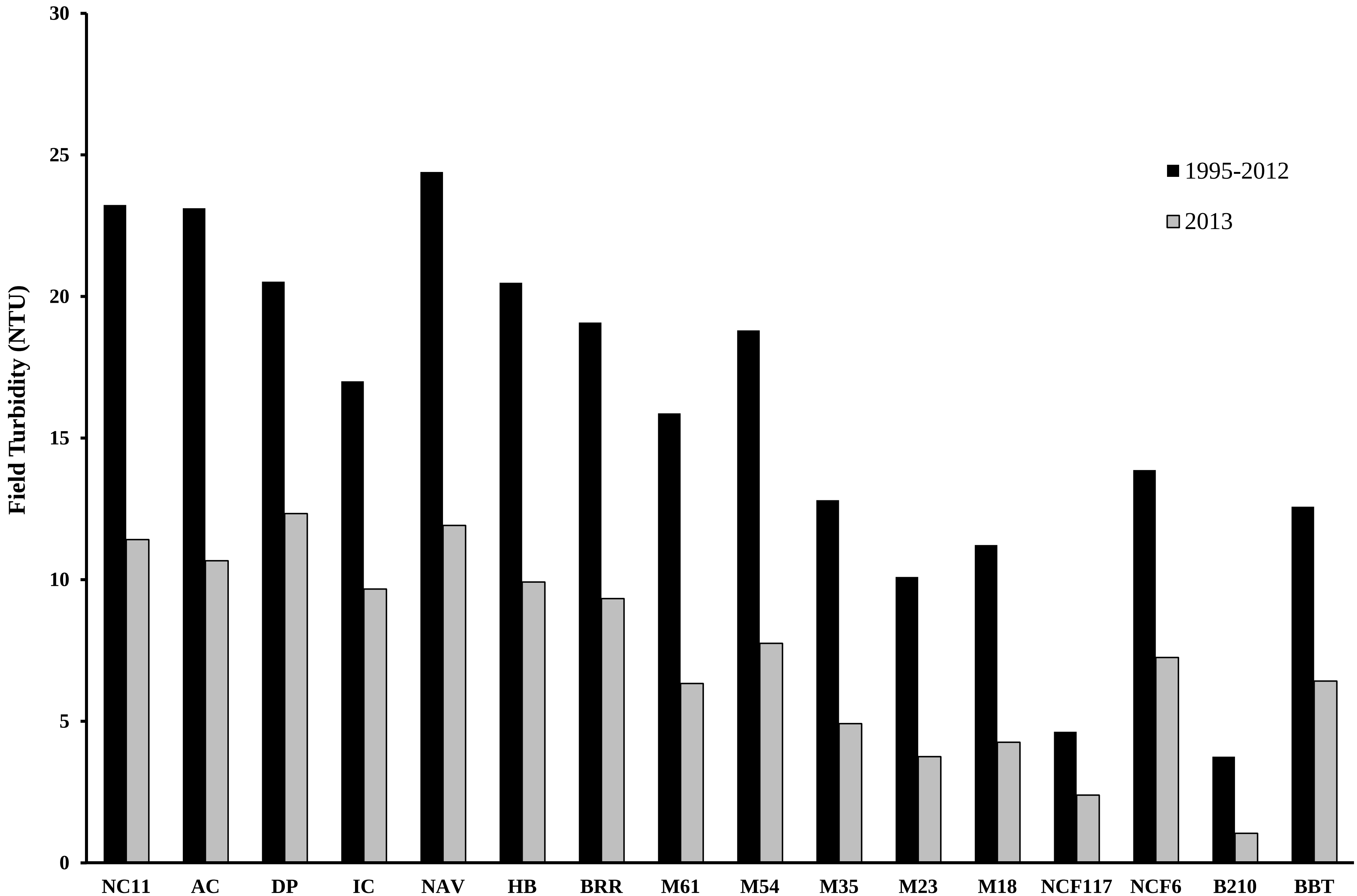


Figure 2.3 Field Turbidity at the Lower Cape Fear River Program mainstem stations, 1995-2012 versus 2013.



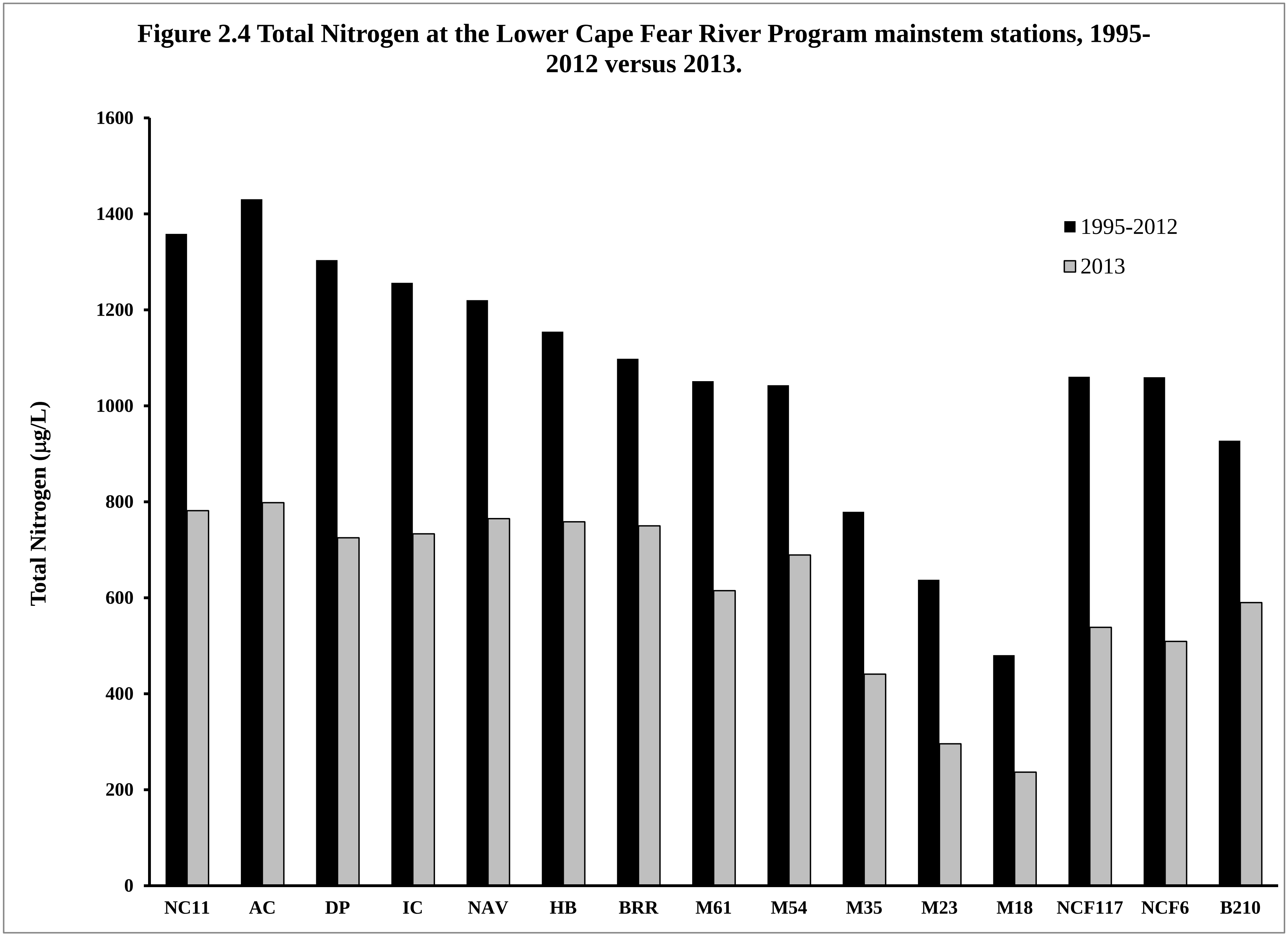
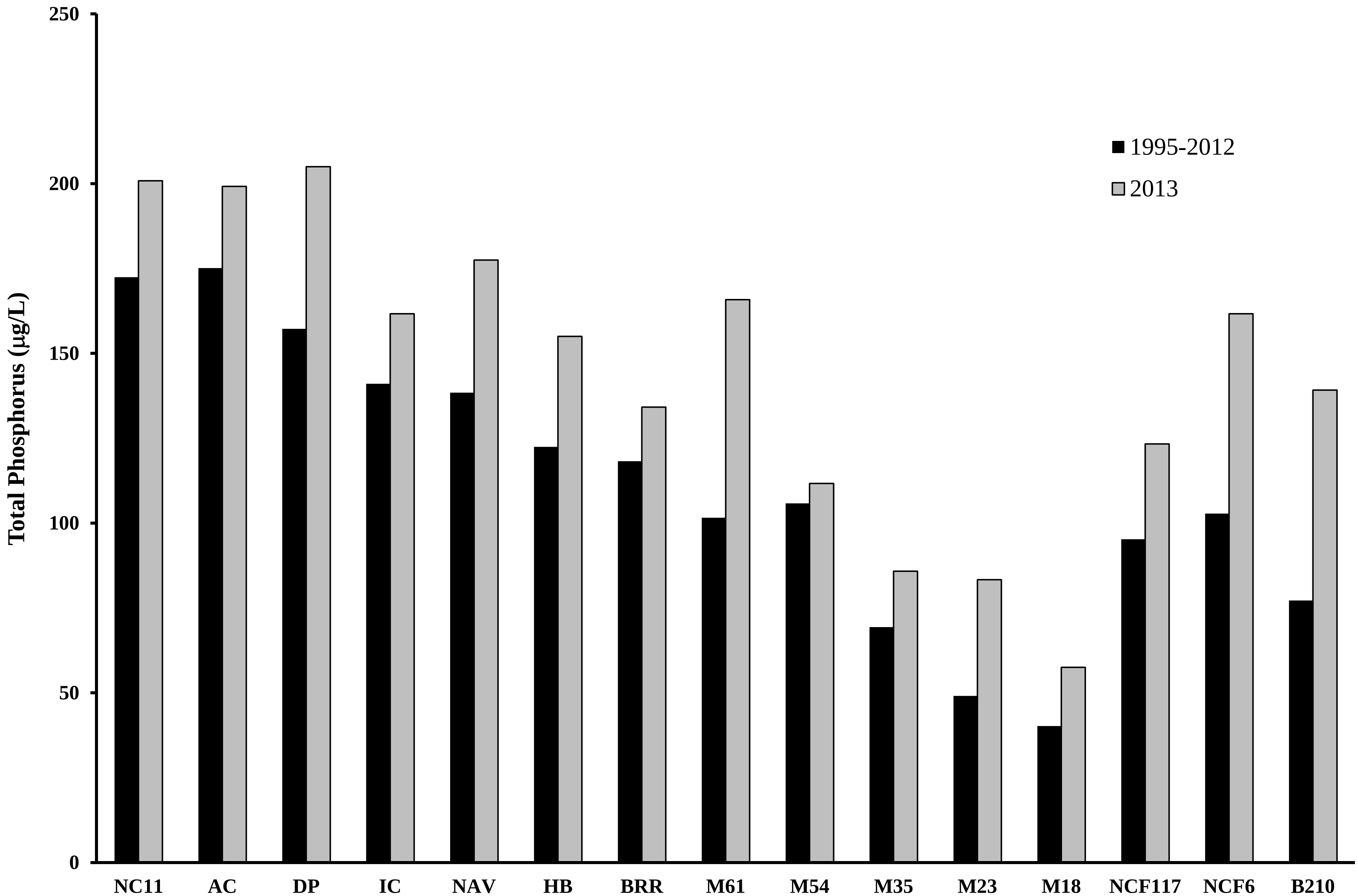


Figure 2.4 Total Nitrogen at the Lower Cape Fear River Program mainstem stations, 1995-2012 versus 2013.
Total Nitrogen (µg/L)
1600
1400
1200
1000
800
600
400
200
0
1995-2012
2013
NC11
AC
DP
IC
NAV
HB
BRR
M61
M54
M35
M23
M18
NCF117
NCF6
B210

Figure 2.5 Total Phosphorus at the Lower Cape Fear River Program mainstem stations, 1995-2012 versus 2013.



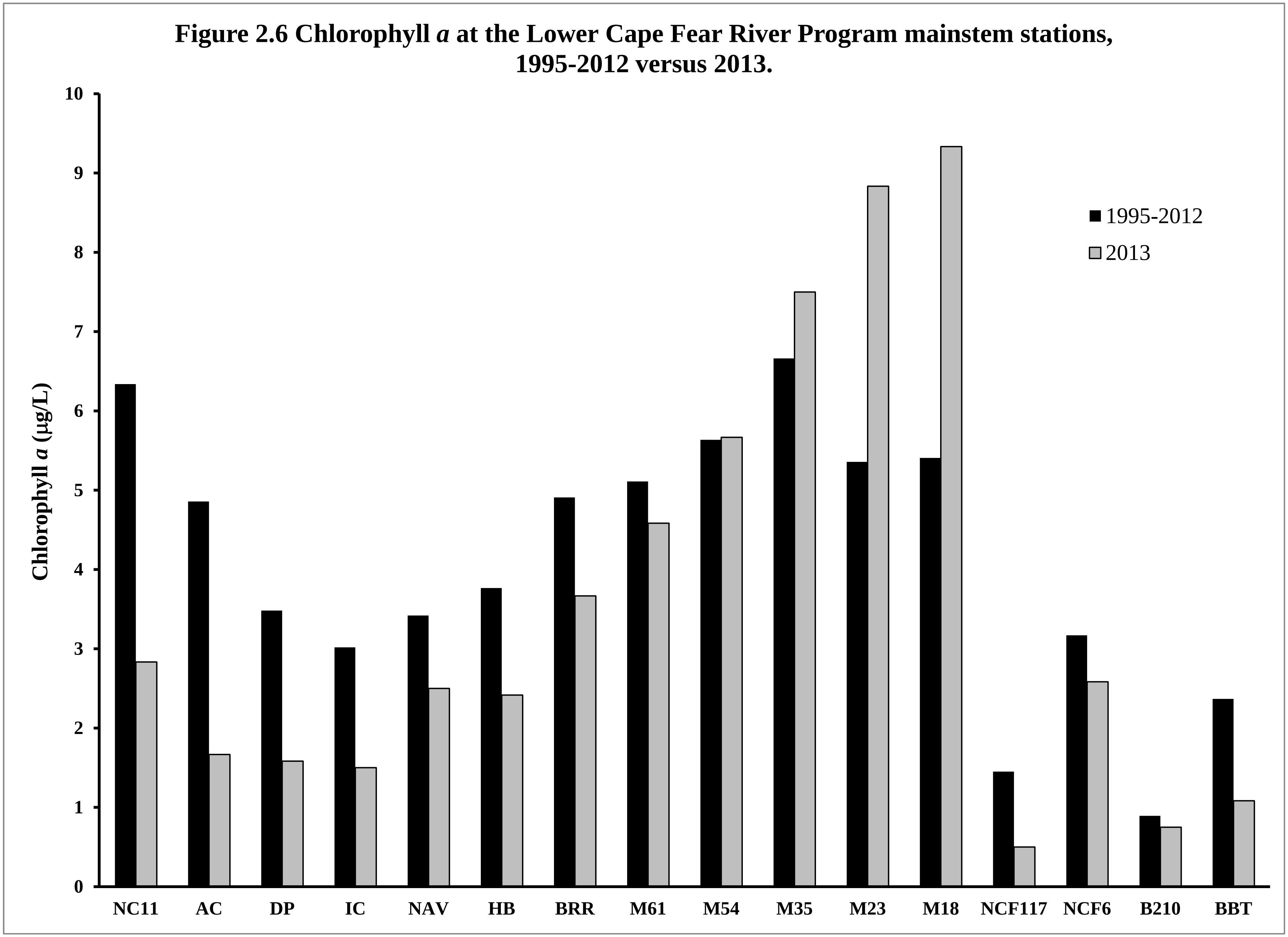


Figure 2.6 Chlorophyll a at the Lower Cape Fear River Program mainstem stations, 1995-2012 versus 2013.
Chlorophyll a (µg/L)
0
1
2
3
4
5
6
7
8
9
10
1995-2012
2013
NC11
AC
DP
IC
NAV
HB
BRR
M61
M54
M35
M23
M18
NCF117
NCF6
B210
BBT