Environmental Assessment of the Lower Cape Fear River System, 2015

By

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November 2016

CMS Report No. 16-02
Center for Marine Science
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Executive Summary

Multiparameter water sampling for the Lower Cape Fear River Program (LCFRP) http://www.uncw.edu/cms/aelab/LCFRP/index.htm, 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 2015. 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 2015 were generally comparable to the average for 1995-2014. 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 2015 DO levels occurred at the lower river and upper estuary stations IC, NAV, HB, BRR and M61 (6.8-7.0 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 2015 Stations NCF117 and B210, representing those rivers, had average DO concentrations of 5.9 and 7.0 mg/L, respectively. Several stream stations were severely stressed in terms of low dissolved oxygen during the year 2015, including NC403, GS, and SR. River stations NAV, HB, and IC were all below 5.0 mg/L on 33% or more of occasions sampled, and DP and M61 were below on 25% of occasions sampled. Considering all sites sampled in 2015, we rated 21% as poor for dissolved oxygen, 18% as fair, and 61% as good, slightly worse than in 2014.

Annual mean turbidity levels for 2015 were lower than the long-term average in all estuary stations. Highest mean turbidities were at NC11-DP, plus NAV (12-18 NTU) with turbidities generally low in the middle to lower estuary. The estuarine stations did not exceed the estuarine turbidity standard on our sampling trips except in January 2015. 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 51 NTU in August at ANC.

Average chlorophyll *a* concentrations across most sites were low in 2015. The standard of 40 µg/L was exceeded twice at Station PB and three times at SR. We note the highest levels in the river and estuary typically occur late spring to late-summer. During the growing season May-September river flow as measured by USGS at Lock and Dam #1 was very close to the average for the blue-green algal bloom years 2009-2012 (1,763 CFS compared with 1,698 CFS). However, clearly some factor other than flow restricted blue-green algal bloom formation in 2015 in the Cape Fear River. For the 2015 period UNCW rated 94% of the stations as good and 6% as fair in terms of chlorophyll *a*, 100% of the stations were rated as good for turbidity.

Fecal coliform counts in the river and at many of the stream stations were very high in 2015. All river sites from NC11 downstream to HB were rated as poor, while the estuarine stations were mostly rated as fair for *Enterococcus*. All of the stream stations in the Northeast Cape Fear basin were rated as poor for fecal coliforms, as were several in the Black River basin. For bacterial water quality overall, 66% of the sites rated as poor, 31% as fair, and only 3% as good in 2015.

In addition, by our UNCW standards excessive nitrate and phosphorus concentrations were problematic at a number of stations.

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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 2015.

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 a 20-year (1995-2015) 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 Resources, 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 5^{th} 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 Resources, Division of Water Quality/Planning, Raleigh, NC, 27699 Natural -1617.

Table 1.1 Description of sampling locations for the Lower Cape Fear River Program, 2015.

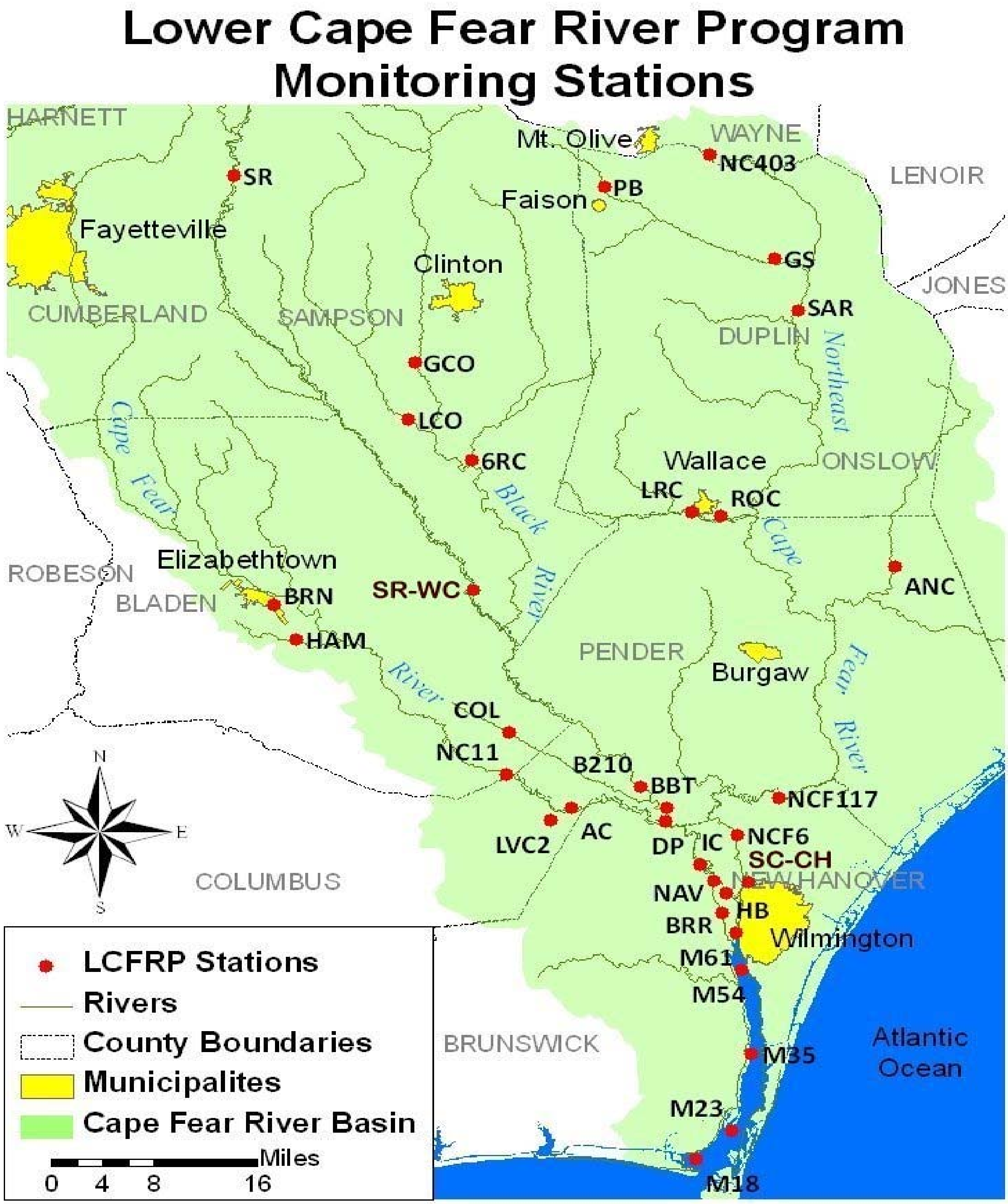
Collected by Boat

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
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
COL	B8981000	Colly Creek at NC 53 at Colly	Pristine area	Bladen	34.4641	-78.2569	C Sw	03030006
B210	B9000000	Black River at NC 210 at Still Bluff	1st bridge upstream of Cape Fear River	Pender	34.4312	-78.1441	C Sw ORW+	03030006
NC403	B9090000	NE Cape Fear River at NC 403 nr Williams	Downstream of Mt. Olive Pickle, CAFOs in watershed	Duplin	35.1784	-77.9807	C Sw	0303007
PB	B9130000	Panther Branch (Creek) nr Faison	Downstream of Bay Valley Foods	Duplin	35.1345	-78.1363	C Sw	0303007
GS	B9191000	Goshen Swamp at NC 11 and NC 903 nr Kornegay	CAFOs in watershed	Duplin	35.0281	-77.8516	C Sw	0303007
SAR	B9191500	NE Cape Fear River SR 1700 nr Sarecta	Downstream of several point source discharges	Duplin	34.9801	-77.8622	C Sw	0303007
ROC	B9430000	Rockfish Creek at US 117 nr Wallace	Upstream of Wallace discharge	Duplin	34.7168	-77.9795	C Sw	0303007
LRC	B9460000	Little Rockfish Creek at NC 11 nr Wallace	DWR Benthic station	Duplin	34.7224	-77.9814	C Sw	0303007
ANC	B9490000	Angola Creek at NC 53 nr Maple Hill	DWR Benthic station	Pender	34.6562	-77.7351	C Sw	0303007
SR WC	B8920000	South River at SR 1007 (Wildcat/Ennis Bridge Road)	Upstream of Black River	Sampson	34.6402	-78.3116	C Sw ORW+	03030006
NCF117	B9580000	NE Cape Fear River at US 117 at Castle Hayne	DWR ambient station, Downstream of point source discharges	New Hanover	34.3637	-77.8965	B Sw	0303007
SC-CH	B9720000	Smith Creek at US 117 and NC 133 at Wilmington	Urban runoff, Downstream of Wilmington Northside WWTP	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 2015 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. Selected 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 US EPA (1997) 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. The Aquatic Ecology Laboratory at the CMS is State-certified by the N.C. Division of Water Quality for the analysis of chlorophyll *a* (chlorophyll at four LCFRP stations are required by NCDWR to be analyzed by state-certified methods).

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 plus LVC2.

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*	EPA 445.0 Rev. 1.2	Yes
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 2015. 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 growing season flow conditions for the Cape Fear River and Estuary.

Physical Parameters

Water temperature

Water temperatures at all stations ranged from 2.5 to 30.5^{o}C, and individual station annual averages ranged from 16.7 to 20.3^{o}C (Table 2.1). Highest temperatures occurred during July and August and lowest temperatures during February. 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 0.0 to 34.6 practical salinity units (psu) and station annual means ranged from 1.1 to 26.5 psu (Table 2.2). Lowest salinities occurred in late spring and early-summer and highest salinities occurred in late fall and winter. The annual mean salinity for 2015 was slightly lower than that of the eighteen-year average for 1995-2014 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 18.6 psu.

Conductivity

Conductivity at the estuarine stations ranged from 0.09 to 52.60 mS/cm and from 0.06 to 4.04 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 3.9 to 8.1 and station annual means ranged from 4.3 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.

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; 2014; 2015). Surface concentrations for all sites in 2015 ranged from 0.5 to 12.7 mg/L and station annual means ranged from 4.9 to 8.8 mg/L (Table 2.5). Average annual DO levels at the river channel and estuarine stations for 2015 were generally comparable to the average for 1995-2014 (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 2015 DO levels occurred at the river and upper estuary stations IC, NAV, HB, BRR and M61 (6.8-7.0 mg/L). Stations NAV, HB, and IC were all below 5.0 mg/L on 33% or more of occasions sampled, and M61 and DP were below on 25% of occasions sampled. Based on number of occasions the river stations were below 5 mg/L UNCW rated NAV, HB and IC as poor for 2015; the mid to lower estuary stations were rated as fair to good. Discharge of 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 2015 mean = 5.9, NCF6 = 6.3, B210 2015 mean = 7.0, all decreased from 2014) . 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 2014. Station GS and NC403 had DO levels below 4.0 mg/L 33% of the occasions sampled, and SR was below that level 58% (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 39% of the sites impacted in 2015 (same as 2014).

Field Turbidity

Field turbidity levels ranged from 0 to 51 Nephelometric turbidity units (NTU) and station annual means ranged from 1 to 18 NTU (Table 2.6). The State standard for estuarine turbidity is 25 NTU. Highest mean turbidities were at NC11-DP (18 NTU), plus NAV (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 2014 sampling trips except during January. Annual mean turbidity levels for 2015 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 51 NTU in August at ANC. The State standard for freshwater turbidity is 50 NTU.

Note: In addition to the laboratory-analyzed turbidity that are required by 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 1.3 to 60.7 mg/L with station annual means from 2.4 to 20.1 mg/L (Table 2.7). The overall highest river values were at NAV, AC, DP, M54 and M18. In the stream stations TSS was generally considerably lower than the river and estuary, except for a few relatively minor incidents at Station PB and an unusual peak of 60.7 mg/L at ROC in August. 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 (reduced through absorbance or reflection) in the water column. River and estuary light attenuation coefficients ranged from 1.16 to 5.74/m and station annual means ranged from 1.71 at M18 to 3.70 at NAV (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 generally high 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 7,570 μg/L and station annual means ranged from 473 to 3,468 μg/L (Table 2.9). 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, then another elevated area in the upper estuary then declining 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 NC403 , with 2,505 μg/L; other elevated TN values were seen at PB, ROC and ANC.

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 5,300 μg/L and station annual means ranged from 23 to 2,059 μg/L (Table 2.10). The highest average riverine nitrate levels were at NC11, AC and DP (678 and 598 μg/L) 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 = 283 μg/L) and the Black River (B210 = 319 μg/L). Lowest river nitrate occurred during late spring and early summer. In general, average concentrations in 2015 exceeded those of the average from 1995-2014 (Fig. 2.4).

Several stream stations showed high levels of nitrate on occasion including ROC, NC403, and PB. ROC primarily receives 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 200 to 500 µg/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 500 µg/L as N in Cape Fear watershed streams to be potentially problematic to the stream's environmental health.

Ammonium/ammonia

Ammonium concentrations ranged from 10 (detection limit) to 1,220 μg/L and station annual means ranged from 25 to 271 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 HB and M54 in the upper estuary. At the stream stations, areas with highest levels of ammonium were PB, NC403, ANC, LRC and GS. NC403 had the highest peak of 1,220 µg/L in June.

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 5,800 μg/L and station annual means ranged from 425 to 2,475 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 individual peaks at or exceeding 2,000 µg/L range occurred in stations ANC, GS, ROC and COL; ANC also had the highest median concentrations.

Total Phosphorus

Total phosphorus (TP) concentrations ranged from 10 (detection limit) to 960 μg/L and station annual means ranged from 37 to 304 μg/L (Table 2.13). For the mainstem and upper estuary, average TP for 2015 was lower than the 1995-2014 average; however, for the lower estuary and the Northeast Cape Fear River TP was higher than the long-term average (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 500 µg/L led to significant increases in bacterial counts, as well as significant increases in BOD over control. Thus, we consider concentrations of phosphorus above 500 µg/L to be potentially problematic to blackwater streams (Mallin et al. 1998; 2004). Streams periodically exceeding this critical concentration included ROC and NC403 and GCO. Station NC403 is downstream of an industrial wastewater discharge, while ROC and GCO are in non-point agricultural areas.

Orthophosphate

Orthophosphate ranged from undetectable to 810 µg/L and station annual means ranged from 7 to 203 µg/L (Table 2.14). Much of the main river 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. Revised metals sampling was re-initiated in late 2015, however, and will be reported on in the 2016 report.

Biological Parameters

Chlorophyll a

During this monitoring period in most locations chlorophyll *a* was low, except for elevated concentrations in July in the upper and middle estuary (Table 2.15). The state standard was not exceeded in the river or estuary samples in 2015. 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 155 μg/L and station annual means ranged from 1-28 μg/L, higher than in 2014. 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 tributary 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 (1995-2014) average monthly flow at Lock and Dam #1 was approximately 3,482 CFS; however, for cyanobacterial bloom years 2009-2012 the growing season average flow was 1,698 CFS (USGS data; (http://nc.water.usgs.gov/realtime/real_time_cape_fear.html). For 2015, discharge in May-September was very close to the 2009-2012 average at 1,763 CFS. However, nuisance cyanobacterial blooms did not occur in the river and upper estuary that year. Average chlorophyll *a* for 2015 displayed no consistent pattern in comparison with the long-term average (Figure 2.6).

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 2013-2014, but flow in 2015 was well within the range when blooms can occur. Clearly other factors are at work in bloom formation.

Phytoplankton blooms occasionally occur at the stream stations, with a few occurring at various months in 2015 (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). Stream station blooms exceeding the state standard of 40 µg/L occurred on three occasions at Station SR and on two occasions at PB (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 2015 (as was the case with 2007 through 2014) 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 2015 BOD5 values ranged from 0.8 – 2.1 mg/L. There were no major differences among sites for BOD5 or BOD20 in 2015. BOD20 values showed similar patterns to BOD5 in 2015.

Fecal Coliform Bacteria/ Enterococcus bacteria

Fecal coliform (FC) bacterial counts ranged from 5 to 60,000 CFU/100 mL (60,000 is the laboratory maximum) and station annual geometric means ranged from 32 to 2,467 CFU/100 mL (Table 2.17). The state human contact standard (200 CFU/100 mL) was exceeded in the mainstem numerous times at all riverine stations in 2015 (Table 2.17). During 2015 the stream stations showed very high fecal coliform pollution levels. BRN exceeded 200 CFU/100 mL 100% of the time sampled; ROC 92%, HAM, LRC, PB, SAR 75%, ANC 58%, BRN 67%, ANC 58%, and 6RC and NC403 42% of the time sampled. Notably excessive counts of 60,000 CFU/100 mL occurred ANC, SAR, NC403, PB, LRC, ROC and 6RC occurred in 2015, mainly in summer and fall. NC403 and PB are located below point source discharges and the other sites are primarily influenced by non-point source pollution. Overall, 2015 was a very bad year for fecal coliform counts, with geometric mean counts in the mainstem river and the blackwater tributaries well exceeding the geometric mean for the 1995-2014 period (Fig. 2.6).

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 2015 stations BRR, M61, M54, M23 and M18 all exceeded the standard on two to three occasions, and M35 exceeded the standard on one occasion. Geometric mean enterococcus counts for 2015 were higher than those of the 2012-2014 period for the Cape Fear Estuary (Fig. 2.6). Overall, elevated fecal coliform and enterococcus counts are problematic in this system, with 97% of the stations rated as Fair or Poor in 2015, much higher than the previous year 2014.

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Table 2.1 Water temperature (^{o}C) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	7.3	11.1	10.9	11.2	11.1	12.4	12.2	12.7
FEB	4.0	4.0	4.2	4.7	5.1	5.6	6.1	6.4
MAR	13.6	14.4	14.2	14.4	14.3	13.9	13.4	13.0
APR	21.1	20.5	20.8	21.2	21.0	20.9	20.2	19.6
MAY	19.3	20.0	20.1	20.1	20.1	21.3	21.0	20.9
JUN	25.3	25.6	26.8	25.5	26.6	26.7	26.2	26.0
JUL	28.1	28.9	28.8	29.2	29.0	28.5	28.2	28.2
AUG	29.1	29.2	30.2	29.3	29.5	29.1	28.6	28.6
SEP	28.7	29.2	28.7	29.0	28.0	28.1	27.7	27.9
OCT	19.6	19.9	19.7	20.0	20.2	20.8	21.1	23.3
NOV	18.5	18.5	18.7	19.3	19.6	20.1	20.7	20.9
DEC	11.8	12.3	12.1	13.2	13.3	14.0	15.1	15.5
mean	**18.9**	**19.5**	**19.6**	**19.8**	**19.8**	**20.1**	**20.0**	**20.3**
std dev	8.3	8.0	8.2	7.8	7.7	7.4	7.2	7.1
median	19.5	20.0	19.9	20.1	20.2	20.9	20.9	20.9
max	29.1	29.2	30.2	29.3	29.5	29.1	28.6	28.6
min	4.0	4.0	4.2	4.7	5.1	5.6	6.1	6.4

	NC11	AC	DP	BBT	IC	NCF6
JAN	6.6	6.7	6.7	7.4	7.2	8.1
FEB	6.4	6.3	6.4	6.5	7.1	7.4
MAR	5.5	5.5	5.7	7.0	6.4	7.5
APR	13.2	13.5	14.0	14.4	14.2	15.2
MAY	22.1	21.7	21.9	22.2	22.1	21.9
JUN	26.4	26.3	26.1	24.3	25.1	24.7
JUL	28.5	28.3	28.5	28.1	28.5	29.3
AUG	30.5	30.1	28.9	28.4	28.9	28.8
SEP	27.6	27.8	27.3	27.2	27.6	27.5
OCT	18.9	19.1	19.1	19.1	19.4	19.8
NOV	17.7	17.9	18.0	18.1	18.0	19.2
DEC	13.2	13.2	13.4	13.5	13.6	13.3
mean	**18.1**	**18.0**	**18.0**	**18.0**	**18.2**	**18.6**
std dev	9.1	9.0	8.8	8.3	8.5	8.2
median	18.3	18.5	18.6	18.6	18.7	19.5
max	30.5	30.1	28.9	28.4	28.9	29.3
min	5.5	5.5	5.7	6.5	6.4	7.4

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	13.9	13.1	12.1	12.1	12.0	13.0	14.0
FEB	8.4	5.4	7.3	6.8	6.0	7.6	6.6
MAR	7.7	7.1	6.6	7.1	6.7	8.3	8.7
APR	15.3	15.9	15.7	17.0	16.6	17.6	17.8
MAY	20.2	23.3	24.3	25.6	26.4	24.6	25.4
JUN	23.1	25.6	24.8	25.7	25.7	25.5	23.2
JUL	23.9	24.6	25.9	23.7	25.0	26.1	24.4
AUG	23.2	23.6	24.6	25.2	25.8	26.1	23.6
SEP	22.8	22.9	22.5	22.9	23.5	23.2	22.8
OCT	19.6	19.4	20.5	19.3	20.1	19.3	18.3
NOV	13.4	11.1	11.8	11.5	10.9	12.3	11.1
DEC	15.6	15.2	15.8	15.2	14.7	16.5	14.9
mean	**17.3**	**17.3**	**17.7**	**17.7**	**17.8**	**18.3**	**17.6**
std dev	5.7	7.0	7.0	7.1	7.7	6.9	6.5
median	17.6	17.7	18.2	18.2	18.4	18.5	18.1
max	23.9	25.6	25.9	25.7	26.4	26.1	25.4
min	7.7	5.4	6.6	6.8	6.0	7.6	6.6

	6RC	LCO	GCO	SR	BRN	HAM
JAN	12.6	12.7	12.4	11.8	12.5	12.1
FEB	9.8	9.4	9.8	8.6	9.1	8.5
MAR	7.2	6.4	6.5	6.6	9.3	9.5
APR	12.8	13.2	14.1	14.4	15.1	14.8
MAY	18.0	18.5	18.9	19.9	18.2	16.4
JUN	23.1	23.6	25.0	24.2	22.1	21.5
JUL	25.0	25.0	25.9	27.2	24.9	25.1
AUG	24.3	24.0	24.4	24.5	24.2	23.8
SEP	21.9	21.6	22.2	22.1	20.7	20.7
OCT	13.7	13.5	13.8	13.0	15.7	14.7
NOV	18.2	18.3	18.6	18.2	19.2	18.9
DEC	14.6	14.0	14.1	13.5	14.3	14.3
mean	**16.8**	**16.7**	**17.1**	**17.0**	**17.1**	**16.7**
std dev	5.9	6.1	6.3	6.7	5.3	5.4
median	16.3	16.2	16.4	16.3	17.0	15.6
max	25.0	25.0	25.9	27.2	24.9	25.1
min	7.2	6.4	6.5	6.6	9.1	8.5

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	6.1	5.5	5.7	5.2	7.0	6.9
FEB	5.5	3.4	2.6	2.5	3.2	5.9
MAR	13.1	13.6	15.8	13.9	13.9	15.1
APR	17.8	18.4	17.8	17.4	17.4	19.1
MAY	22.6	21.4	19.7	21.5	20.5	23.0
JUN	29.9	29.8	26.8	28.2	28.2	30.4
JUL	29.1	28.1	24.8	26.1		29.5
AUG	27.6	25.2	23.8	24.6		28.0
SEP	24.7	23.8	21.7	22.2		25.5
OCT	17.7	13.2	14.7	14.3		19.3
NOV	13.7	18.5	18.6	18.0		15.4
DEC	14.5	13.8	14.6	13.6		15.7
mean	**18.5**	**17.9**	**17.2**	**17.3**	**15.0**	**19.5**
std dev	8.4	8.4	7.3	7.9	9.1	8.2
median	17.8	18.5	18.2	17.7	15.7	19.2
max	29.9	29.8	26.8	28.2	28.2	30.4
min	5.5	3.4	2.6	2.5	3.2	5.9

Table 2.2 Salinity (psu) 2015 at the Lower Cape Fear River Program estuarine stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18	NCF6	SC-CH
JAN	0.0	0.1	0.1	0.1	0.2	7.0	15.0	15.5	0.1	0.3
FEB	0.1	0.1	0.1	3.3	5.2	11.7	21.3	25.8	0.1	3.8
MAR	0.1	0.1	0.1	2.0	3.0	6.2	12.4	18.6	0.0	0.1
APR	0.1	0.1	0.1	1.0	3.9	12.0	24.4	30.1	0.1	2.4
MAY	0.1	0.2	0.3	1.9	6.5	14.0	23.1	30.3	0.1	0.1
JUN	0.1	0.1	2.1	2.8	8.1	14.8	25.4	28.7	0.1	0.4
JUL	0.1	0.8	2.9	5.3	10.0	18.4	29.7	31.3	0.4	6.5
AUG	6.4	10.4	8.5	12.7	15.6	24.2	32.7	33.7	3.1	10.3
SEP	6.1	6.1	7.7	9.7	16.1	25.8	32.7	34.6	0.4	7.5
OCT	0.1	0.1	0.1	0.1	0.3	3.1	7.3	29.8	0.0	6.5
NOV	0.1	0.1	0.1	3.0	4.7	9.2	17.9	20.3	0.1	0.1
DEC	0.1	0.5	0.1	3.7	4.9	11.6	15.3	19.8	0.0	0.1
mean	**1.1**	**1.6**	**1.9**	**3.8**	**6.5**	**13.2**	**21.4**	**26.5**	**0.4**	**3.2**
std dev	2.4	3.3	3.1	3.8	5.2	6.9	8.1	6.4	0.9	3.6
median	0.1	0.1	0.1	2.9	5.1	11.9	22.2	29.3	0.1	1.4
max	6.4	10.4	8.5	12.7	16.1	25.8	32.7	34.6	3.1	10.3
min	0.0	0.1	0.1	0.1	0.2	3.1	7.3	15.5	0.0	0.1

Table 2.3 Specific Conductivity (mS/cm) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	0.09	0.13	0.16	0.18	0.47	12.22	24.33	25.28
FEB	0.12	0.13	0.19	6.15	9.41	19.84	34.49	40.86
MAR	0.13	0.12	0.21	3.70	5.57	10.88	20.74	29.63
APR	0.13	0.14	0.29	2.04	7.00	20.11	38.09	46.29
MAY	0.14	0.51	0.66	3.68	11.35	23.09	36.48	46.57
JUN	0.16	0.17	3.96	5.25	14.07	24.44	39.87	44.45
JUL	0.20	1.50	5.46	9.43	17.08	29.84	45.85	48.05
AUG	11.43	17.81	14.80	21.24	25.56	38.38	50.11	51.46
SEP	10.80	10.78	13.52	16.70	26.37	40.55	49.15	52.60
OCT	0.11	0.11	0.14	0.13	0.54	5.63	12.74	45.91
NOV	0.15	0.16	0.18	5.57	8.46	15.77	29.00	32.30
DEC	0.13	1.05	0.24	6.62	8.66	19.40	25.04	32.01
mean	**1.96**	**2.72**	**3.32**	**6.72**	**11.21**	**21.68**	**33.82**	**41.28**
std dev	4.28	5.63	5.36	6.38	8.39	10.54	11.73	9.15
median	0.13	0.17	0.26	5.41	9.03	19.97	35.48	45.18
max	11.43	17.81	14.80	21.24	26.37	40.55	50.11	52.60
min	0.09	0.11	0.14	0.13	0.47	5.63	12.74	25.28

	NC11	AC	DP	BBT	IC	NCF6
JAN	0.09	0.13	0.10	0.09	0.08	0.12
FEB	0.12	0.12	0.13	0.10	0.11	0.11
MAR	0.09	0.10	0.10	0.08	0.09	0.08
APR	0.11	0.11	0.13	0.08	0.11	0.12
MAY	0.12	0.14	0.12	0.07	0.10	0.10
JUN	0.14	0.15	0.22	0.09	0.13	0.11
JUL	0.10	0.13	0.15	0.11	0.13	0.78
AUG	0.13	0.13	0.23	0.17	0.21	5.72
SEP	0.14	0.15	0.20	0.16	0.22	0.77
OCT	0.10	0.11	0.11	0.08	0.09	0.09
NOV	0.11	0.11	0.10	0.09	0.10	0.13
DEC	0.10	0.10	0.11	0.09	0.11	0.09
mean	**0.11**	**0.12**	**0.14**	**0.10**	**0.12**	**0.69**
std dev	0.02	0.02	0.05	0.03	0.05	1.61
median	0.11	0.12	0.12	0.09	0.11	0.11
max	0.14	0.15	0.23	0.17	0.22	5.72
min	0.09	0.10	0.10	0.07	0.08	0.08

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	0.11	0.14	0.14	0.24	0.38	0.12	0.14
FEB	0.10	0.15	0.14	0.35	0.86	0.12	0.14
MAR	0.08	0.11	0.12	0.22	0.42	0.10	0.11
APR	0.11	0.17	0.16	0.43	0.82	0.13	0.15
MAY	0.10	0.13	0.12	0.36	1.29	0.12	0.12
JUN	0.11	0.18	0.17	0.53	3.19	0.14	0.16
JUL	0.12	0.34	0.23	0.23	1.29	0.11	0.24
AUG	0.11	0.16	0.13	0.99	0.49	0.09	0.09
SEP	0.12	0.21	0.17	1.04	4.04	0.14	0.24
OCT	0.11	0.20	0.19	0.87	1.92	0.14	0.21
NOV	0.08	0.15	0.15	0.42	0.54	0.11	0.14
DEC	0.10	0.11	0.15	0.43	0.66	0.11	0.13
mean	**0.10**	**0.17**	**0.16**	**0.51**	**1.32**	**0.12**	**0.15**
std dev	0.01	0.06	0.03	0.29	1.17	0.02	0.05
median	0.11	0.16	0.15	0.42	0.84	0.12	0.14
max	0.12	0.34	0.23	1.04	4.04	0.14	0.24
min	0.08	0.11	0.12	0.22	0.38	0.09	0.09

	6RC	LCO	GCO	SR	BRN	HAM
JAN	0.14	0.09	0.12	0.07	0.13	0.16
FEB	0.14	0.10	0.12	0.07	0.12	0.16
MAR	0.12	0.09	0.11	0.07	0.10	0.13
APR	0.12	0.08	0.10	0.07	0.10	0.12
MAY	0.12	0.08	0.12	0.08	0.11	0.16
JUN	0.14	0.10	0.20	0.09	0.13	0.21
JUL	0.15	0.15	0.28	0.11	0.15	0.23
AUG	0.11	0.11	0.21	0.15	0.12	0.21
SEP	0.08	0.12	0.26	0.23	0.14	0.23
OCT	0.14	0.11	0.16	0.10	0.11	0.17
NOV	0.13	0.10	0.13	0.09	0.11	0.13
DEC	0.13	0.10	0.13	0.09	0.10	0.14
mean	**0.13**	**0.10**	**0.16**	**0.10**	**0.12**	**0.17**
std dev	0.02	0.02	0.06	0.05	0.02	0.04
median	0.13	0.10	0.13	0.09	0.12	0.16
max	0.15	0.15	0.28	0.23	0.15	0.23
min	0.08	0.08	0.10	0.07	0.10	0.12

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	0.11	0.09	0.06	0.06	0.06	0.68
FEB	0.12	0.09	0.06	0.07	0.13	6.90
MAR	0.10	0.08	0.06	0.06	0.08	0.27
APR	0.12	0.09	0.06	0.07	0.10	4.39
MAY	0.09	0.07	0.07	0.06	0.05	0.21
JUN	0.10	0.09	0.06	0.07	0.11	0.72
JUL	0.14	0.12	0.06	0.09		11.49
AUG	0.19	0.09	0.07	0.07		17.60
SEP	0.15	0.11	0.06	<0.05		13.00
OCT	0.13	0.08	0.09	0.06		11.38
NOV	0.10	0.09	0.06	0.08		0.22
DEC	0.11	0.09	0.06	0.07		0.29
mean	**0.12**	**0.09**	**0.07**	**0.07**	**0.09**	**5.60**
std dev	0.03	0.01	0.01	0.01	0.03	6.27
median	0.12	0.09	0.06	0.07	0.09	2.56
max	0.19	0.12	0.09	0.09	0.13	17.60
min	0.09	0.07	0.06	0.06	0.05	0.21

Table 2.4 pH 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	6.4	6.6	6.9	6.8	7.4	8.0	8.0	8.0
FEB	7.0	7.1	6.7	6.9	7.6	8.0	8.1	8.1
MAR	6.9	6.8	7.0	6.9	7.1	7.4	7.9	8.0
APR	6.9	6.9	7.2	7.0	7.4	7.7	8.0	8.0
MAY	6.8	6.8	6.8	6.9	7.2	7.6	7.9	8.0
JUN	6.7	6.8	6.9	6.7	7.1	7.5	7.9	8.0
JUL	6.9	7.3	7.8	7.4	7.9	8.0	8.0	8.0
AUG	7.0	7.2	7.3	7.2	7.4	7.6	7.9	7.9
SEP	7.2	7.2	7.4	7.5	7.6	7.8	8.0	8.0
OCT	6.4	6.6	6.7	6.6	6.8	7.4	7.7	7.9
NOV	7.0	7.2	7.4	7.2	7.8	7.6	7.8	7.6
DEC	7.3	7.3	7.6	7.2	7.7	7.8	8.0	7.9
mean	**6.9**	**7.0**	**7.1**	**7.0**	**7.4**	**7.7**	**7.9**	**8.0**
std dev	0.3	0.3	0.4	0.3	0.3	0.2	0.1	0.1
median	6.9	7.0	7.1	7.0	7.4	7.7	8.0	8.0
max	7.3	7.3	7.8	7.5	7.9	8.0	8.1	8.1
min	6.4	6.6	6.7	6.6	6.8	7.4	7.7	7.6

	NC11	AC	DP	BBT	IC	NCF6
JAN	6.6	7.0	6.5	6.4	6.2	6.4
FEB	6.1	6.5	6.7	6.5	6.6	6.1
MAR	6.6	6.7	6.7	6.2	6.5	6.2
APR	6.8	6.8	6.9	6.4	6.7	6.6
MAY	6.7	6.7	6.6	6.1	6.5	6.4
JUN	6.8	6.9	6.9	6.3	6.6	6.5
JUL	6.3	6.5	6.6	6.3	6.4	6.5
AUG	6.6	6.5	6.6	6.5	6.5	6.6
SEP	6.3	6.5	6.5	6.4	6.6	6.6
OCT	6.2	6.5	6.5	5.8	6.1	5.8
NOV	5.8	6.4	6.4	6.2	6.2	6.3
DEC	5.9	6.2	6.5	6.2	6.4	6.2
mean	**6.4**	**6.6**	**6.6**	**6.3**	**6.4**	**6.4**
std dev	0.3	0.2	0.2	0.2	0.2	0.2
median	6.5	6.5	6.6	6.3	6.5	6.4
max	6.8	7.0	6.9	6.5	6.7	6.6
min	5.8	6.2	6.4	5.8	6.1	5.8

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	5.3	6.3	6.4	6.4	6.5	6.9	6.7
FEB	5.6	6.3	6.7	6.6	6.5	6.6	6.4
MAR	4.9	6.6	6.8	6.4	6.7	6.9	6.7
APR	6.3	6.9	6.9	6.8	6.8	7.3	7.0
MAY	5.9	6.6	6.7	7.0	6.9	7.0	6.7
JUN	6.4	7.0	6.8	7.1	7.0	7.4	7.0
JUL	6.5	7.1	6.9	6.2	6.7	7.2	7.0
AUG	6.5	6.6	6.6	6.7	6.8	7.0	6.7
SEP	6.9	7.1	6.9	6.9	6.9	7.5	7.3
OCT	5.3	6.8	6.8	6.9	6.8	6.9	6.8
NOV	5.1	6.8	6.9	6.8	6.6	6.6	6.2
DEC	6.2	6.9	7.1	7.1	7.0	7.2	7.1
mean	**5.9**	**6.8**	**6.8**	**6.7**	**6.8**	**7.0**	**6.8**
std dev	0.7	0.3	0.2	0.3	0.2	0.3	0.3
median	6.1	6.8	6.8	6.8	6.8	7.0	6.8
max	6.9	7.1	7.1	7.1	7.0	7.5	7.3
min	4.9	6.3	6.4	6.2	6.5	6.6	6.2

	6RC	LCO	GCO	SR	BRN	HAM
JAN	6.4	6.0	6.2	6.1	6.6	6.7
FEB	6.6	6.3	6.5	6.3	6.6	6.8
MAR	6.4	5.8	6.4	6.3	6.3	6.6
APR	6.7	6.3	6.6	6.5	6.4	6.7
MAY	6.8	6.6	6.7	6.3	6.8	6.9
JUN	6.6	6.8	6.9	6.4	6.9	7.1
JUL	6.8	6.8	7.1	6.3	7.0	7.4
AUG	6.2	6.4	6.5	6.3	6.6	6.8
SEP	6.5	6.7	6.9	6.3	6.8	6.9
OCT	6.2	6.3	6.3	6.1	6.4	6.5
NOV	5.8	5.7	6.0	5.8	6.1	6.2
DEC	6.3	6.2	6.3	6.2	6.4	6.5
mean	**6.4**	**6.3**	**6.5**	**6.2**	**6.6**	**6.8**
std dev	0.3	0.4	0.3	0.2	0.3	0.3
median	6.5	6.3	6.5	6.3	6.6	6.8
max	6.8	6.8	7.1	6.5	7.0	7.4
min	5.8	5.7	6.0	5.8	6.1	6.2

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	6.2	5.9	3.9	5.3	6.2	6.7
FEB	6.2	5.9	4.0	6.1	7.2	7.2
MAR	6.3	6.1	4.1	5.8	6.6	7.1
APR	6.5	6.3	4.1	6.1	6.7	6.7
MAY	6.2	5.9	6.1	6.0	6.0	6.7
JUN	6.2	6.0	4.1	6.7	6.4	6.6
JUL	6.5	6.2	3.9	6.2		6.7
AUG	7.1	5.7	3.9	5.5		6.6
SEP	6.9	6.2	4.1	6.0		7.3
OCT	6.5	5.4	5.6	3.8		7.0
NOV	5.9	5.3	3.9	5.3		6.7
DEC	6.7	5.6	4.0	5.4		7.5
mean	**6.4**	**5.9**	**4.3**	**5.7**	**6.5**	**6.9**
std dev	0.3	0.3	0.7	0.7	0.4	0.3
median	6.4	5.9	4.1	5.9	6.5	6.7
max	7.1	6.3	6.1	6.7	7.2	7.5
min	5.9	5.3	3.9	3.8	6.0	6.6

Table 2.5 Dissolved Oxygen (mg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	10.5	8.7	8.9	8.8	8.9	8.9	8.7	8.9
FEB	12.7	12.6	12.4	11.9	11.8	11.4	10.8	10.4
MAR	9.5	8.9	9.0	8.6	9.0	9.3	9.6	9.4
APR	6.6	6.7	6.9	6.8	7.2	7.5	7.6	7.6
MAY	7.0	6.7	7.0	6.6	6.7	7.4	7.6	7.9
JUN	4.6	4.6	5.1	4.4	5.8	6.2	6.1	6.5
JUL	4.3	4.8	5.6	6.5	7.5	7.0	6.2	6.2
AUG	3.8	3.8	4.5	4.4	5.1	5.5	5.9	6.4
SEP	4.1	4.5	4.6	5.1	4.8	5.3	5.9	6.0
OCT	5.5	5.2	5.3	4.7	4.8	5.5	6.3	6.3
NOV	6.5	6.9	6.2	6.0	6.2	6.6	7.1	7.1
DEC	8.7	8.5	8.6	7.9	8.1	8.0	8.1	8.0
mean	**7.0**	**6.8**	**7.0**	**6.8**	**7.2**	**7.4**	**7.5**	**7.6**
std dev	2.8	2.5	2.3	2.2	2.1	1.8	1.6	1.4
median	6.6	6.7	6.6	6.6	7.0	7.2	7.4	7.4
max	12.7	12.6	12.4	11.9	11.8	11.4	10.8	10.4
min	3.8	3.8	4.5	4.4	4.8	5.3	5.9	6.0

	NC11	AC	DP	BBT	IC	NCF6
JAN	11.5	11.4	11.3	10.5	10.5	9.8
FEB	11.9	11.8	11.7	11.2	11.1	10.0
MAR	11.8	11.8	11.7	10.4	11.2	10.4
APR	9.6	9.4	9.1	8.1	8.5	7.3
MAY	7.1	6.4	6.0	4.2	5.4	5.0
JUN	6.5	5.9	5.2	4.3	4.6	4.4
JUL	5.8	5.4	4.9	3.9	4.3	4.5
AUG	4.4	4.0	3.7	3.7	3.5	4.0
SEP	5.2	5.0	3.9	3.8	3.9	4.3
OCT	7.4	7.1	6.7	4.2	5.0	3.8
NOV	7.2	6.8	6.6	4.3	5.4	5.0
DEC	9.3	9.1	8.6	6.7	7.6	6.5
mean	**8.1**	**7.8**	**7.5**	**6.3**	**6.8**	**6.3**
std dev	2.6	2.8	3.0	3.0	2.9	2.5
median	7.3	7.0	6.7	4.3	5.4	5.0
max	11.9	11.8	11.7	11.2	11.2	10.4
min	4.4	4.0	3.7	3.7	3.5	3.8

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	6.1	7.5	8.2	7.6	7.5	10.9	8.1
FEB	9.5	11.7	12.4	11.0	10.7	12.2	11.2
MAR	8.9	11.0	11.9	10.8	11.5	12.0	10.5
APR	7.3	7.3	7.3	1.4	7.5	10.6	8.2
MAY	6.3	5.3	5.8	3.5	7.2	7.2	5.5
JUN	4.4	5.7	2.7	1.4	7.8	8.1	6.1
JUL	2.6	5.7	0.8	3.3	5.8	6.4	5.5
AUG	4.9	5.7	4.9	4.8	5.3	7.5	6.0
SEP	4.4	6.5	1.8	4.7	6.6	8.7	6.2
OCT	4.5	6.1	3.0	5.9	5.0	7.5	6.9
NOV	6.5	8.4	8.5	8.3	8.2	10.2	9.1
DEC	6.8	7.0	6.9	7.5	6.7	9.6	8.4
mean	**6.0**	**7.3**	**6.2**	**5.9**	**7.5**	**9.2**	**7.6**
std dev	2.0	2.1	3.8	3.3	2.0	2.0	1.9
median	6.2	6.8	6.4	5.4	7.4	9.2	7.5
max	9.5	11.7	12.4	11.0	11.5	12.2	11.2
min	2.6	5.3	0.8	1.4	5.0	6.4	5.5

	6RC	LCO	GCO	SR	BRN	HAM
JAN	9.3	8.3	7.7	7.3	9.7	9.3
FEB	10.1	10.3	8.9	8.3	10.6	10.6
MAR	10.5	10.9	11.0	10.9	10.8	11.0
APR	9.0	8.4	8.2	8.0	9.0	9.3
MAY	8.0	7.8	6.7	3.6	8.7	7.6
JUN	6.8	6.9	6.1	3.6	7.9	6.6
JUL	6.5	6.1	6.2	3.5	7.6	6.9
AUG	6.5	6.8	6.1	0.5	7.4	6.5
SEP	7.1	6.7	6.6	0.5	7.8	6.2
OCT	9.0	9.3	8.1	3.4	9.2	8.4
NOV	6.2	5.7	5.3	3.9	7.6	7.4
DEC	8.5	7.6	6.7	5.7	8.9	8.6
mean	**8.1**	**7.9**	**7.3**	**4.9**	**8.8**	**8.2**
std dev	1.5	1.6	1.6	3.2	1.2	1.6
median	8.3	7.7	6.7	3.8	8.8	8.0
max	10.5	10.9	11.0	10.9	10.8	11.0
min	6.2	5.7	5.3	0.5	7.4	6.2

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	10.1	10.8	9.4	10.9	9.6	9.5
FEB	10.7	12.3	11.5	12.7	12.0	11.0
MAR	8.6	9.1	6.0	8.7	8.6	8.6
APR	6.6	7.0	5.9	7.7	6.6	7.2
MAY	3.9	4.9	9.2	6.5	5.8	4.5
JUN	3.0	4.1	4.2	5.6	3.6	4.0
JUL	3.7	4.9	5.3	4.8	3.4	4.0
AUG	4.3	4.7	4.2	5.8		4.2
SEP	4.4	5.2	5.4	5.9		4.7
OCT	4.5	8.8	7.2	6.9		5.7
NOV	5.2	5.2	4.9	7.1		5.8
DEC	6.0	7.3	5.8	7.6		6.9
mean	**5.9**	**7.0**	**6.6**	**7.5**	**7.1**	**6.3**
std dev	2.6	2.7	2.3	2.3	3.2	2.3
median	4.9	6.1	5.9	7.0	6.6	5.8
max	10.7	12.3	11.5	12.7	12.0	11.0
min	3.0	4.1	4.2	4.8	3.4	4.0

Table 2.6 Field Turbidity (NTU) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	17	11	15	17	44	8	8	4
FEB	8	7	9	8	6	4	5	8
MAR	25	18	16	12	14	12	7	11
APR	5	9	8	10	12	6	8	10
MAY	11	10	9	6	5	3	4	4
JUN	9	6	4	4	7	2	6	4
JUL	8	7	11	8	5	8	4	5
AUG	9	9	8	5	10	6	8	9
SEP	18	18	11	6	15	7	3	5
OCT	10	11	9	8	13	8	5	11
NOV	12	11	10	7	7	5	4	4
DEC	13	11	13	7	7	3	2	2
mean	**12**	**11**	**10**	**8**	**12**	**6**	**5**	**6**
std dev	6	4	3	4	11	3	2	3
median	11	11	10	8	9	6	5	5
max	25	18	16	17	44	12	8	11
min	5	6	4	4	5	2	2	2

	NC11	AC	DP	BBT	IC	NCF6
JAN	19	21	19	11	12	9
FEB	11	11	10	7	7	4
MAR	28	29	28	10	21	10
APR	13	13	13	5	9	5
MAY	12	15	17	9	12	6
JUN	7	8	13	8	14	4
JUL	10	14	16	8	9	7
AUG	11	7	9	5	8	12
SEP	23	17	11	6	10	23
OCT	40	36	28	6	8	3
NOV	30	30	27	5	16	2
DEC	14	17	16	3	7	2
mean	**18**	**18**	**17**	**7**	**11**	**7**
std dev	10	9	7	2	4	6
median	14	16	16	7	10	6
max	40	36	28	11	21	23
min	7	7	9	3	7	2

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	18	1	0	3	6	3	13
FEB	11	2	1	2	8	3	5
MAR	7	3	2	1	10	4	3
APR	8	4	0	8	10	3	5
MAY	10	4	0	2	47	5	5
JUN	12	6	0	4	14	2	6
JUL	8	3	8	18	12	2	6
AUG	51	11	4	8	19	25	51
SEP	5	3	3	3	22	3	5
OCT	10	3	2	2	6	4	4
NOV	5	1	1	1	3	6	3
DEC	6	1	0	1	4	6	4
mean	**13**	**4**	**2**	**4**	**13**	**6**	**9**
std dev	13	3	2	5	12	6	13
median	9	3	1	3	10	4	5
max	51	11	8	18	47	25	51
min	5	1	0	1	3	2	3

	6RC	LCO	GCO	SR	BRN	HAM
JAN	5	2	0	1	4	5
FEB	2	2	0	2	9	3
MAR	3	2	0	1	7	4
APR	2	1	0	0	8	6
MAY	3	4	2	0	7	4
JUN	3	2	1	1	3	4
JUL	1	1	1	14	2	5
AUG	21	11	6	45	11	4
SEP	3	4	3	37	13	6
OCT	3	2	2	2	6	3
NOV	4	2	1	2	10	13
DEC	3	1	1	1	7	5
mean	**4**	**3**	**1**	**9**	**7**	**5**
std dev	5	3	2	16	3	3
median	3	2	1	2	7	5
max	21	11	6	45	13	13
min	1	1	0	0	2	3

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	2	2	2	1	3	9
FEB	2	1	3	1.0	3	12
MAR	0	0	0	0	0	2
APR	1	2	0	0	4	10
MAY	4	5	2	2	5	4
JUN	4	5	2	2	6	10
JUL	0	0	0	0	10	10
AUG	3	6	2	4		6
SEP	2	3	2	2		9
OCT	2	2	2	1		16
NOV	4	2	4	3		7
DEC	2	1	1	1		6
mean	**2**	**2**	**2**	**1**	**4**	**8**
std dev	1	2	1	1	3	4
median	2	2	2	1	4	9
max	4	6	4	4	10	16
min	0	0	0	0	0	2

Table 2.7 Total Suspended Solids (mg/L) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	15.9	11.2	10.2	15.7	45.9	9.8	9.6	8.8
FEB	7.7	8.4	11.9	14.0	11.0	9.8	16.3	17.2
MAR	29.4	18.6	14.0	12.3	14.4	15.1	11.4	16.2
APR	4.7	5.5	7.0	11.3	16.3	11.6	20.8	31.8
MAY	11.3	6.8	8.5	5.9	8.6	9.3	15.3	15.5
JUN	18.1	7.1	8.9	5.7	8.4	15.0	19.6	23.4
JUL	15.9	9.8	14.6	15.2	12.8	15.2	9.9	13.3
AUG	15.3	27.0	18.1	13.9	28.6	20.5	30.1	28.0
SEP	35.0	34.6	15.2	13.8	29.8	21.5	17.7	26.9
OCT	11.1	6.3	6.9	7.5	13.6	9.9	7.5	25.8
NOV	12.2	7.7	6.8	8.4	8.7	8.9	10.7	12.2
DEC	7.7	10.3	9.8	8.6	8.7	6.9	9.3	9.0
mean	**15.4**	**12.8**	**11.0**	**11.0**	**17.2**	**12.8**	**14.9**	**19.0**
std dev	8.9	9.2	3.7	3.6	11.6	4.7	6.5	7.9
median	13.8	9.1	10.0	11.8	13.2	10.8	13.4	16.7
max	35.0	34.6	18.1	15.7	45.9	21.5	30.1	31.8
min	4.7	5.5	6.8	5.7	8.4	6.9	7.5	8.8

	NC11	AC	DP	IC	NCF6
JAN	18.8	22.3	14.2	8.6	8.3
FEB	8.7	8.5	7.2	4.2	3.4
MAR	28.1	30.0	27.0	19.0	6.0
APR	15.5	17.9	16.6	12.1	6.1
MAY	10.9	19.0	18.4	14.8	7.7
JUN	5.9	8.6	14.6	21.3	5.1
JUL	7.2	9.8	13.3	5.2	12.1
AUG	7.6	5.0	11.4	6.1	20.7
SEP	14.6	7.3	11.0	7.1	28.0
OCT	35.0	34.8	23.6	5.3	2.7
NOV	32.9	62.9	33.5	19.1	5.1
DEC	12.0	14.5	15.0	6.7	1.4
mean	**16.4**	**20.1**	**17.2**	**10.8**	**8.9**
std dev	10.2	16.4	7.5	6.2	7.9
median	13.3	16.2	14.8	7.9	6.1
max	35.0	62.9	33.5	21.3	28.0
min	5.9	5.0	7.2	4.2	1.4

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN		2.9		3.8	2.9	3.5	16.1
FEB		1.4		1.4	3.7	4.3	6.9
MAR		1.4		1.4	5.9	5.4	4.3
APR		5.9		13.4	8.6	1.5	7.0
MAY		6.1		5.5	8.0	5.5	8.4
JUN		9.2		10.0	26.9	1.5	4.0
JUL		3.7		16.4	10.4	1.5	4.9
AUG		13.5		8.3	28.5	26.2	60.7
SEP		3.1		3.0	14.6	1.4	2.7
OCT		3.5		1.4	8.8	1.4	1.4
NOV		1.3		1.3	1.5	4.0	3.3
DEC		4.9		1.4	4.2	5.3	5.2
mean		**4.7**		**5.6**	**10.3**	**5.1**	**10.4**
std dev		3.6		5.3	8.9	6.9	16.3
median		3.6		3.4	8.3	3.8	5.1
max		13.5		16.4	28.5	26.2	60.7
min		1.3		1.3	1.5	1.4	1.4

	6RC	LCO	GCO	SR	BRN	HAM
JAN			1.4			
FEB			1.4			
MAR			1.4			
APR			1.4			
MAY			4.9			
JUN			3.7			
JUL			1.6			
AUG			6.9			
SEP			1.4			
OCT			1.4			
NOV			1.5			
DEC			1.4			
mean			**2.4**			
std dev			1.8			
median			1.4			
max			6.9			
min			1.4			

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	3.4	1.3			3.2	17.1
FEB	2.8	1.4			2.9	21.0
MAR	1.4	1.5			1.3	5.4
APR	3.7	4.3			5.4	11.6
MAY	3.6	5.1			5.9	11.0
JUN	5.2	4.3			3.6	11.4
JUL	1.5	1.3			27.1	11.4
AUG	1.4	4.4				14.4
SEP	1.5	1.4				16.2
OCT	1.5	1.4				29.3
NOV	1.4	1.4				8.1
DEC	3.0	1.4				6.4
mean	**2.5**	**2.4**			**7.1**	**13.6**
std dev	1.3	1.6			9.0	6.7
median	2.2	1.4			3.6	11.5
max	5.2	5.1			27.1	29.3
min	1.4	1.3			1.3	5.4

Table 2.8 Light Attenuation (k) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN								
FEB								
MAR	3.63	3.22	3.29	3.20	3.30	2.94	2.07	2.05
APR	2.46	2.66	2.60	3.04	3.00	2.33	1.64	1.66
MAY	3.17	3.26	3.30	3.19	2.79	2.07	1.53	1.30
JUN			3.36		3.38	2.45	2.14	1.75
JUL	4.13	3.23	4.61	3.60	2.79	2.12	1.31	1.41
AUG	3.16	2.79	2.48	2.09	2.42	1.76	1.64	1.60
SEP	4.95	4.21	3.47	2.90	2.83	1.57	1.25	1.16
OCT	3.86	4.49	4.04	5.74	5.35	5.01	4.01	2.07
NOV	4.69	3.82	4.17	4.74	4.15	3.60	2.42	2.42
DEC	3.26	3.23	3.04	3.15	2.86	2.29	1.92	1.63
mean	**3.70**	**3.43**	**3.44**	**3.52**	**3.29**	**2.61**	**1.99**	**1.71**
std dev	0.80	0.62	0.67	1.09	0.86	1.02	0.80	0.38
max	4.95	4.49	4.61	5.74	5.35	5.01	4.01	2.42
min	2.46	2.66	2.48	2.09	2.42	1.57	1.25	1.16

	NC11	AC	DP	BBT	IC	NCF6
JAN						
FEB	2.55	2.35	2.50	2.59	2.47	3.77
MAR	3.62	3.66	3.41	3.31	3.08	3.83
APR	2.65	2.67	2.57	3.28	2.95	3.50
MAY	2.79	3.57	3.63	4.58	3.67	3.92
JUN	2.27	2.29	2.80	4.25	4.13	3.74
JUL	2.86	2.94	3.60	4.46	2.74	3.60
AUG	2.11	1.82				
SEP						
OCT	4.46	4.50	3.98	4.17	4.00	5.51
NOV	4.32	4.50	3.91	4.31	4.22	4.82
DEC	3.10	3.19	3.28	3.62	3.68	4.38
mean	**3.07**	**3.15**	**3.30**	**3.84**	**3.44**	**4.12**
std dev	0.81	0.91	0.56	0.67	0.64	0.66
max	4.46	4.50	3.98	4.58	4.22	5.51
min	2.11	1.82	2.50	2.59	2.47	3.50

Table 2.9 Total Nitrogen (µg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	1,300	1,050	1,230	1,110	1,440	940	920	650
FEB	1,230	1,130	1,770	1,190	960	860	440	330
MAR	2,560	1,760	1,550	1,000	970	960	250	50
APR	1,130	1,200	760	990	1,220	880	260	200
MAY	1,940	1,860	2,030	1,700	1,350	640	100	50
JUN	1,360	1,240	1,340	1,210	900	880	620	560
JUL	1,300	1,320	1,200	880	630	370	300	700
AUG	1,250	880	1,190	860	1,220	1,420	630	400
SEP	1,600	1,470	1,090	1,210	1,070	590	650	500
OCT	1,430	1,650	1,590	1,430	1,600	1,580	1,340	700
NOV	1,910	1,740	1,810	1,640	1,580	1,070	1,070	800
DEC	1,400	1,660	1,420	1,220	1,080	900	1,180	740
mean	**1,534**	**1,413**	**1,415**	**1,203**	**1,168**	**924**	**647**	**473**
std dev	412	320	354	271	291	331	403	266
median	1,380	1,395	1,380	1,200	1,150	890	625	530
max	2,560	1,860	2,030	1,700	1,600	1,580	1,340	800
min	1,130	880	760	860	630	370	100	50

	NC11	AC	DP	IC	NCF6
JAN	1,370	1,240	1,330	1,360	1,420
FEB	1,560	1,430	1,550	1,250	1,330
MAR	940	970	1,020	850	900
APR	1,490	140	520	930	1,570
MAY	2,630	1,290	1,460	1,580	1,930
JUN	1,660	1,780	1,940	1,560	1,450
JUL	1,320	1,470	1,110	1,270	790
AUG	1,880	1,130	1,580	950	640
SEP	2,000	1,800	1,560	1,820	1,640
OCT	1,640	1,420	1,390	1,540	2,090
NOV	1,020	1,460	1,480	1,640	2,770
DEC	630	1,850	530	450	1,280
mean	**1,512**	**1,332**	**1,289**	**1,267**	**1,484**
std dev	528	462	426	401	592
median	1,525	1,425	1,425	1,315	1,435
max	2,630	1,850	1,940	1,820	2,770
min	630	140	520	450	640

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	2,100	1,550	1,100	3,630	5,400	940	1,790
FEB	1,890	2,450	2,230	4,620	5,050	1,540	2,310
MAR	1,640	2,710	2,960	5,140	5,560	1,460	1,790
APR	2,100	1,720	1,300	1,980	1,710	1,330	2,710
MAY	3,270	2,130	1,610	2,290	1,950	1,580	2,390
JUN	1,950	700	930	2,610	1,030	740	2,190
JUL	2,140	1,890	2,120	2,350	1,350	1,160	6,100
AUG	3,900	1,760	1,250	2,400	2,070	1,690	3,470
SEP	2,090	1,910	1,620	1,490	1,100	1,130	6,880
OCT	3,440	880	1,200	2,040	900	1,220	7,570
NOV	5,910	1,900	920	3,210	2,700	1,930	2,510
DEC	2,120	1,850	970	3,390	2,050	1,280	1,900
mean	**2,713**	**1,788**	**1,518**	**2,929**	**2,573**	**1,333**	**3,468**
std dev	1,232	565	630	1,104	1,747	330	2,113
median	2,110	1,870	1,275	2,505	2,000	1,305	2,450
max	5,910	2,710	2,960	5,140	5,560	1,930	7,570
min	1,640	700	920	1,490	900	740	1,790

	6RC	LCO	GCO	SR	BRN	HAM
JAN	1,800	1,380	1,140	650	1,470	1,160
FEB	2,260	2,520	1,690	520	1,430	1,060
MAR	2,590	1,960	2,160	510	1,580	1,400
APR	1,260	490	110	800	820	130
MAY	1,780	1,680	1,340	1,140	1,790	940
JUN	2,120	1,450	1,370	740	760	850
JUL	1,580	2,510	1,760	1,430	1,410	750
AUG	1,890	1,680	1,230	1,350	1,900	550
SEP	1,420	1,670	1,430	2,100	1,380	730
OCT	2,120	1,480	1,960	1,660	1,480	1,180
NOV	2,210	2,200	1,470	1,800	2,990	3,000
DEC	2,650	1,180	1,190	50	650	1,270
mean	**1,973**	**1,683**	**1,404**	**1,063**	**1,472**	**1,085**
std dev	433	571	515	616	620	696
median	2,005	1,675	1,400	970	1,450	1,000
max	2,650	2,520	2,160	2,100	2,990	3,000
min	1,260	490	110	50	650	130

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	1,350	1,340	820	860	530	1,020
FEB	1,160	1,220	820	650	390	1,220
MAR	3,440	120	1,100	1,000	600	800
APR	1,520	520	2,400	1,300	500	720
MAY	2,160	1,720	2,130	1,540	1,670	1,530
JUN	1,200	1,110	1,740	860	630	880
JUL	1,550	1,440	2,400	1,870	1,380	880
AUG	1,220	1,440	2,030	1,530		1,010
SEP	2,270	1,110	2,200	1,850		1,190
OCT	700	1,500	1,620	1,260		1,660
NOV	2,970	1,690	3,550	2,320		2,780
DEC	1,550	2,120	3,930	350		990
mean	**1,758**	**1,278**	**2,062**	**1,283**	**814**	**1,223**
std dev	804	536	966	570	499	566
median	1,535	1,390	2,080	1,280	600	1,015
max	3,440	2,120	3,930	2,320	1,670	2,780
min	700	120	820	350	390	720

Table 2.10 Nitrate/Nitrite (μg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	600	450	530	510	540	440	420	150
FEB	830	830	770	690	560	460	240	130
MAR	460	460	150	100	170	160	150	30
APR	230	200	260	90	320	180	60	10
MAY	540	460	430	400	350	240	100	10
JUN	660	640	540	410	400	280	120	60
JUL	400	420	400	380	230	70	10	10
AUG	350	280	290	260	220	120	30	10
SEP	500	470	490	410	370	190	50	10
OCT	430	350	390	330	300	280	240	100
NOV	810	940	810	540	480	70	170	10
DEC	600	560	520	520	480	400	280	140
mean	**534**	**505**	**465**	**387**	**368**	**241**	**156**	**56**
std dev	178	213	193	176	128	135	121	58
median	520	460	460	405	360	215	135	20
max	830	940	810	690	560	460	420	150
min	230	200	150	90	170	70	10	10

	NC11	AC	DP	IC	NCF6
JAN	670	640	630	660	620
FEB	860	830	850	750	630
MAR	340	470	520	550	500
APR	90	140	120	130	70
MAY	830	490	560	480	330
JUN	1,060	1,080	1,040	660	450
JUL	1,020	970	810	670	290
AUG	780	530	580	450	240
SEP	700	700	560	620	240
OCT	640	520	490	340	190
NOV	520	260	480	340	270
DEC	630	550	530	450	380
mean	**678**	**598**	**598**	**508**	**351**
std dev	273	270	228	179	171
median	685	540	560	515	310
max	1,060	1,080	1,040	750	630
min	90	140	120	130	70

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	600	850	500	3,130	4,500	340	790
FEB	490	1,850	1,430	4,020	4,350	840	1,410
MAR	240	1,910	2,160	4,440	4,760	860	1,090
APR	10	20	10	280	810	130	1,410
MAY	70	330	110	590	950	280	990
JUN	150	400	30	410	30	240	1,690
JUL	140	490	20	1,050	150	460	5,300
AUG	600	260	50	900	70	190	1,470
SEP	90	310	20	590	10	230	4,780
OCT	140	380	10	1,240	10	120	3,870
NOV	110	200	120	2,910	2,300	730	910
DEC	220	550	170	2,290	1,050	680	1,000
mean	**238**	**629**	**386**	**1,821**	**1,583**	**425**	**2,059**
std dev	207	618	690	1,477	1,901	279	1,614
median	145	390	80	1,145	880	310	1,410
max	600	1,910	2,160	4,440	4,760	860	5,300
min	10	20	10	280	10	120	790

	6RC	LCO	GCO	SR	BRN	HAM
JAN	1,300	880	640	150	670	660
FEB	1,760	1,820	1,290	220	730	660
MAR	1,890	1,260	1,960	310	880	1,000
APR	460	190	110	10	220	130
MAY	880	580	240	40	990	240
JUN	1,320	750	570	40	560	150
JUL	880	1,910	1,160	30	910	150
AUG	490	380	330	50	300	150
SEP	620	170	330	10	480	30
OCT	1,420	580	660	60	580	380
NOV	610	400	70	100	1,690	600
DEC	1,450	880	390	80	650	670
mean	**1,090**	**817**	**646**	**92**	**722**	**402**
std dev	497	580	561	92	383	306
median	1,090	665	480	55	660	310
max	1,890	1,910	1,960	310	1,690	1,000
min	460	170	70	10	220	30

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	450	740	20	360	230	320
FEB	660	820	20	350	190	620
MAR	40	120	10	10	10	10
APR	20	20	10	10	10	120
MAY	660	420	30	240	170	330
JUN	200	310	40	360	230	280
JUL	150	140	10	570	180	280
AUG	220	340	30	330		310
SEP	270	110	10	350		290
OCT	100	200	20	160		160
NOV	170	190	50	220		180
DEC	450	420	30	150		190
mean	**283**	**319**	**23**	**259**	**146**	**258**
std dev	222	249	13	161	96	149
median	210	255	20	285	180	280
max	660	820	50	570	230	620
min	20	20	10	10	10	10

Table 2.11 Ammonia (μg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	40	50	70	70	110	90	80	40
FEB	40	30	30	50	80	60	30	10
MAR	30	70	40	70	70	80	50	30
APR	90	90	80	120	180	100	10	10
MAY	70	70	70	70	120	10	10	10
JUN	10	250	10	10	20	10	10	10
JUL	140	120	100	70	50	40	40	40
AUG	60	50	60	30	20	30	10	10
SEP	40	50	40	10	10	10	10	10
OCT	40	30	50	50	70	70	80	50
NOV	140	100	100	150	110	110	160	120
DEC	50	40	70	70	80	60	10	20
mean	**63**	**79**	**60**	**64**	**77**	**56**	**42**	**30**
std dev	41	61	27	41	49	36	46	32
median	45	60	65	70	75	60	20	15
max	140	250	100	150	180	110	160	120
min	10	30	10	10	10	10	10	10

	NC11	AC	DP	IC	NCF6
JAN	60	110	80	30	60
FEB	120	170	130	80	60
MAR	80	110	100	80	60
APR	70	70	100	70	60
MAY	100	90	80	80	60
JUN	30	40	60	10	10
JUL	10	40	40	20	10
AUG	220	300	270	130	50
SEP	90	100	140	90	10
OCT	80	90	90	50	20
NOV	30	40	20	20	10
DEC	30	30	20	20	10
mean	**77**	**99**	**94**	**57**	**35**
std dev	56	75	67	37	25
median	75	90	85	60	35
max	220	300	270	130	60
min	10	30	20	10	10

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	70	10	10	10	10	60	10
FEB	110	10	10	10	50	10	20
MAR	50	20	10	190	10	20	30
APR	180	100	80	760	580	150	130
MAY	40	10	10	580	80	60	20
JUN	180	90	60	1,220	60	60	90
JUL	170	30	640	90	10	120	170
AUG	720	50	20	170	80	50	110
SEP	40	50	20	90	10	10	40
OCT	10	40	30	60	10	130	130
NOV	70	20	10	30	50	160	40
DEC	110	40	30	40	70	90	40
mean	**146**	**39**	**78**	**271**	**85**	**77**	**69**
std dev	190	30	179	383	159	53	54
median	90	35	20	90	50	60	40
max	720	100	640	1,220	580	160	170
min	10	10	10	10	10	10	10

	6RC	LCO	GCO	SR	BRN	HAM
JAN	90	30	10	10	40	40
FEB	70	110	20	10	80	40
MAR	60	10	10	10	130	40
APR	20	10	10	10	10	20
MAY	80	50	30	10	30	50
JUN	50	110	30	60	60	440
JUL	50	90	50	80	20	30
AUG	60	50	40	160	40	40
SEP	40	40	40	180	50	30
OCT	30	10	10	30	10	20
NOV	30	10	10	10	60	100
DEC	90	30	40	40	40	110
mean	**56**	**46**	**25**	**51**	**48**	**80**
std dev	24	38	15	60	33	117
median	55	35	25	20	40	40
max	90	110	50	180	130	440
min	20	10	10	10	10	20

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	10	10	10	10	20	40
FEB	60	30	40	20	100	70
MAR	50	20	10	10	50	90
APR	70	50	40	40	150	110
MAY	170	20	30	10	10	20
JUN	30	50	270	20	60	250
JUL	70	100	510	120	60	250
AUG	40	40	20	30		20
SEP	10	50	100	50		10
OCT	40	10	40	30		90
NOV	10	10	10	10		50
DEC	60	30	30	30		60
mean	**52**	**35**	**93**	**32**	**64**	**88**
std dev	43	26	150	31	48	82
median	45	30	35	25	60	65
max	170	100	510	120	150	250
min	10	10	10	10	10	10

Table 2.12 Total Kjeldahl Nitrogen (μg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	700	600	700	600	900	500	500	500
FEB	400	300	1,000	500	400	400	200	200
MAR	2,100	1,300	1,400	900	800	800	100	50
APR	900	1,000	500	900	900	700	200	200
MAY	1,400	1,400	1,600	1,300	1,000	400	50	50
JUN	700	600	800	800	500	600	500	500
JUL	900	900	800	500	400	300	300	700
AUG	900	600	900	600	1,000	1,300	600	400
SEP	1,100	1,000	600	800	700	400	600	500
OCT	1,000	1,300	1,200	1,100	1,300	1,300	1,100	600
NOV	1,100	800	1,000	1,100	1,100	1,000	900	800
DEC	800	1,100	900	700	600	500	900	600
mean	**1,000**	**908**	**950**	**817**	**800**	**683**	**496**	**425**
std dev	426	340	321	255	286	349	341	248
median	900	950	900	800	850	550	500	500
max	2,100	1,400	1,600	1,300	1,300	1,300	1,100	800
min	400	300	500	500	400	300	50	50

	NC11	AC	DP	IC	NCF6
JAN	700	600	700	700	800
FEB	700	600	700	500	700
MAR	600	500	500	300	400
APR	1,400	50	400	800	1,500
MAY	1,800	800	900	1,100	1,600
JUN	600	700	900	900	1,000
JUL	300	500	300	600	500
AUG	1,100	600	1,000	500	400
SEP	1,300	1,100	1,000	1,200	1,400
OCT	1,000	900	900	1,200	1,900
NOV	500	1,200	1,000	1,300	2,500
DEC	50	1,300	50	50	900
mean	**838**	**738**	**696**	**763**	**1,133**
std dev	498	348	317	393	656
median	700	650	800	750	950
max	1,800	1,300	1,000	1,300	2,500
min	50	50	50	50	400

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	1,500	700	600	500	900	600	1,000
FEB	1,400	600	800	600	700	700	900
MAR	1,400	800	800	700	800	600	700
APR	2,100	1,700	1,300	1,700	900	1,200	1,300
MAY	3,200	1,800	1,500	1,700	1,000	1,300	1,400
JUN	1,800	300	900	2,200	1,000	500	500
JUL	2,000	1,400	2,100	1,300	1,200	700	800
AUG	3,300	1,500	1,200	1,500	2,000	1,500	2,000
SEP	2,000	1,600	1,600	900	1,100	900	2,100
OCT	3,300	500	1,200	800	900	1,100	3,700
NOV	5,800	1,700	800	300	400	1,200	1,600
DEC	1,900	1,300	800	1,100	1,000	600	900
mean	**2,475**	**1,158**	**1,133**	**1,108**	**992**	**908**	**1,408**
std dev	1,264	540	438	578	378	337	880
median	2,000	1,350	1,050	1,000	950	800	1,150
max	5,800	1,800	2,100	2,200	2,000	1,500	3,700
min	1,400	300	600	300	400	500	500

	6RC	LCO	GCO	SR	BRN	HAM
JAN	500	500	500	500	800	500
FEB	500	700	400	300	700	400
MAR	700	700	200	200	700	400
APR	800	300	50	800	600	50
MAY	900	1,100	1,100	1,100	800	700
JUN	800	700	800	700	200	700
JUL	700	600	600	1,400	500	600
AUG	1,400	1,300	900	1,300	1,600	400
SEP	800	1,500	1,100	2,100	900	700
OCT	700	900	1,300	1,600	900	800
NOV	1,600	1,800	1,400	1,700	1,300	2,400
DEC	1,200	300	800	50	50	600
mean	**883**	**867**	**763**	**979**	**754**	**688**
std dev	343	472	426	656	422	576
median	800	700	800	950	750	600
max	1,600	1,800	1,400	2,100	1,600	2,400
min	500	300	50	50	50	50

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	900	600	800	500	300	700
FEB	500	400	800	300	200	600
MAR	3,400	50	1,100	1,000	600	800
APR	1,500	500	2,400	1,300	500	600
MAY	1,500	1,300	2,100	1,300	1,500	1,200
JUN	1,000	800	1,700	500	400	600
JUL	1,400	1,300	2,400	1,300	1,200	600
AUG	1,000	1,100	2,000	1,200		700
SEP	2,000	1,000	2,200	1,500		900
OCT	600	1,300	1,600	1,100		1,500
NOV	2,800	1,500	3,500	2,100		2,600
DEC	1,100	1,700	3,900	200		800
mean	**1,475**	**963**	**2,042**	**1,025**	**671**	**967**
std dev	873	497	961	556	489	584
median	1,250	1,050	2,050	1,150	500	750
max	3,400	1,700	3,900	2,100	1,500	2,600
min	500	50	800	200	200	600

Table 2.13 Total Phosphorus (µg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	120	90	80	90	190	60	60	40
FEB	70	80	80	80	80	60	40	50
MAR	140	90	100	70	80	80	60	40
APR	100	110	90	100	100	70	60	90
MAY	130	100	100	110	70	50	40	40
JUN	150	150	120	130	60	80	70	70
JUL	170	120	140	150	120	110	50	60
AUG	110	110	100	50	90	60	40	40
SEP	160	140	120	100	110	60	40	40
OCT	120	120	120	150	150	120	100	70
NOV	160	170	180	130	100	90	70	70
DEC	70	60	70	60	50	40	30	20
mean	**125**	**112**	**108**	**102**	**100**	**73**	**55**	**53**
std dev	32	30	29	32	38	23	18	19
median	125	110	100	100	95	65	55	45
max	170	170	180	150	190	120	100	90
min	70	60	70	50	50	40	30	20

	NC11	AC	DP	IC	NCF6
JAN	140	130	140	110	110
FEB	100	90	90	60	50
MAR	100	110	130	80	100
APR	90	100	90	90	80
MAY	130	130	110	110	140
JUN	200	200	230	190	140
JUL	250	240	240	160	130
AUG	210	130	170	140	110
SEP	220	170	150	140	170
OCT	170	160	160	120	170
NOV	180	180	190	140	180
DEC	70	70	70	50	70
mean	**155**	**143**	**148**	**116**	**116**
std dev	56	47	52	39	40
median	155	130	145	115	120
max	250	240	240	190	190
min	70	70	70	50	50

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	560	70	50	120	120	50	250
FEB	130	30	10	50	140	30	90
MAR	190	50	40	70	170	50	80
APR	190	160	110	920	300	80	300
MAY	310	210	150	450	230	110	280
JUN	230	190	120	580	290	110	340
JUL	70	40	150	80	260	10	50
AUG	960	230	140	270	500	180	610
SEP	190	180	160	110	340	110	550
OCT	330	120	120	110	330	110	560
NOV	310	80	120	140	190	160	210
DEC	180	80	50	90	150	90	190
mean	**304**	**120**	**102**	**249**	**252**	**91**	**293**
std dev	231	68	48	257	104	48	184
median	210	100	120	115	245	100	265
max	960	230	160	920	500	180	610
min	70	30	10	50	120	10	50

	6RC	LCO	GCO	SR	BRN	HAM
JAN	70	30	130	40	80	90
FEB	60	30	110	30	100	70
MAR	60	40	60	40	120	50
APR	60	40	80	50	90	90
MAY	90	60	230	40	100	130
JUN	110	60	320	80	90	180
JUL	10	10	370	10	10	10
AUG	180	90	560	200	160	210
SEP	140	80	790	80	100	180
OCT	80	60	270	70	60	100
NOV	130	50	230	80	100	180
DEC	60	10	130	30	70	70
mean	**88**	**47**	**273**	**63**	**90**	**113**
std dev	44	24	207	47	34	60
median	75	45	230	45	95	95
max	180	90	790	200	160	210
min	10	10	60	10	10	10

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	60	50	40	20	10	90
FEB	60	40	30	20	20	80
MAR	60	40	40	30	20	50
APR	80	60	40	30	30	110
MAY	260	120	70	50	40	140
JUN	160	140	130	60	50	110
JUL	130	130	120	70	120	110
AUG	110	50	10	20		50
SEP	140	120	90	50		100
OCT	80	60	40	20		140
NOV	150	100	170	60		160
DEC	80	30	30	10		60
mean	**114**	**78**	**68**	**37**	**41**	**100**
std dev	56	39	47	19	34	34
median	95	60	40	30	30	105
max	260	140	170	70	120	160
min	60	30	10	10	10	50

Table 2.14 Orthophosphate (μg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	20	30	20	30	30	30	40	20
FEB	30	20	20	20	20	20	10	10
MAR	20	20	20	20	20	20	20	10
APR	30	30	40	40	40	30	10	10
MAY	30	30	30	30	30	20	10	10
JUN	40	40	40	40	40	30	20	10
JUL	50	40	40	30	20	10	10	10
AUG	50	20	50	50	50	40	20	20
SEP	50	50	50	40	40	30	10	10
OCT	20	20	30	40	40	30	30	20
NOV	60	70	60	50	50	40	30	30
DEC	20	20	20	20	20	20	20	10
mean	**35**	**33**	**35**	**34**	**33**	**27**	**19**	**14**
std dev	14	15	14	11	12	9	10	7
median	30	30	35	35	35	30	20	10
max	60	70	60	50	50	40	40	30
min	20	20	20	20	20	10	10	10

	NC11	AC	DP	BBT	IC	NCF6
JAN	30	30	30	30	20	30
FEB	40	40	40	30	30	20
MAR	20	20	20	10	20	30
APR	20	30	30	20	20	20
MAY	50	30	30	20	20	50
JUN	80	80	80	30	50	50
JUL	50	100	70	50	60	50
AUG	90	80	70	50	60	40
SEP	80	70	60	50	60	50
OCT	20	20	20	20	20	60
NOV	40	40	40	40	30	60
DEC	20	20	20	10	10	30
mean	**45**	**47**	**43**	**30**	**33**	**41**
std dev	26	28	22	15	19	14
median	40	35	35	30	25	45
max	90	100	80	50	60	60
min	20	20	20	10	10	20

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	340	20	10	40	30	10	90
FEB	110	10	10	20	30	0	40
MAR	220	20	10	20	30	10	40
APR	70	40	30	160	40	10	50
MAY	180	70	50	150	30	30	110
JUN	60	60	30	170	10	20	110
JUL	70	40	80	80	70	40	50
AUG	810	60	40	80	140	30	360
SEP	80	50	40	20	10	30	290
OCT	220	30	30	30	30	20	320
NOV	190	30	30	30	40	20	80
DEC	90	20	20	30	40	10	70
mean	**203**	**38**	**32**	**69**	**42**	**19**	**134**
std dev	209	19	20	59	35	12	118
median	145	35	30	35	30	20	85
max	810	70	80	170	140	40	360
min	60	10	10	20	10	0	40

	6RC	LCO	GCO	SR	BRN	HAM
JAN	10	10	90	0	20	20
FEB	10	10	70	0	10	20
MAR	10	10	30	10	10	10
APR	20	10	0	20	10	20
MAY	20	10	110	10	20	30
JUN	30	20	190	0	20	50
JUL	10	10	370	10	10	10
AUG	50	30	350	10	40	90
SEP	50	30	500	0	20	70
OCT	20	20	170	10	20	30
NOV	20	20	120	10	20	50
DEC	20	10	60	0	10	20
mean	**23**	**16**	**172**	**7**	**18**	**35**
std dev	14	8	155	7	9	25
median	20	10	115	10	20	25
max	50	30	500	20	40	90
min	10	10	0	0	10	10

	NCF117	B210	COL	SR-WC	LVC2	SC-CH
JAN	20	10	10	0	0	20
FEB	20	10	10	0	0	20
MAR	20	10	10	0	0	10
APR	30	10	10	10	0	30
MAY	140	50	30	20	10	50
JUN	50	40	70	20	10	40
JUL	60	50	80	30	30	20
AUG	60	50	10	20		50
SEP	70	40	50	10		30
OCT	30	30	20	10		30
NOV	50	30	90	10		40
DEC	20	10	10	0		20
mean	**48**	**28**	**33**	**11**	**7**	**30**
std dev	34	17	31	10	11	13
median	40	30	15	10	0	30
max	140	50	90	30	30	50
min	20	10	10	0	0	10

Table 2.15 Chlorophyll *a* (µg/l) 2015 at the Lower Cape Fear River Program stations.

	NAV	HB	BRR	M61	M54	M35	M23	M18
JAN	2	2	2	2	4	2	2	2
FEB	6	6	6	3	3	3	4	6
MAR	16	10	12	6	6	4	6	6
APR	1	1	2	2	4	7	6	8
MAY	1	2	2	1	3	6	5	10
JUN	2	2	8	4	9	6	5	7
JUL	3	12	20	30	38	20	8	8
AUG	3	6	7	10	12	6	5	6
SEP	5	8	5	18	13	6	6	7
OCT	2	2	2	1	1	1	1	3
NOV	1	1	1	1	1	1	1	2
DEC	2	2	2	1	4	1	3	4
mean	**4**	**5**	**6**	**7**	**8**	**5**	**4**	**6**
std dev	4	4	6	9	10	5	2	3
median	2	2	4	3	4	5	5	6
max	16	12	20	30	38	20	8	10
min	1	1	1	1	1	1	1	2

	NC11	AC	DP	BBT	IC	NCF6
JAN	4	4	3	3	2	1
FEB	6	6	6	4	4	1
MAR	6	5	5	2	4	2
APR	5	5	4	1	2	1
MAY	1	1	1	1	1	1
JUN	5	4	3	1	2	1
JUL	3	2	2	2	3	3
AUG	5	4	3	1	2	2
SEP	5	4	3	2	2	4
OCT	3	3	2	1	1	0
NOV	2	2	2	1	1	0
DEC	1	1	1	0	1	0
mean	**4**	**3**	**3**	**2**	**2**	**1**
std dev	2	2	2	1	1	1
median	5	4	3	1	2	1
max	6	6	6	4	4	4
min	1	1	1	0	1	0

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	2	10	16	3	3	8	2
FEB	3	3	2	2	2	35	7
MAR	2	4	9	3	9	9	3
APR	4	2	4	9	4	3	1
MAY	11	2	3	12	17	2	1
JUN	5	1	8	29	155	1	0
JUL	9	4	25	8	33	2	2
AUG	9	5	16	10	26	22	5
SEP	15	1	5	9	42	1	0
OCT	1	1	5	12	23	2	0
NOV	0	0	0	1	2	1	0
DEC	1	1	2	4	7	12	1
mean	**5**	**3**	**8**	**9**	**27**	**8**	**2**
std dev	5	3	7	8	42	11	2
median	4	2	5	9	13	3	1
max	15	10	25	29	155	35	7
min	0	0	0	1	2	1	0

	6RC	LCO	GCO	SR	BRN	HAM
JAN	2	1	2	2	1	1
FEB	2	2	3	4	3	5
MAR	3	2	3	4	2	2
APR	2	3	1	3	1	1
MAY	1	1	1	5	1	0
JUN	0	0	1	8	1	0
JUL	1	0	1	61	1	3
AUG	4	1	2	145	5	1
SEP	0	0	1	95	1	20
OCT	0	0	0	1	2	1
NOV	1	1	2	5	2	4
DEC	1		1	3	1	
mean	**1**	**1**	**2**	**28**	**2**	**3**
std dev	1	1	1	47	1	6
median	1	1	1	5	1	1
max	4	3	3	145	5	20
min	0	0	0	1	1	0

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

Table 2.16 Biochemical Oxygen Demand (mg/l) 2015 at the Lower Cape Fear River Program stations.

5-Day Biochemical Oxygen Demand

	NC11	AC	BBT	NCF117	B210	LVC2
JAN	1.5	2.1	1.9	1.7	1.4	1.3
FEB	1.9	1.4	1.0	1.6	1.6	1.5
MAR	1.5	1.3	1.6	1.3	1.1	1.0
APR	1.5	1.8	1.5	0.8	1.0	1.0
MAY				2.1	1.8	1.2
JUN	1.3	1.0	1.2			
JUL	1.4	1.8	1.4			
AUG	1.3	2.1	1.1	0.9	1.2	
SEP						
OCT						
NOV						
DEC						
mean	1.5	1.6	1.4	1.4	1.4	1.2
stdev	0.2	0.4	0.3	0.5	0.3	0.2
median	1.5	1.8	1.4	1.5	1.3	1.2
max	1.9	2.1	1.9	2.1	1.8	1.5
min	1.3	1.0	1.0	0.8	1.0	1.0

20-Day Biochemical Oxygen Demand

	NC11	AC	BBT	NCF117	B210	LVC2
JAN	4.2	5.5	4.9	4.3	3.3	3.2
FEB	3.9	3.3	2.4	3.8	2.9	3.0
MAR	4.3	3.7	3.4	3.1	2.5	2.4
APR	3.2	3.9	3.7	3.0	2.8	3.0
MAY				5.7	4.5	3.4
JUN	3.5	3.0	3.4			
JUL	4.0	4.9	3.8			
AUG	3.0	4.6	2.5	2.8	3.0	
SEP						
OCT						
NOV						
DEC						
mean	3.7	4.1	3.4	3.8	3.2	3.0
stdev	0.5	0.9	0.8	1.1	0.7	0.4
median	3.9	3.9	3.4	3.5	3.0	3.0
max	4.3	5.5	4.9	5.7	4.5	3.4
min	3.0	3.0	2.4	2.8	2.5	2.4

Table 2.17 Fecal Coliform (cfu/100 mL) and Enterococcus (MPN) 2015 at the Lower Cape Fear River Program stations.

	NC11	AC	DP	IC	NCF6	NAV	HB
JAN	455	728	1,550	2,000	800	2,100	91
FEB	388	5	5	10	73	230	340
MAR	1,640	1,640	1,270	13,000	500	5	82
APR	109	145	190	637	290	64	82
MAY	28	172	181	127	82	37	19
JUN	73	163	73	91	91	19	109
JUL	260	190	270	64	1,820	37	82
AUG	37	310	819	530	819	637	910
SEP	10	64	37	19	82	4,800	1,640
OCT	100	82	73	19	10	28	73
NOV	1,820	1,090	2,000	1,910	1,730	819	546
DEC	728	546	455	637	637	64	364
mean	**471**	**428**	**577**	**1,587**	**578**	**737**	**362**
std dev	601	477	649	3,507	604	1,356	460
max	1,820	1,640	2,000	13,000	1,820	4,800	1,640
min	10	5	5	10	10	5	19
Geomean	175	201	221	235	258	127	174

ENTEROCOCCUS

	BRR	M61	M54	M35	M23	M18
JAN	30	41	30	5	20	20
FEB	98	146	10	20	20	10
MAR	41	10	31	10	10	10
APR	10	20	31	10	10	10
MAY	10	5	10	5	10	5
JUN	41	86	10	20	5	5
JUL	31	30	5	5	10	5
AUG	341	108	84	135	464	1,785
SEP	958	537	591	84	520	11,199
OCT	120	85	52	183	98	512
NOV	216	909	1,396	1,664	313	31
DEC	41	52	135	74	228	20
mean	**161**	**169**	**199**	**185**	**142**	**1,134**
std dev	258	262	393	450	183	3,074
max	958	909	1,396	1,664	520	11,199
min	10	5	5	5	5	5
Geomean	65	63	45	32	42	40

	ANC	SAR	GS	NC403	PB	LRC	ROC
JAN	3,100	370	91	154	9,000	145	1,100
FEB	109	145	5	19	28	91	250
MAR	10	1,360	1,730	37	1,730	637	172
APR	145	200	91	100	17,000	290	260
MAY	5,800	5,300	9,000	2,000	5,900	2,500	14,000
JUN	37	127	172	73	23,000	230	230
JUL	47,000	51,000	8,000	60,000	60,000	60,000	60,000
AUG	60,000	60,000	11,000	1,000	580	60,000	2,100
SEP	220	340	181	154	154	109	290
OCT	60,000	2,600	2,000	4,100	21,000	330	1,460
NOV	13,000	16,000	19,000	2,900	3,100	7,000	11,000
DEC	91	270	91	91	145	290	220
mean	**15,793**	**11,476**	**4,280**	**5,886**	**11,803**	**10,969**	**7,590**
std dev	23,503	20,236	5,875	16,367	16,623	22,008	16,416
max	3,100	60,000	19,000	60,000	60,000	60,000	60,000
min	10	127	5	19	28	91	172
Geomean	1,136	1,485	654	398	2,467	920	1,146

	6RC	LCO	GCO	SR	BRN	HAM
JAN	136	73	100	440	210	280
FEB	55	19	5	28	590	637
MAR	650	330	1,280	163	1,270	1,730
APR	1,460	540	1,640	154	3,500	11,000
MAY	28	28	91	46	220	127
JUN	100	28	19	118	1,090	580
JUL	819	163	154	37	819	570
AUG	60,000	2,700	728	41,000	12,000	9,000
SEP	172	190	127	28	1,090	546
OCT	64	19	109	46	226	290
NOV	400	420	637	580	240	28
DEC	145	73	37	145	360	163
mean	**5,336**	**382**	**411**	**3,565**	**1,801**	**2,079**
std dev	16,487	718	525	11,288	3,197	3,590
max	60,000	2,700	1,640	41,000	12,000	11,000
min	28	19	5	28	210	28
Geomean	304	121	142	160	741	559

	NCF117	B210	COL	SRWC	LVC2	SC-CH
JAN	91	210	64	163	270	55
FEB	10	55	37	118	55	5
MAR	637	1,000	1,180	1,000	1,000	570
APR	5	46	290	37	19	37
MAY	64	64	109	55	172	91
JUN	37	82	46	55	55	28
JUL	37	73	217	145	55	91
AUG	9,000	1,360	9,000	1,180		728
SEP	10	91	145	100		43
OCT	470	37	5	28		1,360
NOV	546	46	109	1,460		6,000
DEC	10	64	64	46		172
mean	**910**	**261**	**939**	**366**	**232**	**765**
std dev	2,450	420	2,450	500	324	1,626
max	9,000	1,360	9,000	1,460	1,000	6,000
min	5	37	5	28	19	5
Geomean	79	109	136	142	106	140

Figure 2.1 Salinity at the Lower Cape Fear River Program estuarine stations 1995-2014 versus 2015.

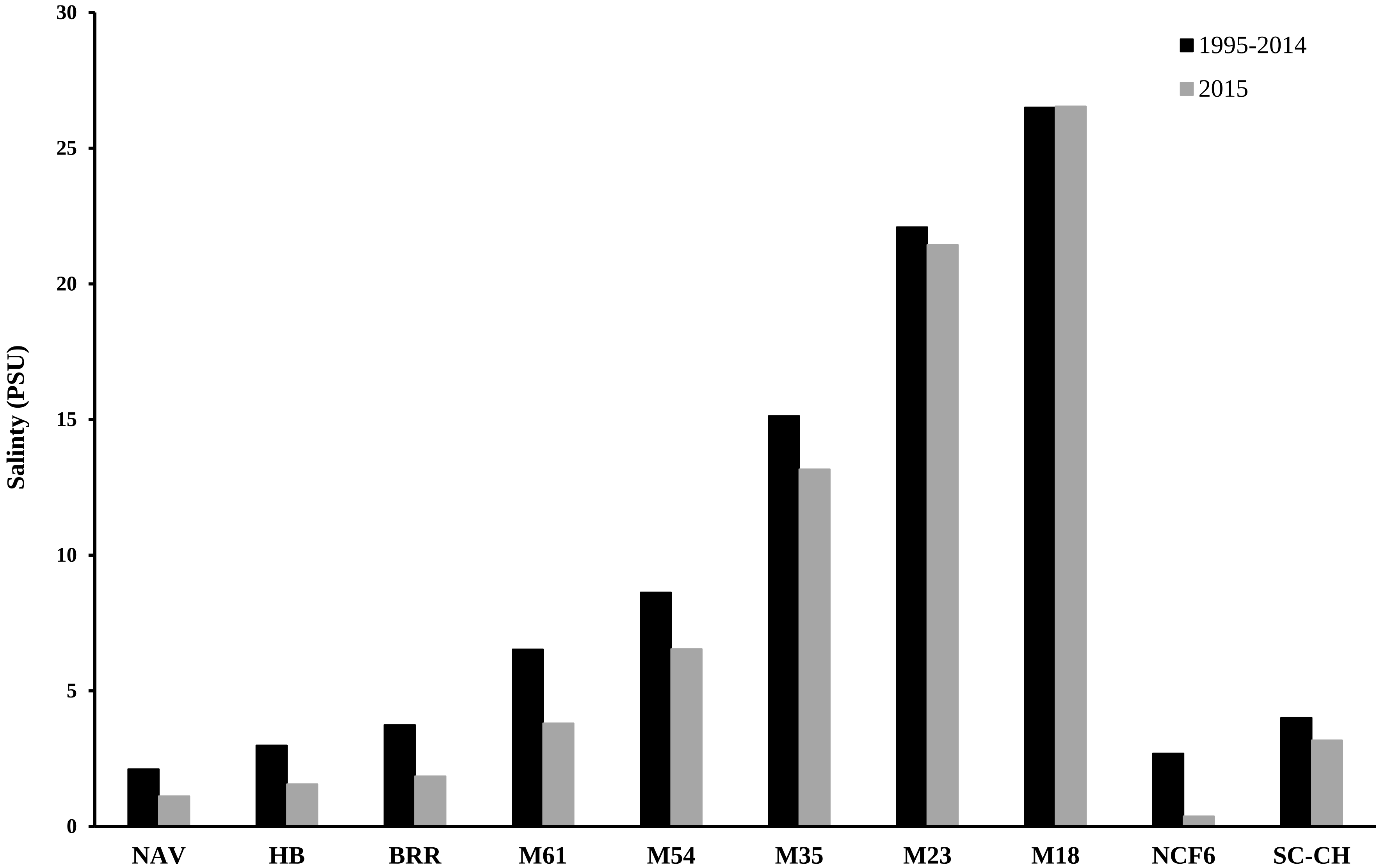

Figure 2.2 Dissolved Oxygen at the Lower Cape Fear River Program stations 1995-2014 versus 2015.

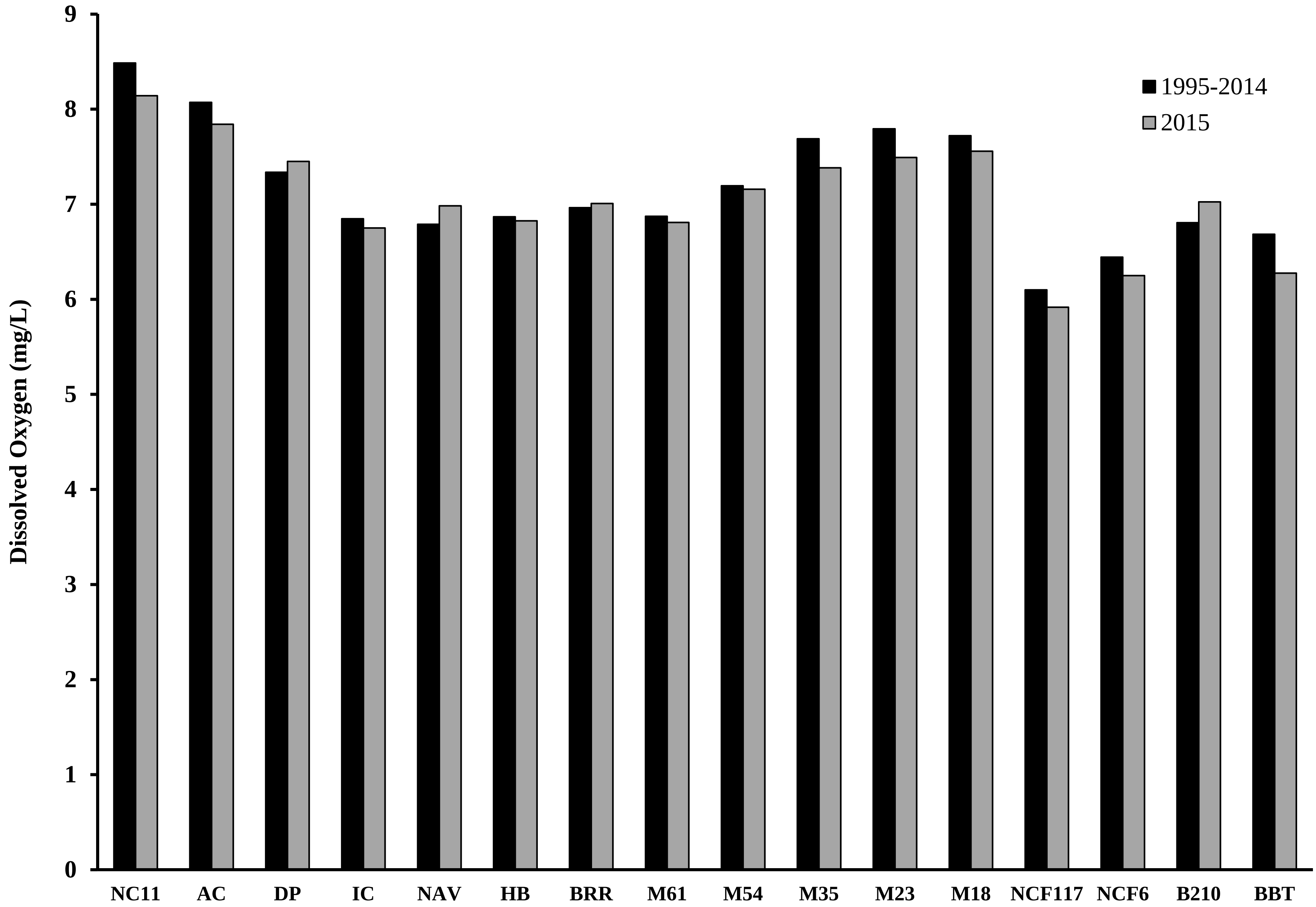

Figure 2.3 Field Turbidity at the Lower Cape Fear River Program stations, 1995-2014 versus 2015.

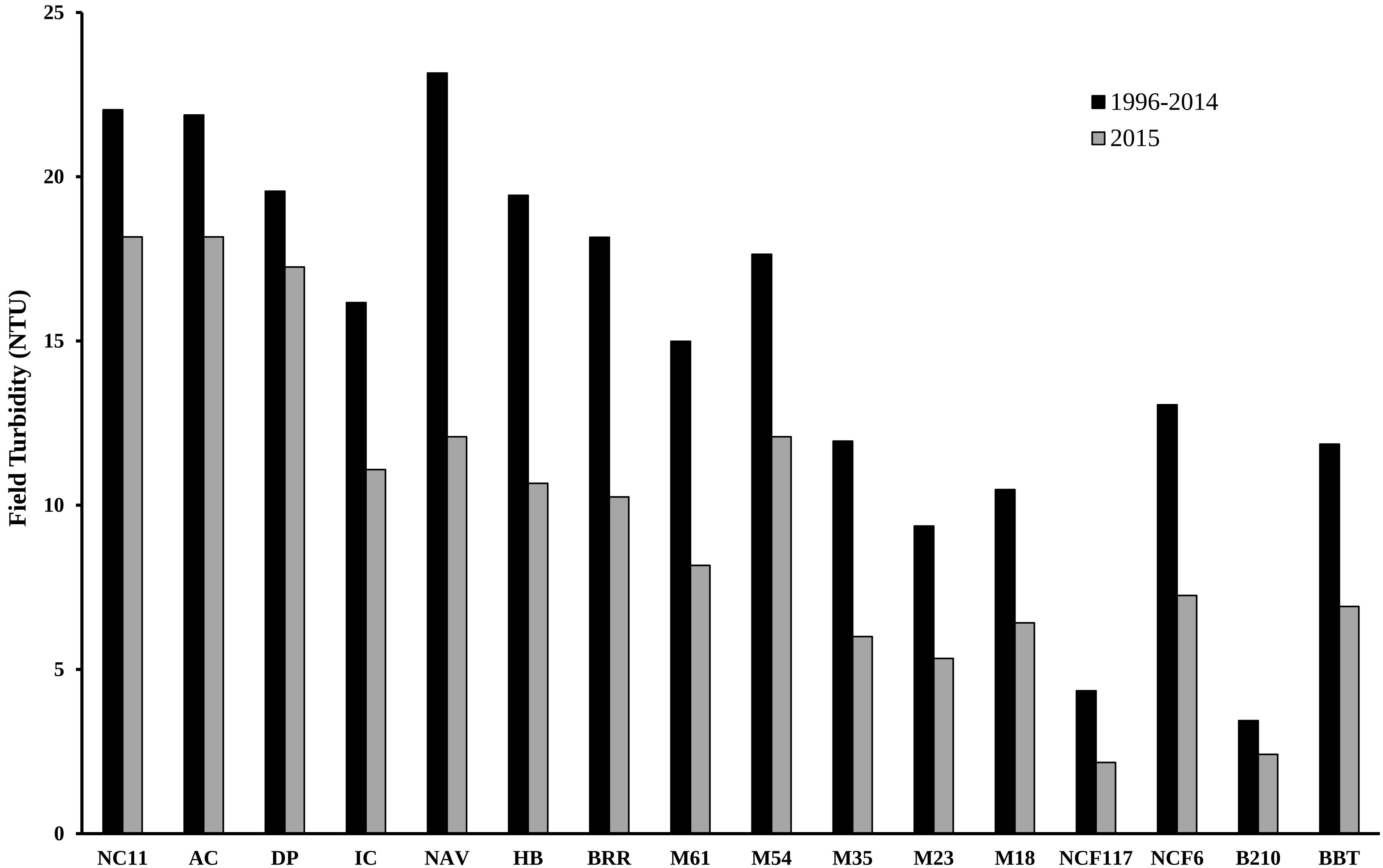

Figure 2.4 Nitrate + Nitrite at the Lower Cape Fear River Program Stations, 1995-2014 versus 2015.

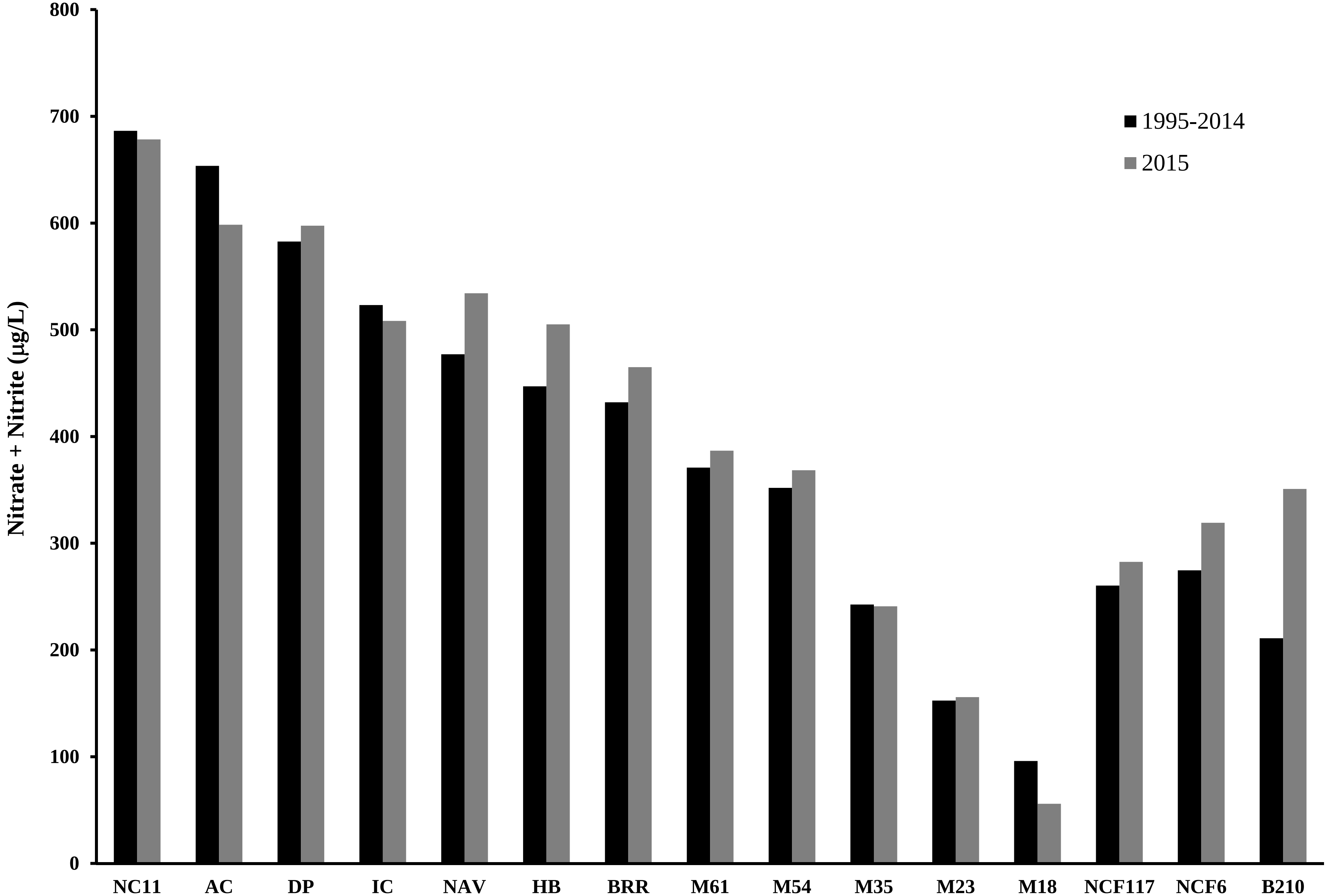

Figure 2.5 Total Phosphorus at the Lower Cape Fear River Program mainstem stations, 1995-2014 versus 2015.

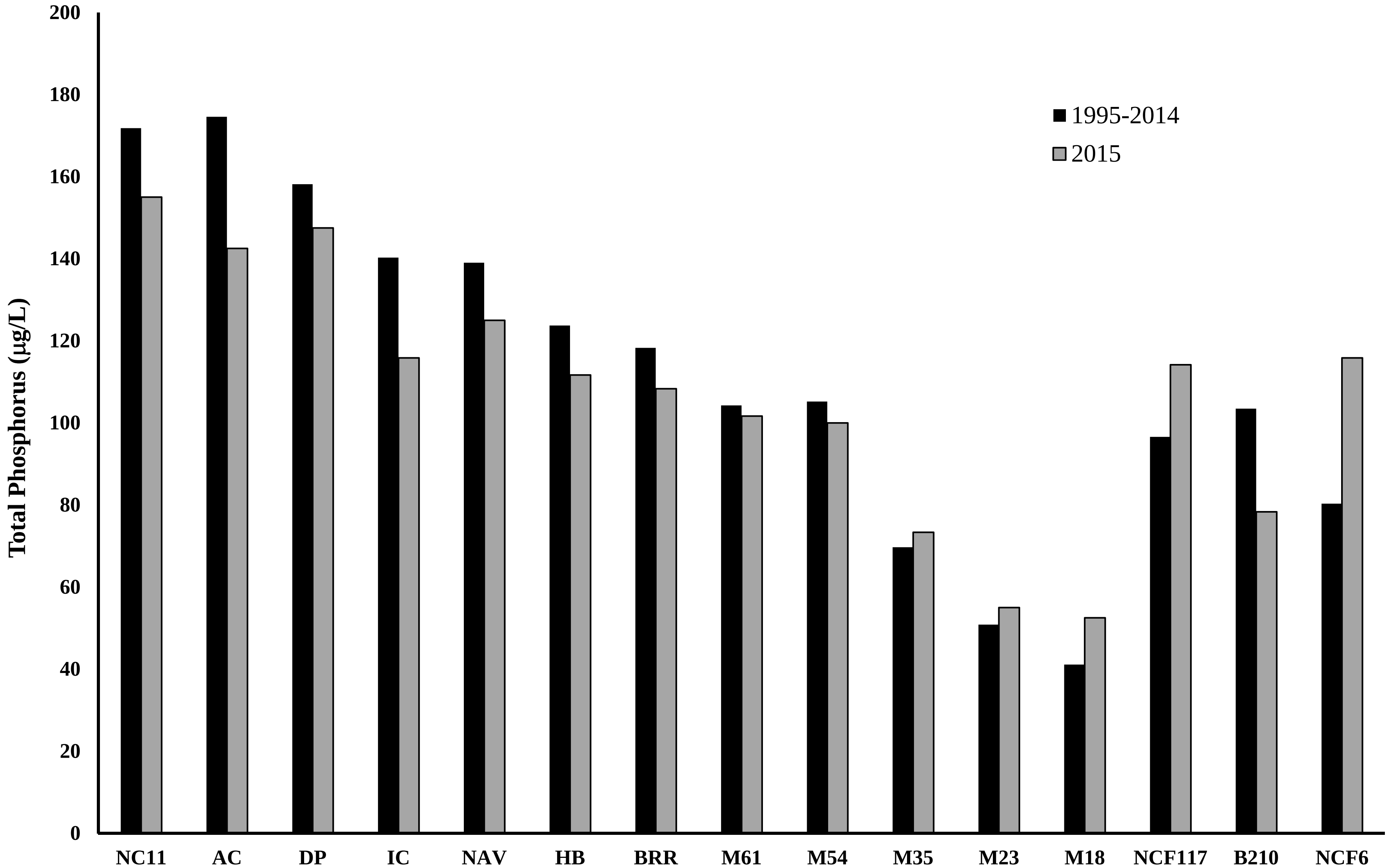

Figure 2.6 Chlorophyll *a* at the Lower Cape Fear River Program mainstem stations, 1995-2014 versus 2015.

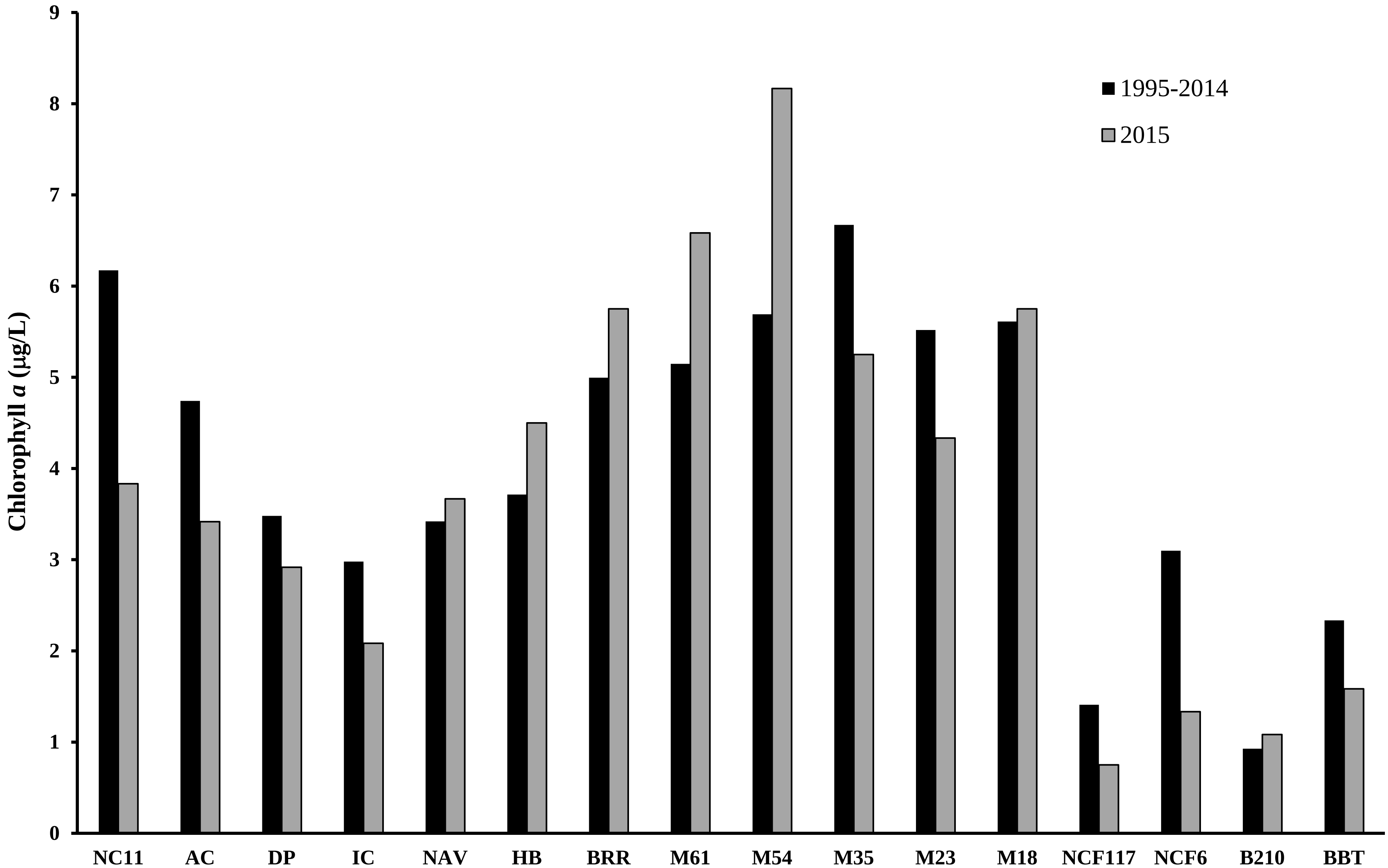

Figure 2.7 Geometric Mean Fecal Coliform (NC11-B210) and Enterococcus (BRR-M18) at the Lower Cape Fear River Program mainstem stations, 1995-2014 (Entero 2012-2014) vs. 2015.