WATER QUALITY MONITORING IN THE PAMLICO/ALBEMARLE PENINSULA

NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES & COMMUNITY DEVELOPMENT

DIVISION OF ENVIRONMENTAL MANAGEMENT

WATER QUALITY SECTION

March 1984

CEIP REPORT # 39

The preparation of this report (map, document, etc.) was financed through a Coastal Energy Impact Program grant provided by the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration. This CEIP grant was part of NOAA grant number NA-83-AA-D-CZ 028.

Table of Contents

TABLES

FIGURES

Summary

Between January 1983 and February 1984, eleven sites in the Pamlico-Albemarle peninsula area were sampled for a wide range of water quality parameters. Primary emphasis of the study was placed upon whether or not mercury exists in the ambient water, sediment, and fish tissue present in the area of interest. A secondary purpose was to assess ambient water quality by examination of macroinvertebrate and phytoplankton communities.

Eighty-seven water samples for total mercury analysis were collected during the study. Nine samples (10%) were determined to contain levels of total mercury above the Division of Environmental Management (DEM) laboratory's detection limit of 0.2 ug/l. Of these nine samples, the values were 0.3 ug/l (seven samples), 0.4 ug/l (one sample), and 1.6 ug/l (one sample). However, these values for total mercury may represent either sample contamination or difficulty in analytical accuracy rather than actual environmental conditions.

Fish were collected from seven sites in the study area. Mercury was found in 73 out of a total of 102 fish (72%) that were analyzed for mercury. Of the fish containing mercury, one contained a mercury concentration greater than the Food and Drug Administration's action standard of 1.0 mg/kg. This fish was a bowfin (from Kendrick Creek) containing a mercury level of 1.3 mg/kg.

Mercury was found at nine sites selected for sediment analysis. Thirteen out of fifteen samples (86%) contained levels of mercury ranging up to 0.1 mg/kg. There are no prescribed limits on mercury in sediment, thus these findings do not indicate violations of water quality standards and simply signify the presence of mercury in the substrate environment.

Although the sources of mercury compounds present in the Pamlico - Albemarle peninsula have not been determined, the measurement of this ubiquitous metallic element has been detailed to an extent that provides a greater understanding of its presence in the Pamlico - Albemarle environment.

At all sites, with one exception, conductivity, salinity, and dissolved residue values were found to be positively associated. These values were indicative of salt water intrusion from the nearby estuarine areas.

The six stations sampled for phytoplankton indicated much variation in phytoplankton standing crop, utilization of available nutrients, and potential for algal blooms. Pantego Creek, Pungo Creek, and Bath Creek showed the most potential for problems associated with eutrophication. In these creeks, inorganic nutrients were reduced to low levels and dominance by certain groups of algae (blue-greens in the summer, dinoflagellates in the fall) were observed. The Pungo River did not exhibit the same tendencies toward dominace by blue-greens shown by the three other creeks and available nutrients were not depleted early in the growing season. This may have been due to either a difference in water quality or simply the location of the station sampled. The stations on the north side of the peninsula had more nutrients than were utilized throughout the growing season. Factors other than nitrogen and phosphorous appeared to be limiting phytoplankton growth in the Alligator River and Scuppernong River. There was extensive aquatic macrophyte growth at both of these locations.

Benthic macroinvertebrates were collected at seven sites in the Pamlico-Albemarle peninsula during June 1983. Data is also available from six of these sites sampled in August 1982. Three sites drain into the Albemarle Sound and four sites drain into the more saline Pamlico Sound.

Taxa richness values were low at all sites. Low macroinvertebrate diversity in this area is due, in part, to low current velocities, low dissolved oxygen values, and variable salinity. Intrusions of brackish water constitute a severe stress for most freshwater organisms, leading to a sharp decline in species richness. For this reason it is difficult to directly compare the Albemarle and Pamlico sites.

Within the Albemarle area, Kendrick Creek clearly had the best water quality. This conclusion is based on taxa richness and the abundance of certain indicator organisms. The poorest water quality was noted at the Scuppernong River area. This area had a low number of intolerant species and abundant "enrichment" indicators.

Within the Pamlico area, the stations with the poorest water quality were Pantego Creek and Pungo Creek. This evaluation is based on the abundance of both "enrichment" and "high organic" indicator species. Data from Bath Creek and the Pungo River indicated similar problems, but of lesser severity.

INTRODUCTION

Since the 1973-74 Organization of Petroleum Exporting Countries' oil embargo and oil price increase, the United States has undertaken initiatives to become energy self-sufficient. Of the many different technologies being studied and/or utilized, production of alcohol for fuel is one energy source that has been developed in the United States. A source of material suitable for methanol production and fuel exists in mass quantities in coastal wetland areas of North Carolina. This material is an organically rich substance known as peat. Peat consists of partially decomposed and, thus, carbonized plant matter. In North Carolina, these peat deposits lie near or at the surface of certain coastal areas. If such areas are drained of water, then the peat can be harvested. Once the peat has been harvested and dried, it can be burned to produce a gas essential to the production of methanol.

The process of converting peat to methanol has raised concerns about the release of trace metals, particularly mercury, into the surrounding environment. Research conducted on peat has indicated that the substance has the potential to absorb and retain metals (Krauskopf, 1967). In fact, some manufacturing facilities that have mercury compounds in their waste streams utilize peat as a filter to remove mercury from their wastewater.

In December of 1980, a Peat Mining Task Force was organized to analyze issues associated with peat mining impacts. This knowledgeable group recommended that precautions be taken to protect the quality of the coastal water and dependent fish population in the area of intended peat mining. The task group also emphasized that peat mining studies in other areas of the world can not be extrapolated to predict peat mining impacts in North Carolina.

The goal of this portion of the Coastal Energy Impact Program (CEIP) study was to determine levels of mercury (and other parameters) in the aquatic environment and if such levels are above government standards for water and fish tissue found in the Pamlico - Albemarle area.

DESCRIPTION OF STUDY AREA

The Pamlico - Albemarle Peninsula is a low-lying region bordered by three sounds - the Albemarle, Pamlico, and Croatan, and by an estuarine water body; the Pamlico River. The 1634 square mile peninsular area is naturally characterized by deep organic soils, extensive swamps, marshes, evergreen wetlands, elevations of fifteen feet or less, and a low tidal range. There are about 600 square miles of peat deposits, some as deep as 16 feet. The volume of peat resources is estimated at 300 million dry tons. The area is well-populated in terms of fish and wildlife (Figure 1). While the peninsula is 70% covered by forests, other land uses include four natural lakes, agriculture, small towns and roads, all of which account for use of the remaining 30% of the land area.

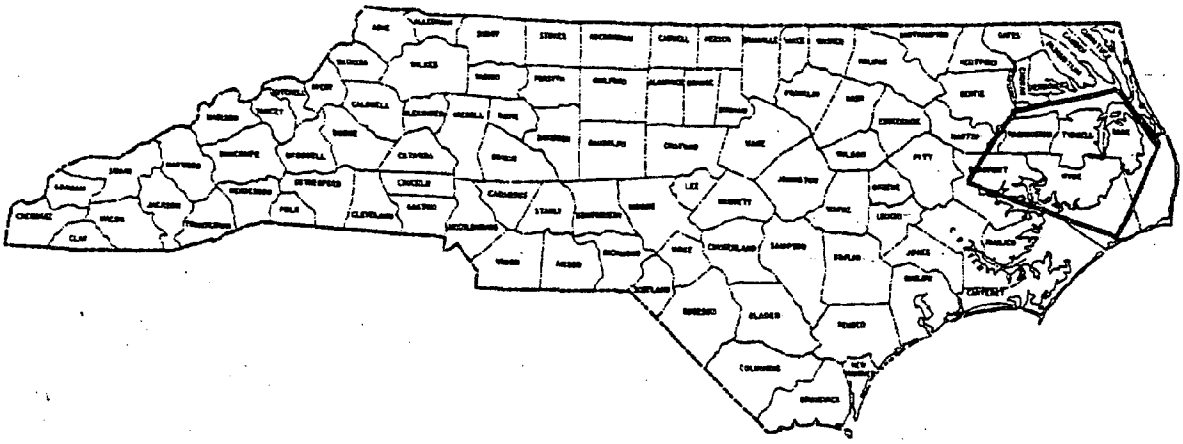


Figure 1
The Pamlico/Albemarle Peninsula of North Carolina (outlined)

Point and Non-Point Sources

There are 77 discharges with NPDES permits located in the three sub-basins of the study area. Several of the large facilities (e.g. Texas Gulf Sulfur, Inc., N.C. Phosphate Co., National Spinning Co., and Whitetail Farms) possess more than one permit. The categories and numbers of discharging facilities are: seafood processing companies (21), manufacturing and service industries (9), municipal wastewater plants (7), water filtration plants (4), housing developments (4), state facilities (2), a large agribusiness operation, and a camp. (See Tables 1, 2, and 3 and Figures 2, 3, and 4).

Non-point sources in the study area consist of towns, forests, and agricultural operations. Due to the extensive area being farmed, rainfall runoff from this activity has more potential impact on the ambient waters than the scattered small towns or the forested areas.

Hydrology

Flow in the study area is affected by wind-driven tidal influence as well as currents from inland rivers. Fresh water present in the Pamlico - Albemarle peninsula is drained from a 14,200 square-mile area (Walker, 1965).

During times of low river flow or storm-driven ocean tides, the salinity of water in the peninsula area increases. Heavy spring rains produce a flushing action that serves to lower salinity as well as mitigate possibly destructive algal blooms in the Pamlico waters. Due to the vast physical dimensions of the sounds in the study area, total flow information is not available (Giese et. al., 1979).

Figure 2.

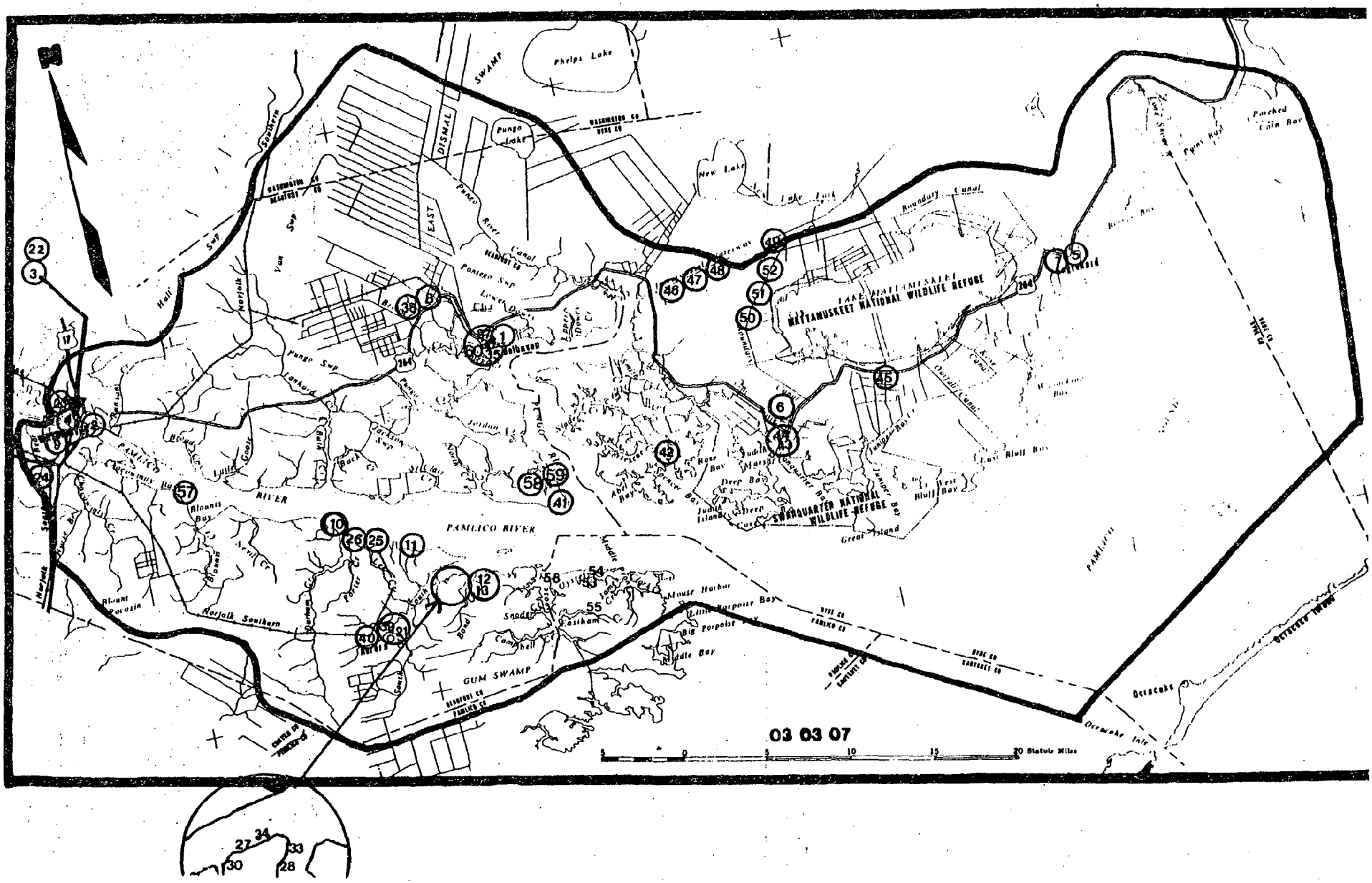

Phelps Lake
DISMAL SWAMP
Pungo Lake
New Lake
Lake Mattamuskeet
MATTAMUSKEET NATIONAL WILDLIFE REFUGE
SWANQUARTER NATIONAL WILDLIFE REFUGE
PAMLICO RIVER
GUM SWAMP
Ocracoke
Ocracoke Inlet
03 03 07
Statute Miles

Table 1. Sub-basin 03-03-07

Map #	Discharger	Receiving Stream	Latitude	Longitud
1	Belhaven WWTP NC0026492	Battalina Creek (Beaufort)	35°32'23.5"	76°36'44.
2	Maola Ice Cream Co. NC0007595	Pamlico (Beaufort)	35°32'27"	77°03'19
3	Washington WWTP NC0020648	Kennedy Creek (Beaufort)	35°33'27"	77°04'31
4	National Spinning Co. NC0001627	Tar River (Beaufort)	35°33'20"	77°04'50
5	Murray Nixon Fishery NC0040746	Far Creek (Hyde)	35°30'29.5"	75°59'30
6	Mid-East Regional Housing Authority NC0035751	UT Swanquarter Bay (Hyde)	35°25'32"	76°20'0
7	Engelhard, Fish, Shrimp & Oyster Co NC0000744	Far Creek (Hyde)	35°30'29"	75°59'3
8	Beaufort Co Elementary NC0036919	UT Pantego Cr (Beaufort)	35°35'11"	76°40'0
9	Singer Home Furniture NC0033197	UT to Cranford Cr (Beaufort)	35°3100"	77°06'0
10	N.C. Phosphate Co NC0028126 - 001	Pamlico River (Beaufort)	35°24'35"	76°49'3
11	N.C. Phosphate Co. NC0028126 - 002	Pamlico River (Beaufort)	35°22'55.5"	76°41'0
12	Daniel's Seafood NC0038296	Muddy Creek (Beaufort)	35°20'34"	76°41'2
13	Carolina Seafood NC0004057	Muddy Creek (Beaufort)	35°20'34.5"	76°41'2
14	Texas Gulf, Inc NC0003255 - 005B - 005CD	UT to South Cr (Beaufort)	35°19'49"	76°44'5
15	Texas Gulf, Inc NC0003255 - 005CE	UT to South Cr (Beaufort)	35°19'35"	76°45'0
16	Texas Gulf, Inc. NC0003255 - 005CC	UT to Short Creek (Beaufort)	35°19'31"	76°44'5
17	Texas Gulf, Inc. NC0003255 - 005C - 005CF	UT to South Creek (Beaufort)	35°19'21"	76°44'5

Table 1 (Cont.)

Map #	Discharger	Receiving Stream	Latitude	Longitud
18	Texas Gulf, Inc NC0003255 - 005D - 005CG	UT to Little Creek (Beaufort)	35°18'45"	76°45'02
19	Texas Gulf, Inc NC0003255 - 005CB	UT to Short Cr (Beaufort)	35°19'40"	76°44'22
20	Texas Gulf, Inc. NC0003255 - 005A - 005CA	UT to Long Cr. (Beaufort)	35°19'21"	76°44'11
21	Aurora WWTP NC0021521	South Creek (Beaufort)	35°17'50.5"	76°46'3
22	National Spinning NC0041548 - 001 - 002 - 003	Kennedy Creek (Beaufort)	35°33'17" 35°33'13" 35°33'05"	77°04'3 77°04'3 77°04'3
23	Water Care of Pamlico NC0039268	UT to Kennedy Cr (Beaufort)	35°33'22.5"	77°04'1
24	Mid-East Regional Housing NC0040452	UT to Chapel Branch (Beaufort)	35°31'59.5"	77°07'1
25	Texas Gulf, Inc. NC0003255	Pamlico River (Beaufort)	35°23'05"	76°46'2
26	Texas Gulf, Inc. NC0003255 - 011	Pamlico River (Beaufort)	35°23'36.5"	76°48'2
27	Texas Gulf, Inc NC0003255 - 001C	South Creek (Beaufort)	35°20'48"	76°43'1
28	Texas Gulf, Inc. NC0003255 - 002	Bond Creek (Beaufort)	35°20'12"	76°42'2
29	Texas Gulf, Inc. NC0003255 -003B	UT to Long Creek (Beaufort)	35°19'37"	76°43'4
30	Texas Gulf, Inc. NC0003255 - 003A	Long Creek (Beaufort)	35°20'17"	76°44'0
31	Texas Gulf, Inc. NC0003255 - 004A	UT to Long Creek (Beaufort)	35°19'17"	76°43'5
32	Texas Gulf, Inc. NC0003255 - 004B	Bond Creek (Beaufort)	35°19'13"	76°42'4
33	Texas Gulf, Inc NC0003255 - 001A	Bond Creek (Beaufort)	35°20'33.5"	76°42'0
34	Texas Gulf, INC. NC0003255 - 001B	South Creek (Beaufort)	35°20'54"	76°42'2

Table 1 (Cont.)

Map #	Discharger	Receiving Stream	Latitude	Longitude
35	Blue Channel Co. NC0040771	Pantego Creek (Beaufort)	35°32'09"	76°37'22
36	Belhaven Fish & Oyster NC0001198	Pantego Creek (Beaufort)	35°32'12.5"	76°37'26
37	Belhaven WTP NC0002925	UT Shoemaker (Beaufort	35°32'50.5"	76°37"44
38	Spencers Rest Home NC0040584	UT Pantego Cr. (Beaufort)	35°35'07"	76°40'20
39	Aurora Packing Co. NC0004081	South Creek (Beaufort)	35°18'16"	76°46'57
40	Potter Oil Co. NC0037044	Bailey Creek (Beaufort)	35°18'30"	76°48'33
41	Shiu - Ling Lu * NC0045209	Pamlico River (Beaufort)	35°23'21"	76°35'19
42	Capt'n Carls Seafood NC0032298	Germantown Bay (Hyde)	35°25'33"	76°27'31
43	Clark Marina NC0007196	UT Swanquarter Bay (Hyde)	35°24'16.5"	76°20'09
44	SwanquarterCrab NC0002551	UT SwanquarterBay (Hyde)	35°24'27"	76°20'01
45	Mattamuskeet School NC0032468	Juniper Canal (Hyde)	35°26'24.5"	76°13'0
46	White Tail Farms NC0050288 - 001	Intracoastal Waterway (Hyde)	35°33'25"	76°25'3(
47	Whitetail Farms NC0050288	Intercoastal Waterway (Hyde)	35°33'51"	76°23'1(
48	Whitetail Farms NC0050288 - 003	Intercoastal Waterway (Hyde)	35°34'17"	76°20'4
49	Whitetail Farms NC0050288	Intracoastal Waterway (Hyde)	35°34'48.5"	76°17'4
50	Whitetail Farms NC0050288	Boundary Canal (Hyde)	35°31'46.5"	76°20'0
51	Whitetail Farms NC0050288 -006 -007	Boundary Canal (Hyde)	35°32'17" 35°33'56"	76°19'0 76°18'5

* ceased discharging

Table 1 (Cont.)

Map #	Discharger	Receiving Stream	Latitude	Longitude
52	Whitetail Farms NC0050288 - 008	Boundary Canal (Hyde)	35°33'50"	76°17'58
53	Caroon Brothers Seafood NC0002470	Oyster Creek (Pamlico)	35°19'14.5"	76°33'42
54	Harbor Packing Co. NC0002500	Oyster Creek (Pamlico)	35°19'14.5"	76°33'40
55	Lowland Seafood NC0004090	Eastham Creek (Pamlico)	35°17'47"	76°35'05
56	Sadler Seafood Co NC0049964	Goose Creek (Pamlico)	35°19'14.5"	76°33'40
57	Camp Hardee NC0055476	Pamlico River (Beaufort)	35°28'27"	76°59'44
58	Hopkins Seafood & Grocery NC0051667	N. Prong Wright Creek (Beaufort)	35°24'42"	76°36'13
59	Jordan Seafood NC0051675	Wright Creek (Beaufort)	35°24'49"	76°35'28
60	Sea Safari Ltd. NC0046647	Pantego Creek (Beaufort)	35°32'06"	76°37'18

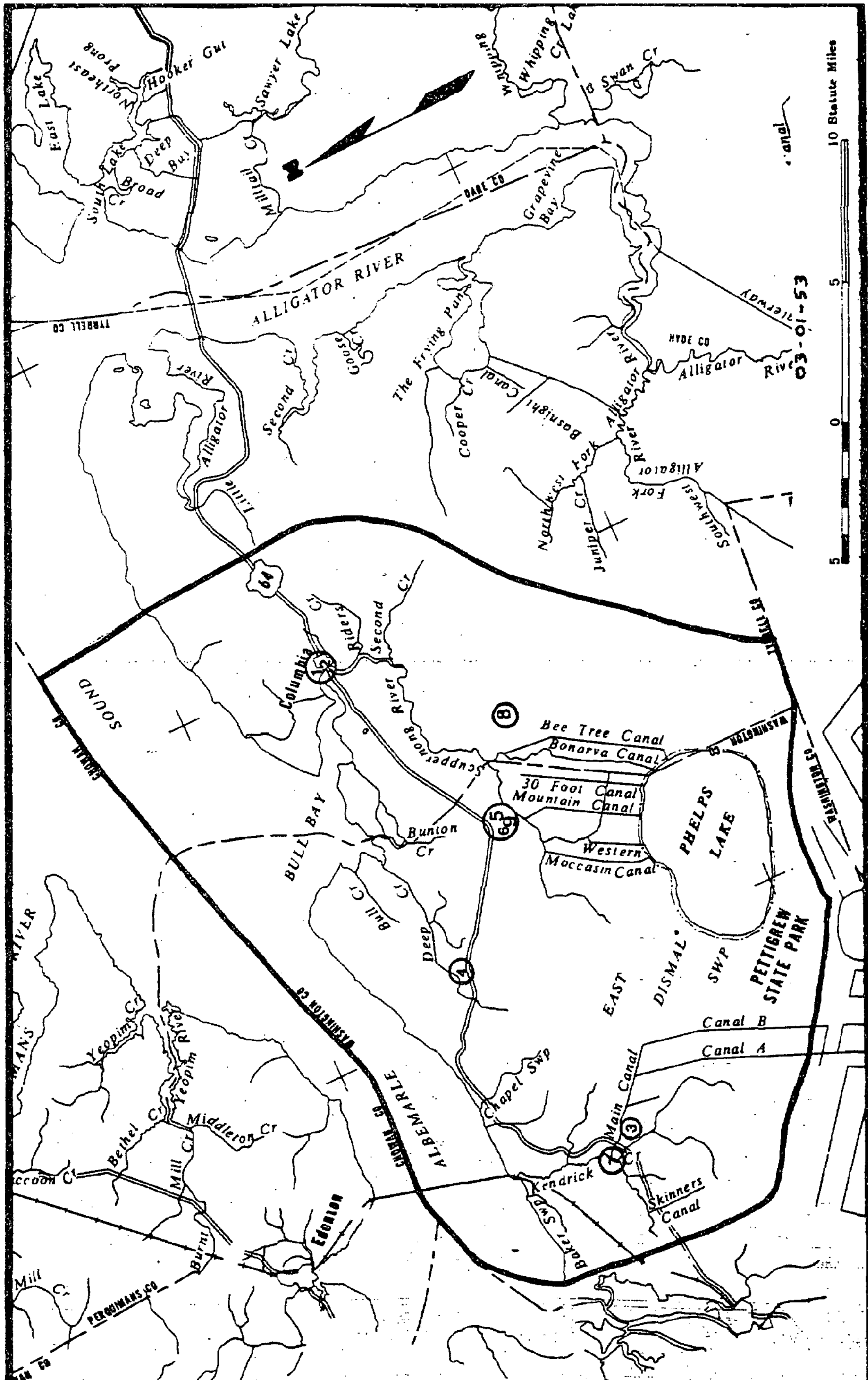

ALLIGATOR RIVER
Alligator River
Little Alligator River
Second Cr
Goose Cr
The Frying Pan
Cooper Cr
Basnight Canal
Northwest Fork
Juniper Cr
Southwest Fork Alligator River
Grapevine Bay
Milltail Cr
Sawyer Lake
Hooker Gut
Northeast Prong
East Lake
South Lake
Deep Bay
Broad Cr
Whipping Cr
Swan Cr
DARE CO
TYRRELL CO
HYDE CO
03-01-53
10 Statute Miles
SOUND
ALBEMARLE
BULL BAY
Columbia
Riders Cr
Second Cr
Scuppernong River
Bee Tree Canal
Bonarva Canal
30 Foot Canal
Mountain Canal
Western
Moccasin Canal
PHELPS LAKE
PETTIGREW STATE PARK
EAST DISMAL SWP
Bunton Cr
Bull Cr
Deep Cr
Chapel Swp
Main Canal
Canal A
Canal B
Kendrick Cr
Skinners Canal
Baker Swp
WASHINGTON CO
CHOWAN CO
PERQUIMANS CO
Edenton
Yeopim Cr
Yeopim River
Bethel Cr
Middleton Cr
Mill Cr
Burnt Mill Cr
Raccoon Cr

Figure 3

Table 2 Sub-basin 03-01-53

Map #	Discharger	Receiving Stream	Latitude	Longitude
1	Columbia WWTP NC0020443	Scuppernong River (Tyrrell)	35°55'11"	76°15'12.
2	Voliva, W.B. Oil Co. NC0037664	Scuppernong River (Tyrrell)	35°55'04"	76°15'18"
3	Roper WTP NC0031925	UT to Main Canal (Washington)	35°52'35"	76°36'42.
4	N.C. Dept of Correction NC0027901	UT to Deep Creek (Washington)	35°54'59"	76°27'55"
5	Creswell WTP NC0027600	UT to Scuppernong (Washington)	35°52'35"	76°23'24'
6	Creswell High School NC0033022	UT to Scuppernong (Washington)	35°52'34"	76°23'35'
7	Roper WWTP NC0036315	Kendrick Creek (Washington)	35°53'12"	76°36'50'
8	Lantern Acres NC0048810-001	UT to Scuppernong Riv. (Tyrrell)	35°49'44"	76°19'00
9	Creswell WWTP NC0048861	Scuppernong River (Washington)	—	-

Figure 4

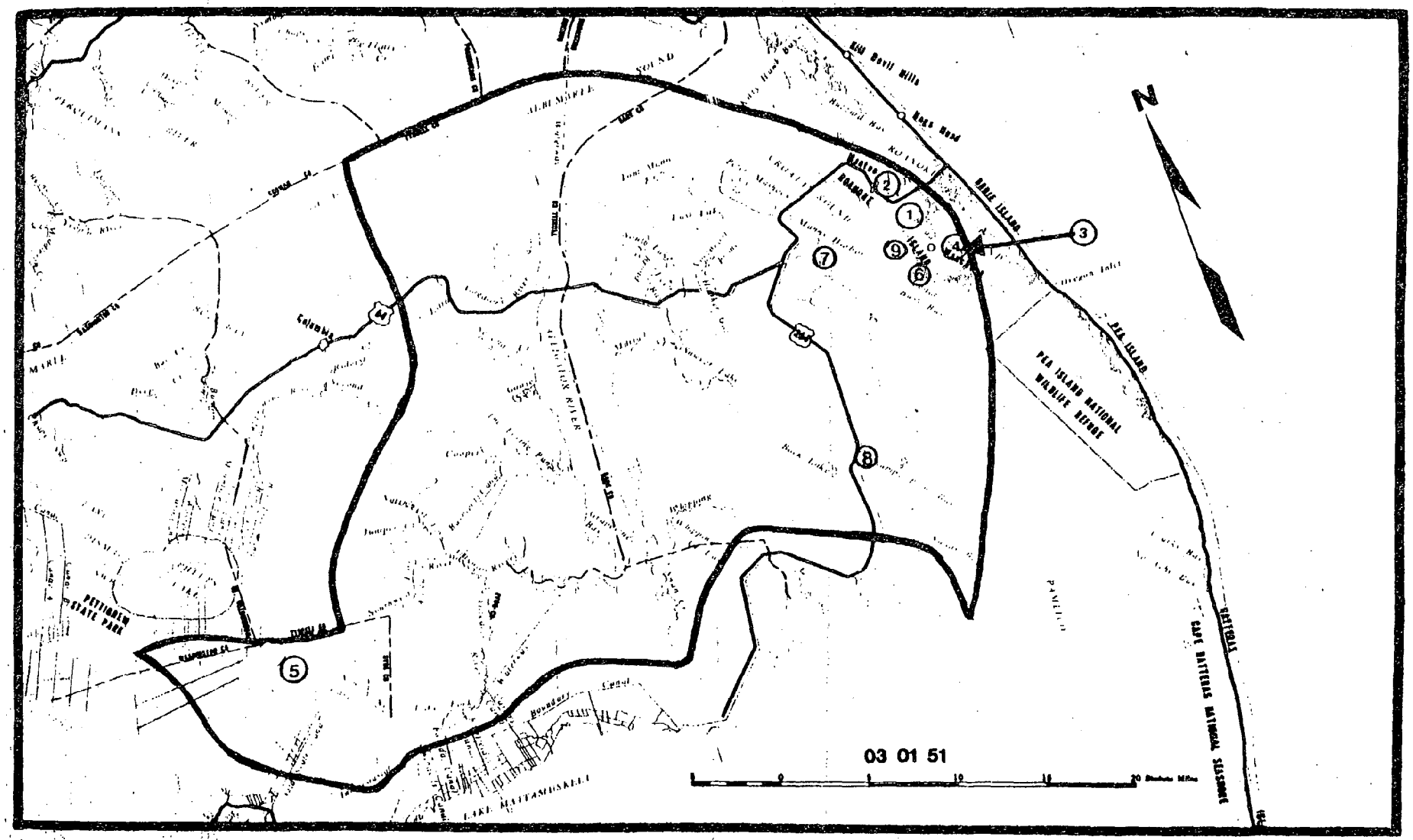

N
03 01 51
PEA ISLAND NATIONAL WILDLIFE REFUGE
CAPE HATTERAS NATIONAL SEASHORE
PEA ISLAND
MARLE ISLAND
ROANOKE
ROANOKE SOUND
ALBEMARLE SOUND
PETTIGREW STATE PARK
LAKE MATTAMUSKEET
1
2
3
4
5
6
7
8
9

Table 3 Sub-basin 03-01-51

Map #	Discharger	Receiving Stream	Latitude	Longitude
1	Dare Co. Water NC0035670	UT to Croatan Sound (Dare)	35°53'13.5"	75°39'40"
2	Manteo WWTP NC0025488	Shallow Bag Bay (Dare)	35°54'28.5"	75°40'12.5"
3	Wanchese Fish #2 NC0033766	Mill Creek (Dare)	35°50'23.5"	75°37'51.5"
4	Wanchese Harbor Devel NC0041386	Mill Creek (Dare)	35°50'26"	75°37'47.5"
5	Lantern Acres NC0048810-002	UT to NW Fork Alligator River (Tyrrell)	35°47'17.5"	76°17'20.5"
6	James Fletcher Seafood NC0050873	Oyster Creek (Dare)	35°50'22"	75°37'31"
7	N.C.D.O.T. NC0056065	Croatan Sound (Dare)	35°52'12"	75°45'10"
8	Wahoo Sportsman, Inc. NC0049972	Stumpy Point Bay (Dare)	35°41'50"	75°46'10"
9	St. Elmo's Seafood NC0057738	Croatan Sound (Dare)	-	-

TABLE 4

Sampling Site Locations, Stream Classifications, Sample Types

Map Location Number	Sampling Site	Stream Classification	Water Column	Phytoplankton	Sediment	Benthos	Fish
(1)	Scuppernong River at SR1105 near Columbia, NC 02081166	C-SW	X	X	X	X	X
(2)	Alligator River above Cherry Ridge Landing near Gum Neck, NC 0208117810	SC-SW	X	X	X	X	X
(3)	Alligator River at Newport News Point near Gum Neck, NC 0208117820	SC-SW	X		X		
(4)	Alligator River 3 miles upstream from Catfish Point near Frying Pan Landing, NC 0208117830	SC-SW	X		X		
(5)	Alligator River at U.S. Hwy 264 near Alligator, NC 0208117840	SC-SW	X				
(6)	Kendrick Creek at SR1130 at Mackeys, NC 02081185	SC	X		X	X	X
(7)	Intracoastal Waterway at U.S. Hwy 264 near Scranton, NC 0208455655	SC-SW	X				
(8)	Bath Creek at N.C. Hwy 92 near Bath, NC 02084534	SC	X	X	X	X	X
(9)	Pungo River at U.S. Hwy 264 near Ponzer, NC 0208455650	SB	X	X	X	X	X
(10)	Pantego Creek at N.C. Hwy 92 at Belhaven, NC 0208455850	SC	X	X	X	X	X
(11)	Pungo Creek at N.C. Hwy 92 at Sidney Crossroads, NC 0208457020	SC	X	X	X	X	X

Table 5

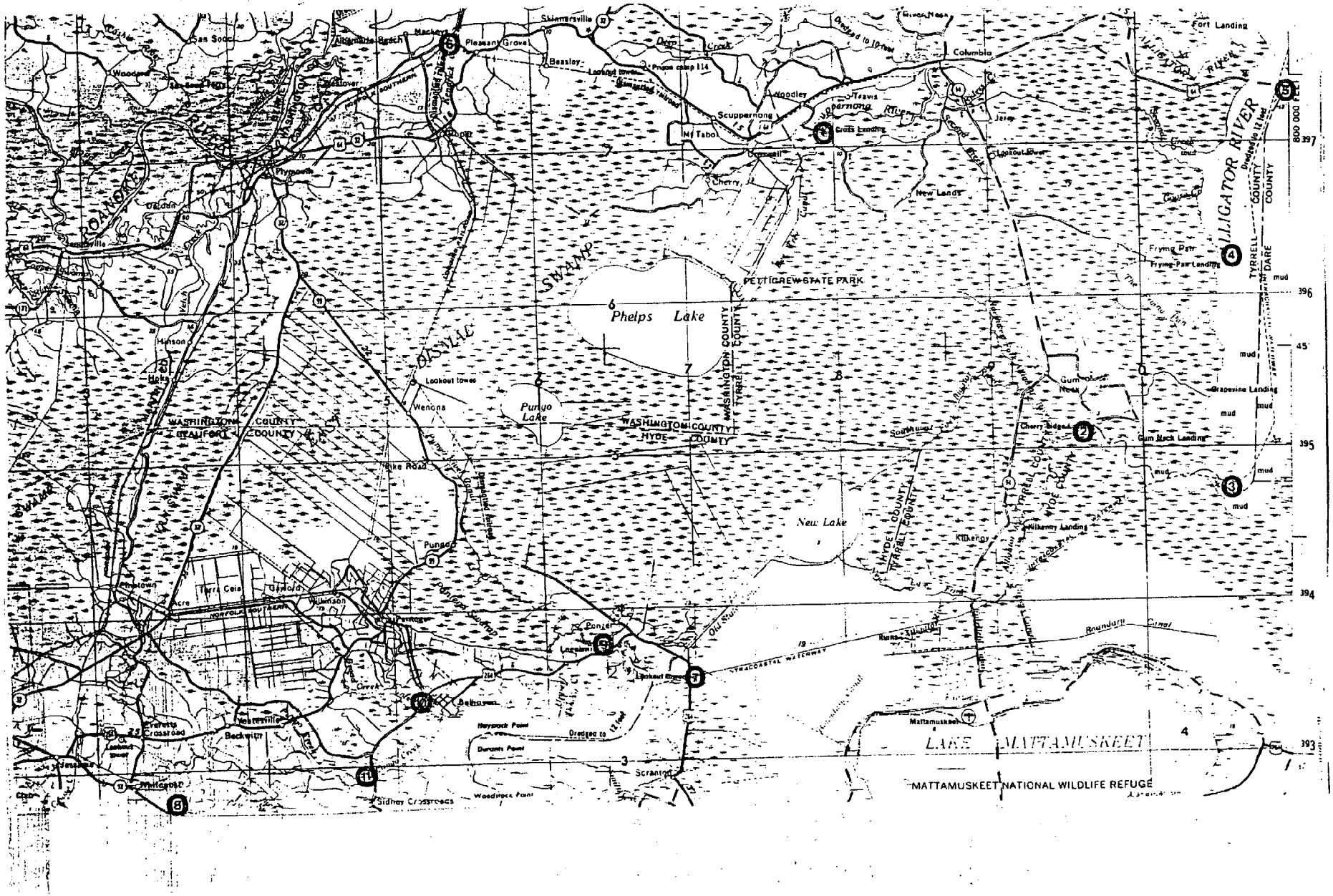
Sampling Site Characteristics

Map Location Number	Sampling Site	Width	Depth	Water Color	Substrate	Macrophytes	Bank Composition
1	Scuppernong River at SR1105 near Columbia, N.C. 02081166	300'	20'	black	silt	alligator weed	swamp
2	Alligator River above Cherry Ridge Landing near Gum Neck, NC 0208117810	500'	25'	black	silt	alligator weed	swamp
3	Alligator River at Newport News Point near Gum Neck, NC 0208117820	4,752'	8'	black	silt	none	swamp
4	Alligator River 3 miles upstream from Catfish Point near Frying Pan Landing, NC 0208117830	17,424'	10'	black	silt	none	swamp
5	Alligator River at U.S. Hwy 264 near Alligator, NC 0208117840	14,256'	10'	black	silt	none	swamp
6	Kendrick Creek at SR1130 near Mackeys, NC 02081185	250'	15'	black	silt	alligator weed	swamp
7	Intracoastal Waterway at U.S. Hwy 264 near Scranton, NC 0208455655	500'	35'	black	silt	none	marsh, swamp
8	Bath Creek at N.C. Hwy 92 near Bath, NC 02084534	2,640'	10'	brown	silt	lilly pads	4' high banks
9	Pungo River at US Hwy 264 near Ponzer, NC 0208455650	300'	10'	black	silt	none	marsh
10	Pantego Creek at NC Hwy 92 at Belhaven, NC 0208455850	500'	15'	black	silt	none	marsh, swamp
11	Pungo Creek at NC Hwy 92 at	500'	20'	black	silt	none	marsh, swamp

Figure 5

Pamlico/Albemarle Peninsula

Sampling Site Locations



Methodology of Sampling and Sample Analyses

Grab water samples were obtained at each site. Metals samples were collected in disposable plastic pint bottles. Other samples were collected in prepared reusable bottles. Chlorophyll a and phytoplankton samples were collected at 0.15 m below the water surface.

Benthic macroinvertebrates were collected by using standardized qualitative techniques (DEM, 1983).

Sediment samples were collected by using a Wildco-Petersen dredge device. The collected samples were stored in acid-rinsed, glass, half-pint jars.

Fish samples were collected by using electroshocking techniques and stationary gill nets.

All samples were properly preserved and cooled upon collection and then transported to the D.N.R.C.D. laboratory located near Cary, North Carolina where they were analyzed by appropriate procedures listed in Standard Methods for the Examination of Water and Wastewater.

Dissolved oxygen, pH, alkalinity, temperature, conductivity and visual observations of cloud cover percentage, wind direction and force, presence of dead fish, degree of water turbidity, odor, and flow, presence of suds, oil, floating debris, and sludge were assessed and recorded at each site.

Conductivity, salinity, and temperature were determined by the use of a Yellow Springs Instrument (Y.S.I.) Model 33 S-C-T meter. This type of meter was subjected to twice-daily calibration procedures involving standards of known values in order to provide accurate, reliable, quality-assured data.

The dissolved oxygen concentration of water at all sample sites was determined by the use of a Y.S.I. model 57 dissolved oxygen meter. This meter was subjected to twice-daily Winkler calibration procedures to provide quality assurance for data.

The pH values of water collected at all sites in this study were determined by use of a Corning Model 4 pH meter. This pH meter was also used to assist in accurate acidity and alkalinity titration determinations. The pH data was quality-assured by twice-daily calibration of the pH meter against buffers of known pH values.

WATER COLUMN

PARAMETRIC DATA

Salinity, Conductivity, and Total Residue

Each station within the study area, except for one, had detectable salinity levels. Mean salinities at these stations ranged from 0.28 ppth to 6.6 ppth (Figure 6). Kendrick Creek at S.R. 1300 at Mackeys, N.C. (02081185) was the only station where no salinity values were above the detection limit of 0.1 ppth. The Scuppernong River at S.R. 1105 near Columbia (02081166) had low salinity values with only 15% above 1.0 ppth (Figure 7). The salinity levels in these estuarine areas are due to the mixing of fresh and salt water by wind and tidal forces. The salinity in this area is also dependent on freshwater flow conditions. Salinity is more likely to be present in higher concentrations when low flow conditions exist in the river systems draining upstream freshwater areas, thus allowing more salt water intrusion. Storm-driven ocean tides may also push saline waters further upstream. The creeks and rivers on the southern side of the peninsula had higher salinities during the drought conditions in the latter part of 1983. The slightly saline conditions at most of the stations were the cause of high conductivity and total residue values. These two parameters were present in greater concentrations when higher salinities were present. These values, ranging from 72 umhos/cm^3 to 19,530 umhos/cm^3 for conductivity and from 130 mg/l to 12,900 mg/l for total residue should not be considered abnormal as this is quite ordinary when the dissolved constituents in seawater are present.

Conductivity is a direct measurement of the water's capacity to conduct an electric current. The highest mean conductivity value (9990 umhos/cm^3) occurred at the Intracoastal Waterway at U.S. Hwy 264 at Scranton (0208455655) (Figure 8). The highest mean salinity value (6.6 ppth) was found here, also.

The highest mean total residue value (5685 mg/l) was found at Bath Creek at N.C. Hwy 92 near Bath (02084534) (Figure 9). Due to the salinity present in the study area, the major type of residue at every station was dissolved residue.

Data summaries for these and other water column parameters are presented in Table 6.

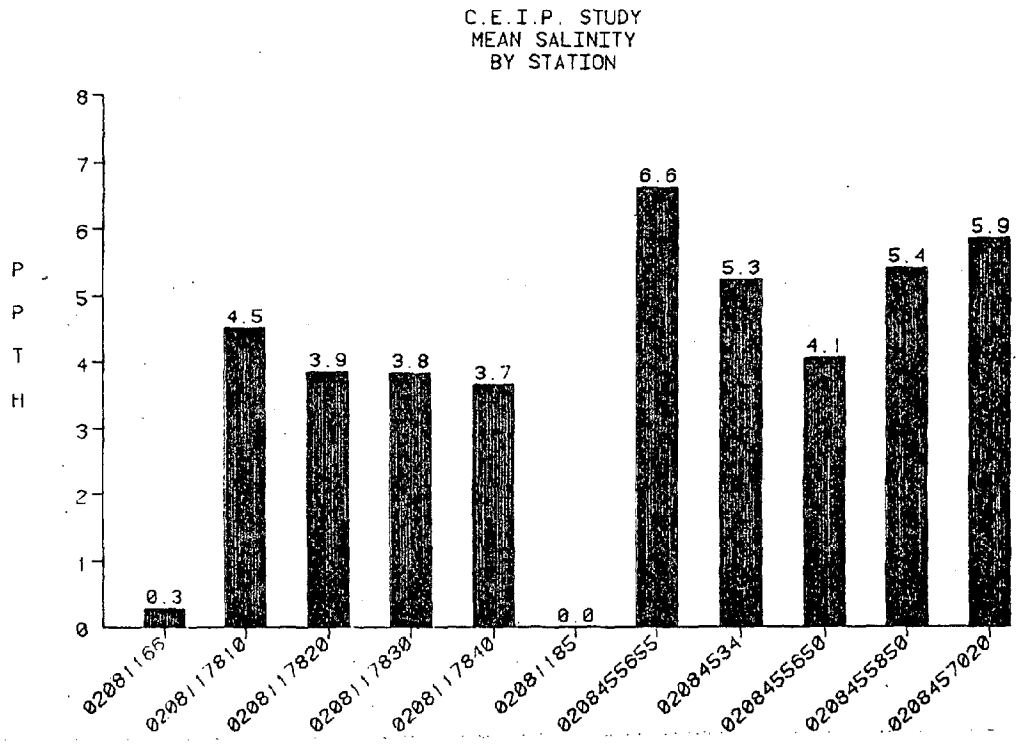


Figure 6

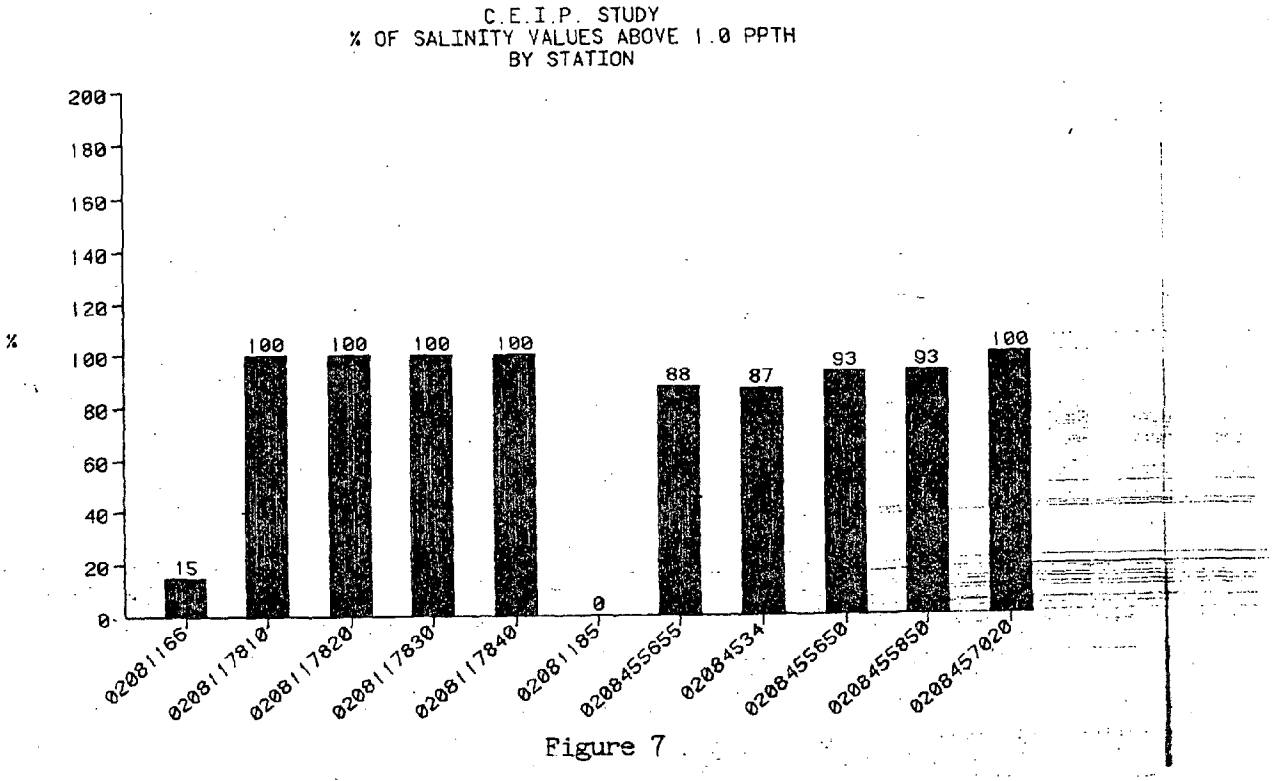


Figure 7

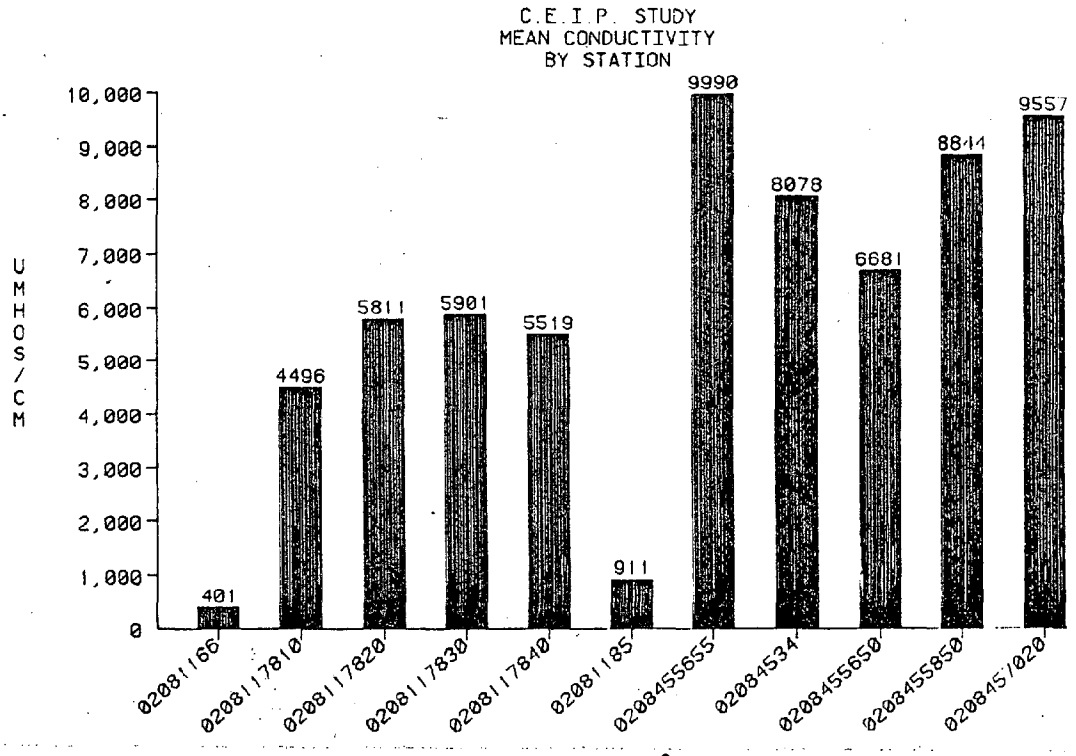


Figure 8

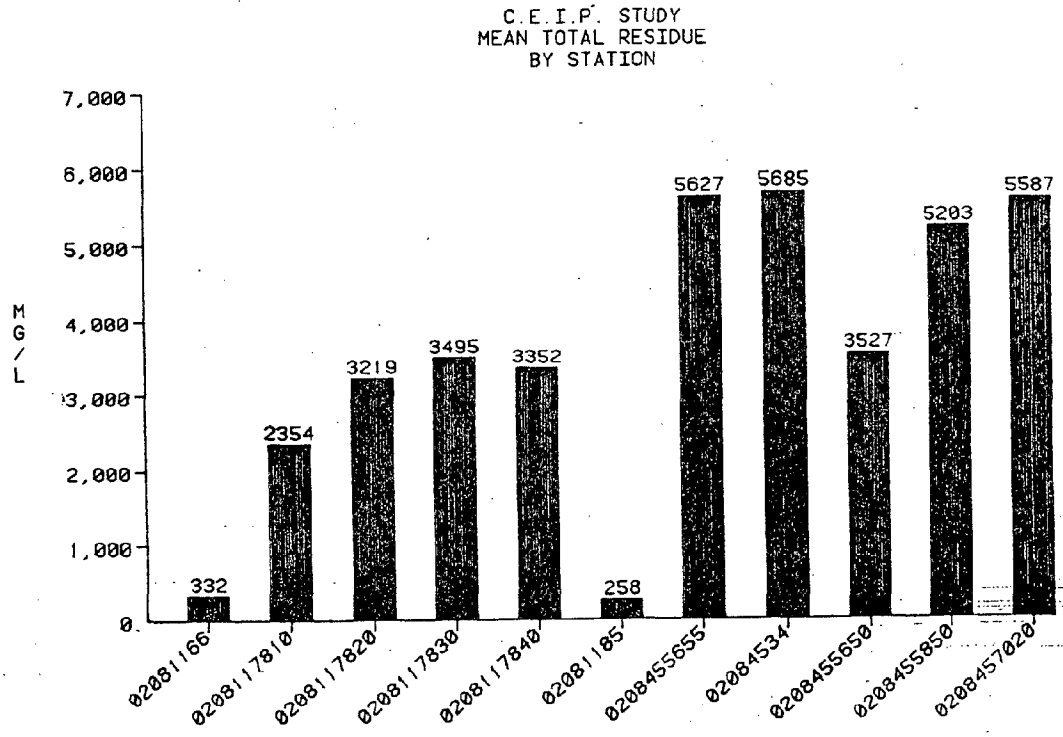


Figure 9

Table 6

Water Column Parametric Data Tabulation

0208

SCUPPERNONG R @ SR 1105 NR COLUMBIA NC PEAT
37177 NORTH CAROLINA TYRRELL
SOUTHEAST 030151
PASQUOTANK
/TYPA/AMBNT/STREAM 21NC01WQ 03010205000

INDEX
MILES
PARAMETER

				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMU
00010	WATER	TEMP	CENT		26	18.7153	47.7558	6.91055	.369246	1.35527	28.0000	5.70
00076	TURB	TRBIDMTR	HACH FTU		11	16.9364	184.829	13.5952	.802721	4.09910	45.0000	6.80
00094	CNDUCTVY	FIELD	MICROMHO		26	400.885	299050	546.855	1.36412	107.247	2380.00	91.0
00300	DO		MG/L		26	3.33076	6.44462	2.53863	.762175	.497865	8.20000	.100
00310	BOD	5 DAY	MG/L		18	2.51111	1.36930	1.17017	.465998	.275812	5.00000	1.20
00400	PH		SU		25	6.09199	.252452	.502446	.082476	.100489	6.70000	4.80
00431	T ALK	FIELD	MG/L		8	23.7500	70.2143	8.37940	.352817	2.96256	40.0000	10.0
00480	SALINITY		PPTH		19	.284210	.280292	.529426	1.86290	.121459	2.10000	.000
				K	1	.100000					.100000	.100
				TOT	20	.275000	.267237	.516949	1.87982	.115593	2.10000	.000
00500	RESIDUE	TOTAL	MG/L		18	332.500	99277.6	315.084	.947620	74.2659	1400.00	160.
00530	RESIDUE	TOT NFLT	MG/L		18	10.5556	74.8497	8.65157	.819622	2.03919	41.0000	3.00
01002	ARSENIC	AS,TOT	UG/L	K	8	10.0000	.000000	.000000		.000000	10.0000	10.0
01027	CADMIUM	CD,TOT	UG/L	K	11	22.7273	81.8187	9.04537	.397996	2.72728	50.0000	20.0
01034	CHROMIUM	CR,TOT	UG/L		1	60.0000					60.0000	60.0
				K	10	50.0000	.000000	.000000		.000000	50.0000	50.0
				TOT	11	50.9091	9.09258	3.01539	.059231	.909174	60.0000	50.0
01042	COPPER	CU,TOT	UG/L	K	11	21.8182	36.3641	6.03026	.276387	1.81819	40.0000	20.0
01051	LEAD	PB,TOT	UG/L	K	11	100.000	.000000	.000000		.000000	100.000	100.
01067	NICKEL	NI,TOTAL	UG/L	K	11	100.000	.000000	.000000		.000000	100.000	100.
01092	ZINC	ZN,TOT	UG/L		1	30.0000					30.0000	30.0
				K	10	23.0000	90.0000	9.48683	.412471	3.00000	50.0000	20.0
				TOT	11	23.6363	85.4555	9.24421	.391101	2.78723	50.0000	20.0
31616	FEC COLI	MFM-FCBR	/100ML		10	1792.00	.285E+08	5345.05	2.98273	1690.25	17000.0	10.0
				K	1	10.0000					10.0000	10.0
				TOT	11	1630.00	.260E+08	5099.14	3.12831	1537.45	17000.0	10.0
32209	CHLRPHYL	A	UG/L		15	11.1813	212.567	14.5797	1.30393	3.76446	51.0000	1.00
				K	3	1.00000	.000000	.000000		.000000	1.00000	1.00
				TOT	18	9.48444	190.300	13.7949	1.45448	3.25149	51.0000	1.00
32213	PHPHTN-A	FLR MTHD	UG/L		11	5.15545	6.80784	2.60918	.506102	.786698	10.0000	2.00
				K	7	1.00000	.000000	.000000		.000000	1.00000	1.00
				TOT	18	3.53944	8.34976	2.88959	.816398	.681084	10.0000	1.00
32217	CHLRPHYL	A	UG/L		17	11.8235	215.904	14.6937	1.24275	3.56374	50.0000	1.00

Table 6 - continued

020811781

ALLIGATOR R US CHERRY RIDGE LANDING PEAT
37177 NORTH CAROLINA TYRRELL
SOUTHEAST 030151
PASQUOTANK

/TYPA/AMBNT/ESTURY 21NC01WQ 821030

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		9	19.8444	64.3579	8.02234	.404261	2.67411	29.2000	9.00000
00076	TURB	TRBIDMTR	HACH FTU		4	4.30000	9.42668	3.07029	.714021	1.53514	8.20000	1.00000
00094	CNDUCTVY	FIELD	MICROMHO		9	4495.55	.136E+08	3690.97	.821027	1230.32	10140.0	288.000
00300	DO		MG/L		9	6.25555	4.46036	2.11196	.337613	.703985	9.60000	4.10000
00310	BOD	5 DAY	MG/L		5	1.22000	.052001	.228036	.186915	.101981	1.60000	1.00000
00400	PH		SU		8	5.62500	.476438	.690245	.122710	.244038	6.60000	4.50000
00431	T ALK	FIELD	MG/L		2	6.00000	72.0000	8.48528	1.41421	6.00000	12.0000	.000000
00480	SALINITY		PPTH		6	4.51666	4.57370	2.13862	.473496	.873089	7.00000	1.90000
00500	RESIDUE	TOTAL	MG/L		5	2354.00	3873128	1968.03	.836035	880.128	4610.00	270.000
00530	RESIDUE	TOT NFLT	MG/L		5	5.20000	16.7000	4.08656	.785878	1.82757	12.0000	2.00000
01002	ARSENIC	AS,TOT	UG/L	K	1	10.0000					10.0000	10.0000
01027	CADMIUM	CD,TOT	UG/L	K	5	26.0000	180.000	13.4164	.516016	6.00000	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	5	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	5	24.0000	80.0000	8.94427	.372678	4.00000	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L	K	5	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	5	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L		1	40.0000					40.0000	40.0000
				K	4	27.5000	225.000	15.0000	.545454	7.50000	50.0000	20.0000
				TOT	5	30.0000	200.000	14.1421	.471404	6.32456	50.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML		3	113.333	15233.3	123.423	1.08903	71.2585	250.000	10.0000
				K	2	10.0000	.000000	.000000		.000000	10.0000	10.0000
				TOT	5	72.0000	10820.0	104.019	1.44471	46.5188	250.000	10.0000
32209	CHLRPHYL	A	UG/L		4	4.50000	4.33333	2.08167	.462592	1.04083	7.00000	2.00000
				K	2	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	6	3.33333	5.86668	2.42212	.726637	.988828	7.00000	1.00000
32213	PHPHTN-A	FLR MTHD	UG/L		5	2.00000	1.00000	1.00000	.500000	.447214	3.00000	1.00000
				K	1	1.00000					1.00000	1.00000
				TOT	6	1.83333	.966669	.983193	.536287	.401387	3.00000	1.00000
32217	CHLRPHYL	A	UG/L		6	4.50000	5.90000	2.42899	.539776	.991632	8.00000	1.00000

Table 6 - continued

0208117820

ALLIGATOR RIVER @ NEWPORT NEWS POINT PEAT
37177 NORTH CAROLINA TYRRELL
SOUTHEAST 030151
PASQUOTANK
/TYPA/AMBNT/ESTURY 21NC01WQ 811024

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		22	20.1818	43.2848	6.57912	.325993	1.40267	27.0000	8.00000
00076	TURB	TRBIDMTR	HACH FTU		3	9.10000	91.8301	9.58280	1.05305	5.53263	20.0000	2.00000
00094	CNDUCTVY	FIELD	MICROMHO		22	5811.09	7159027	2675.64	.460436	570.447	12000.0	1520.00
00300	DO		MG/L		22	8.14090	3.41304	1.84744	.226933	.393876	11.2000	3.40000
00310	BOD	5 DAY	MG/L		10	1.14000	.113778	.337310	.295886	.106667	1.80000	.700000
00400	PH		SU		21	6.31428	.212317	.460779	.072974	.100550	7.00000	5.20000
00431	T ALK	FIELD	MG/L		2	10.0000	72.0000	8.48528	.848528	6.00000	16.0000	4.00000
00480	SALINITY		PPTH		19	3.85789	2.93704	1.71378	.444227	.393168	7.00000	1.00000
00500	RESIDUE	TOTAL	MG/L		11	3219.09	1216889	1103.13	.342683	332.605	4400.00	930.000
00530	RESIDUE	TOT NFLT	MG/L		11	10.0000	50.2000	7.08520	.708519	2.13627	26.0000	2.00000
01027	CADMIUM	CD,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	3	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	3	26.6667	133.334	11.5470	.433014	6.66669	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML		1	30.0000					30.0000	30.0000
				K	2	10.0000	.000000	.000000		.000000	10.0000	10.0000
				TOT	3	16.6667	133.334	11.5470	.692822	6.66668	30.0000	10.0000
32209	CHLRPHYL	A	UG/L		12	4.32500	3.14022	1.77207	.409726	.511551	7.00000	1.00000
32213	PHPHTN-A	FLR MTHD	UG/L		8	2.15500	.763635	.873862	.405505	.308957	3.24000	1.00000
				K	4	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	12	1.77000	.809352	.899640	.508272	.259704	3.24000	1.00000
32217	CHLRPHYL	A	UG/L		11	5.18182	4.96365	2.22792	.429950	.671744	9.00000	2.00000

Table 6 - continued

0208117830

ALLIGATOR RIVER 3 MILES US CATFISH POINT PEAT
37177 NORTH CAROLINA TYRRELL
SOUTHEAST 030151
PASQUOTANK
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		22	19.8681	46.5716	6.82434	.343482	1.45495	27.2000	8.10000
00076	TURB	TRBIDMTR	HACH FTU		3	9.43333	83.7635	9.15224	.970203	5.28405	20.0000	4.00000
00094	CNDUCTVY	FIELD	MICROMHO		22	5900.68	2323078	1524.16	.258303	324.953	7400.00	2850.00
00300	DO		MG/L		22	8.66818	3.08611	1.75673	.202665	.374537	11.5000	4.50000
00310	BOD	5 DAY	MG/L		10	1.07000	.100111	.316403	.295704	.100056	1.60000	.500000
00400	PH		SU		21	6.58095	.124609	.353000	.053640	.077031	7.60000	6.00000
00431	T ALK	FIELD	MG/L		2	14.5000	40.5000	6.36396	.438894	4.50000	19.0000	10.0000
00480	SALINITY		PPTH		18	3.84444	.862635	.928781	.241591	.218916	5.30000	1.60000
00500	RESIDUE	TOTAL	MG/L		11	3494.55	872229	933.932	.267254	281.591	4410.00	1700.00
00530	RESIDUE	TOT NFLT	MG/L		11	25.5454	1590.07	39.8757	1.56097	12.0230	140.000	3.00000
01027	CADMIUM	CD,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	3	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	3	26.6667	133.334	11.5470	.433014	6.66669	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML	K	3	10.0000	.000000	.000000		.000000	10.0000	10.0000
32209	CHLRPHYL	A	UG/L		11	4.40182	3.32405	1.82320	.414192	.549715	9.00000	2.00000
32213	PHPHTN-A	FLR MTHD	UG/L		5	4.19600	7.71209	2.77706	.661836	1.24194	8.00000	1.00000
				K	6	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	11	2.45273	5.87059	2.42293	.987852	.730541	8.00000	1.00000
32217	CHLRPHYL	A	UG/L		10	5.70000	12.9000	3.59166	.630116	1.13578	15.0000	2.00000

Table 6 - continued

0208117840

ALLIGATOR R @ US HWY64 NR ALLIGATOR NC PEAT
37177 NORTH CAROLINA TYRRELL
SOUTHEAST 030151
PASQUOTANK
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		22	19.7908	44.9689	6.70589	.338838	1.42970	27.5000	8.00000
00076	TURB	TRBIDMTR	HACH FTU		3	9.46666	35.2534	5.93746	.627196	3.42799	16.0000	4.40000
00094	CNDUCTVY	FIELD	MICROMHO		22	5519.45	1616188	1271.29	.230330	271.041	7170.00	3050.00
00300	DO		MG/L		22	8.67272	2.35547	1.53475	.176963	.327211	10.9000	6.00000
00310	BOD	5 DAY	MG/L		10	1.20000	.057780	.240374	.200312	.076013	1.60000	.900000
00400	PH		SU		21	6.58571	.108313	.329109	.049973	.071817	7.60000	6.10000
00431	T ALK	FIELD	MG/L		2	14.5000	40.5000	6.36396	.438894	4.50000	19.0000	10.0000
00480	SALINITY		PPTH		21	3.65714	.732581	.855909	.234038	.186775	5.40000	1.80000
00500	RESIDUE	TOTAL	MG/L		11	3351.82	719437	848.196	.253056	255.741	4200.00	1800.00
00530	RESIDUE	TOT NFLT	MG/L		11	11.5455	140.473	11.8521	1.02656	3.57355	45.0000	1.00000
01027	CADMIUM	CD,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	3	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	3	26.6667	133.334	11.5470	.433014	6.66669	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	3	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L	K	3	30.0000	300.000	17.3205	.577350	10.0000	50.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML	K	3	10.0000	.000000	.000000		.000000	10.0000	10.0000
32209	CHLRPHYL	A	UG/L		11	5.84091	7.32844	2.70711	.463474	.816224	11.0000	2.00000
32213	PHPHTN-A	FLR MTHD	UG/L		4	2.64500	2.89077	1.70023	.642808	.850113	5.00000	1.00000
				K	7	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	11	1.59818	1.55604	1.24741	.780522	.376110	5.00000	1.00000
32217	CHLRPHYL	A	UG/L		10	6.50000	11.6111	3.40751	.524232	1.07755	12.0000	2.00000
											.300000	.300000

Table 6 - continued

02081185

KENDRICK CR @ SR1300 @ MACKEYS NC PEAT
37187 NORTH CAROLINA WASHINGTON
SOUTHEAST 030153
PASQUOTANK
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

INDEX
MILES

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		9	19.0555	54.3781	7.37415	.386982	2.45805	29.0000	6.20000
00076	TURB	TRBIDMTR	HACH FTU		6	23.7833	795.482	28.2043	1.18588	11.5144	80.0000	5.20000
00094	CNDUCTVY	FIELD	MICROMHO		9	911.333	4586926	2141.71	2.35009	713.904	6600.00	72.0000
00300	DO		MG/L		9	5.46666	10.9276	3.30568	.604699	1.10189	10.2000	.100000
00310	BOD	5 DAY	MG/L		8	2.02500	.742150	.861482	.425423	.304580	3.30000	1.00000
00400	PH		SU		9	6.13333	.367584	.606287	.098851	.202096	7.00000	5.20000
00431	T ALK	FIELD	MG/L		4	25.0000	120.667	10.9848	.439393	5.49242	39.0000	14.0000
00480	SALINITY		PPTH		1	.000000					.000000	.000000
				K	2	.100000	-.372E-08	.000000		.000000	.100000	.100000
				TOT	3	.066667	.003333	.057735	.866027	.033333	.100000	.000000
00500	RESIDUE	TOTAL	MG/L		8	258.000	11025.4	105.002	.406985	37.1238	419.000	130.000
00530	RESIDUE	TOT NFLT	MG/L		8	10.2500	132.786	11.5233	1.12422	4.07409	38.0000	3.00000
01002	ARSENIC	AS,TOT	UG/L	K	2	10.0000	.000000	.000000		.000000	10.0000	10.0000
01027	CADMIUM	CD,TOT	UG/L		1	20.0000					20.0000	20.0000
				K	5	26.0000	180.000	13.4164	.516016	6.00000	50.0000	20.0000
				TOT	6	25.0000	150.000	12.2474	.489898	5.00000	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	6	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	6	23.3333	66.6670	8.16499	.349928	3.33334	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L		1	100.000					100.000	100.000
				K	5	100.000	.000000	.000000		.000000	100.000	100.000
				TOT	6	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L		1	100.000					100.000	100.000
				K	5	100.000	.000000	.000000		.000000	100.000	100.000
				TOT	6	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L		1	90.0000					90.0000	90.0000
				K	5	26.0000	180.000	13.4164	.516016	6.00000	50.0000	20.0000
				TOT	6	36.6667	826.668	28.7518	.784141	11.7379	90.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML		6	703.333	2453547	1566.38	2.22708	639.472	3900.00	20.0000
32209	CHLRPHYL	A	UG/L		7	10.0000	148.333	12.1792	1.21792	4.60331	35.0000	1.00000
				K	1	1.00000					1.00000	1.00000
				TOT	8	8.87500	137.268	11.7161	1.32013	4.14228	35.0000	1.00000
32213	PHPHTN-A	FLR MTHD	UG/L		5	5.20000	9.20002	3.03315	.583299	1.35647	10.0000	2.00000
				K	3	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	8	3.62500	9.98214	3.15945	.871573	1.11703	10.0000	1.00000
32217	CHLRPHYL	A	UG/L		8	11.5000	184.286	13.5752	1.18045	4.79955	41.0000	2.00000

Table 6 - continued

020845565

INTRACOASTAL WATERWAY @ US HWY264 SCRANTON PEAT
37095 NORTH CAROLINA HYDE
SOUTHEAST 030151
PASQUOTANK
21NC01WQ B11024

/CANAL/TYPA/AMBNT

INDEX
MILES

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		8	19.2750	75.6994	8.70054	.451390	3.07610	31.3000	4.00000
00076	TURB	TRBIDMTR	HACH FTU		10	11.4200	54.8507	7.40612	.648522	2.34202	25.0000	4.00000
00094	CNDUCTVY	FIELD	MICROMHO		8	9990.50	.302E+08	5498.21	.550344	1943.91	16320.0	1600.00
00300	DO		MG/L		8	7.77500	8.01357	2.83082	.364093	1.00085	11.0000	3.50000
00310	BOD	5 DAY	MG/L		7	2.80000	3.09335	1.75879	.628141	.664762	6.30000	1.10000
				L	1	7.70000					7.70000	7.70000
				TOT	8	3.41250	5.65270	2.37754	.696716	.840587	7.70000	1.10000
00400	PH		SU		7	6.74285	.306274	.553421	.082075	.209173	7.60000	6.00000
00431	T ALK	FIELD	MG/L		7	31.3857	362.221	19.0321	.606394	7.19346	62.6000	8.00000
00480	SALINITY		PPTH		8	6.62500	13.3650	3.65582	.551821	1.29253	11.0000	.800000
00500	RESIDUE	TOTAL	MG/L		6	5626.66	.276E+08	5261.07	.935024	2147.82	12900.0	350.000
00530	RESIDUE	TOT NFLT	MG/L		10	25.3000	333.568	18.2638	.721891	5.77553	66.0000	5.00000
01002	ARSENIC	AS,TOT	UG/L	K	3	10.0000	.000000	.000000		.000000	10.0000	10.0000
01027	CADMIUM	CD,TOT	UG/L	K	11	30.9091	229.092	15.1358	.489687	4.56361	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	11	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L		1	60.0000					60.0000	60.0000
				K	10	26.0000	93.3333	9.66092	.371574	3.05505	40.0000	20.0000
				TOT	11	29.0909	189.092	13.7511	.472694	4.14611	60.0000	20.0000
01051	LEAD	PB,TOT	UG/L		4	150.000	3333.33	57.7350	.384900	28.8675	200.000	100.000
				K	7	100.000	.000000	.000000		.000000	100.000	100.000
				TOT	11	118.182	1636.37	40.4521	.342287	12.1968	200.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	11	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L		3	46.6667	233.336	15.2753	.327329	8.81922	60.0000	30.0000
				K	8	27.5000	192.857	13.8873	.504993	4.90990	50.0000	20.0000
				TOT	11	32.7273	261.819	16.1808	.494414	4.87870	60.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML		5	58.0000	5070.00	71.2039	1.22765	31.8434	180.000	10.0000
32209	CHLRPHYL	A	UG/L		8	27.2500	831.357	28.8333	1.05810	10.1941	76.0000	1.00000
				K	1	1.00000					1.00000	1.00000
				TOT	9	24.3333	804.000	28.3549	1.16527	9.45163	76.0000	1.00000
32213	PHPHTN-A	FLR MTHD	UG/L		6	6.33333	7.86669	2.80476	.442857	1.14504	11.0000	3.00000
				K	3	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	9	4.55556	12.0278	3.46811	.761292	1.15604	11.0000	1.00000
32217	CHLRPHYL	A	UG/L		9	25.3333	595.750	24.4080	.963474	8.13600	66.0000	3.00000

Table 6 - continued

0208453-

BATH CREEK @ NC HWY 92 NEAR BATH NC PEAT
37013 NORTH CAROLINA BEAUFORT
SOUTHEAST 030307
TAR-PAMLICO RIVER
21NC01WQ 770527

/TYPA/AMBNT/ESTURY

INDEX
MILES

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		16	20.6625	51.1349	7.15087	.346080	1.78772	30.9000	10.0000
00076	TURB	TRBIDMTR	HACH FTU		14	13.0714	107.559	10.3711	.793415	2.77178	44.0000	5.00000
00094	CNDUCTVY	FIELD	MICROMHO		16	8077.81	.339E+08	5825.88	.721220	1456.47	17180.0	540.000
00300	DO		MG/L		16	8.94999	2.72407	1.65048	.184411	.412619	10.8000	4.30000
00310	BOD	5 DAY	MG/L		14	3.96428	1.53328	1.23826	.312354	.330939	6.10000	1.70000
				L	1	8.40000					8.40000	8.40000
				TOT	15	4.25999	2.73547	1.65393	.388246	.427042	8.40000	1.70000
00400	PH		SU		15	7.71999	.814610	.902557	.116912	.233039	8.90000	6.00000
00431	T ALK	FIELD	MG/L		14	38.0571	299.536	17.3071	.454766	4.62552	65.0000	18.0000
00480	SALINITY		PPTH		15	5.25333	12.3370	3.51240	.668605	.906898	10.8000	.000000
00500	RESIDUE	TOTAL	MG/L		4	5685.00	9761498	3124.34	.549576	1562.17	8480.00	2970.00
00530	RESIDUE	TOT NFLT	MG/L		15	15.0000	38.5714	6.21059	.414039	1.60357	32.0000	8.00000
01002	ARSENIC	AS,TOT	UG/L	K	9	10.0000	.000000	.000000		.000000	10.0000	10.0000
01027	CADMIUM	CD,TOT	UG/L	K	14	26.4286	163.188	12.7745	.483360	3.41413	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	14	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	14	24.2857	72.5282	8.51635	.350673	2.27609	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L		3	100.000	.000000	.000000		.000000	100.000	100.000
				K	11	100.000	.000000	.000000		.000000	100.000	100.000
				TOT	14	100.000	.000000	.000000		.000000	100.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	14	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L		3	36.6667	433.334	20.8167	.567728	12.0185	60.0000	20.0000
				K	11	25.4545	147.273	12.1356	.476757	3.65903	50.0000	20.0000
				TOT	14	27.8571	202.748	14.2390	.511143	3.80552	60.0000	20.0000
31616	FEC COLI	MFM-FCBR	/100ML		11	51.8182	4836.36	69.5440	1.34208	20.9683	240.000	10.0000
				K	5	10.0000	.000000	.000000		.000000	10.0000	10.0000
				TOT	16	38.7500	3625.00	60.2080	1.55375	15.0520	240.000	10.0000
32209	CHLRPHYL	A	UG/L		15	26.7333	793.496	28.1691	1.05371	7.27322	120.000	4.00000
32213	PHPHTN-A	FLR MTHD	UG/L		14	8.64286	39.7857	6.30759	.729804	1.68577	27.0000	1.00000
				K	1	1.00000					1.00000	1.00000
				TOT	15	8.13333	40.8381	6.39047	.785713	1.65001	27.0000	1.00000
32217	CHLRPHYL	A	UG/L		15	32.1333	900.981	30.0164	.934119	7.75019	130.000	4.00000

Table 6 - continued

0208455

PUNGO RIVER @US HWY 264 NR PONZER NC PEAT
37013 NORTH CAROLINA BEAUFORT
SOUTHEAST 030307
TAR-PAMLICO
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

INDEX
MILES

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		14	20.5071	48.5168	6.96540	.339658	1.86158	32.0000	11.0000
00076	TURB	TRBIDMTR	HACH FTU		16	8.01875	37.8722	6.15404	.767457	1.53851	28.0000	3.30000
00094	CNDUCTVY	FIELD	MICROMHO		14	6681.21	.306E+08	5535.17	.828469	1479.34	15300.0	136.000
00300	DO		MG/L		14	7.17142	4.75452	2.18049	.304052	.582760	11.2000	4.0000
00310	BOD	5 DAY	MG/L		14	1.86428	.610175	.781137	.419002	.208768	3.80000	1.0000
00400	PH		SU		14	6.51428	.445951	.667796	.102513	.178476	7.20000	4.6000
00431	T ALK	FIELD	MG/L		13	25.2846	158.471	12.5885	.497873	3.49143	56.5000	8.0000
00435	T ACDITY	CACO3	MG/L		2	17.0000	2.00000	1.41421	.083189	1.00000	18.0000	16.000
00480	SALINITY		PPTH		14	4.05714	10.4488	3.23246	.796733	.863910	9.00000	.00000
00500	RESIDUE	TOTAL	MG/L		6	3526.67	.149E+08	3865.89	1.09619	1578.24	10800.0	200.00
00530	RESIDUE	TOT NFLT	MG/L		17	8.11765	27.8603	5.27829	.650224	1.28017	18.0000	2.0000
01002	ARSENIC	AS,TOT	UG/L	K	12	10.0000	.000000	.000000		.000000	10.0000	10.000
01027	CADMIUM	CD,TOT	UG/L	K	17	25.2941	138.971	11.7886	.466061	2.85916	50.0000	20.00
01034	CHROMIUM	CR,TOT	UG/L	K	17	50.0000	.000000	.000000		.000000	50.0000	50.000
01042	COPPER	CU,TOT	UG/L	K	17	23.5294	61.7654	7.85910	.334012	1.90611	40.0000	20.000
01051	LEAD	PB,TOT	UG/L		2	150.000	5000.00	70.7107	.471404	50.0000	200.000	100.00
				K	15	100.000	.000000	.000000		.000000	100.000	100.00
				TOT	17	105.882	588.242	24.2537	.229063	5.88239	200.000	100.00
01067	NICKEL	NI,TOTAL	UG/L	K	17	100.000	.000000	.000000		.000000	100.000	100.00
01092	ZINC	ZN,TOT	UG/L		2	20.0000	.000000	.000000		.000000	20.0000	20.000
				K	15	26.0000	154.286	12.4212	.477738	3.20713	50.0000	20.000
				TOT	17	25.2941	138.971	11.7886	.466061	2.85916	50.0000	20.000
31616	FEC COLI	MFM-FCBR	/100ML		8	122.500	20392.9	142.804	1.16574	50.4887	440.000	20.000
				K	2	10.0000	.000000	.000000		.000000	10.0000	10.000
				TOT	10	100.000	18111.1	134.578	1.34577	42.5571	440.000	10.000
32209	CHLRPHYL	A	UG/L		9	11.8889	158.611	12.5941	1.05932	4.19803	34.0000	1.0000
				K	2	1.00000	.000000	.000000		.000000	1.00000	1.0000
				TOT	11	9.90909	146.291	12.0951	1.22060	3.64680	34.0000	1.0000
32213	PHPHTN-A	FLR MTHD	UG/L		10	4.60000	16.0444	4.00555	.870772	1.26667	15.0000	1.0000
				K	1	1.00000					1.00000	1.0000
				TOT	11	4.27273	15.6182	3.95199	.924933	1.19157	15.0000	1.0000
32217	CHLRPHYL	A	UG/L		11	12.7273	177.018	13.3048	1.04538	4.01155	43.0000	3.0000

Table 6 - continued

020845

PANTEGO CREEK @ NC HWY 92 @BELHAVEN NC PEAT
37013 NORTH CAROLINA BEAUFORT
SOUTHEAST 030307

TAR-PAMLICO
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

INDEX
MILES

PARAMETER			RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010 WATER	TEMP	CENT		15	19.6066	46.7974	6.84086	.348906	1.76630	29.9000	10.0000
00076 TURB	TRBIDMTR	HACH FTU		16	14.7625	116.535	10.7952	.731256	2.69879	36.0000	4.10000
00094 CNDUCTVY	FIELD	MICROMHO		15	8843.86	.314E+08	5607.73	.634081	1447.91	19530.0	880.000
00300 DO		MG/L		15	9.09333	6.24927	2.49985	.274911	.645459	16.2000	5.60000
00310 BOD	5 DAY	MG/L		14	4.45713	13.8226	3.71788	.834141	.993645	16.0000	1.00000
			L	1	7.60000					7.60000	7.60000
			TOT	15	4.66666	13.4938	3.67339	.787156	.948465	16.0000	1.00000
00400 PH		SU		14	7.53571	.576360	.759184	.100745	.202900	8.60000	6.00000
00431 T ALK	FIELD	MG/L		14	38.7143	253.231	15.9132	.411043	4.25299	65.6000	9.00000
00435 T ACDITY	CACO3	MG/L		1	16.0000					16.0000	16.0000
00480 SALINITY		PPTH		15	5.43333	11.5467	3.39804	.625407	.877371	12.5000	.400000
00500 RESIDUE	TOTAL	MG/L		6	5203.33	.202E+08	4503.01	.865408	1838.35	12200.0	830.000
00530 RESIDUE	TOT NFLT	MG/L		17	18.2941	188.846	13.7421	.751178	3.33296	60.0000	6.00000
01002 ARSENIC	AS,TOT	UG/L	K	11	10.0000	.000000	.000000		.000000	10.0000	10.0000
01027 CADMIUM	CD,TOT	UG/L	K	16	25.6250	146.250	12.0934	.471937	3.02335	50.0000	20.000
01034 CHROMIUM	CR,TOT	UG/L		1	60.0000					60.0000	60.0000
			K	15	50.0000	.000000	.000000		.000000	50.0000	50.0000
			TOT	16	50.6250	6.25000	2.50000	.049383	.625000	60.0000	50.0000
01042 COPPER	CU,TOT	UG/L		1	20.0000					20.0000	20.0000
			K	15	24.0000	68.5714	8.28079	.345033	2.13809	40.0000	20.0000
			TOT	16	23.7500	65.0000	8.06226	.339463	2.01556	40.0000	20.0000
01051 LEAD	PB,TOT	UG/L		4	100.000	.000000	.000000		.000000	100.000	100.000
			K	12	100.000	.000000	.000000		.000000	100.000	100.000
			TOT	16	100.000	.000000	.000000		.000000	100.000	100.000
01067 NICKEL	NI,TOTAL	UG/L	K	16	100.000	.000000	.000000		.000000	100.000	100.00
01092 ZINC	ZN,TOT	UG/L		6	55.5000	2309.50	48.0572	.865896	19.6193	150.000	23.000
			K	10	29.0000	210.000	14.4914	.499703	4.58258	50.0000	20.000
			TOT	16	38.9375	1071.40	32.7322	.840634	8.18304	150.000	20.000
31616 FEC COLI	MFM-FCBR	/100ML		10	27.0000	467.778	21.6282	.801043	6.83943	80.0000	10.000
			K	1	10.0000					10.0000	10.000
			TOT	11	25.4545	447.273	21.1488	.830847	6.37661	80.0000	10.000
32209 CHLRPHYL	A	UG/L		15	33.2667	608.925	24.6764	.741775	6.37142	74.0000	1.0000
			K	2	1.00000	.000000	.000000		.000000	1.00000	1.0000
			TOT	17	29.4706	647.640	25.4488	.863532	6.17223	74.0000	1.0000
32213 PHPHTN-A	FLR MTHD	UG/L		14	11.4286	238.264	15.4358	1.35063	4.12539	60.0000	2.0000
			K	3	1.00000	.000000	.000000		.000000	1.00000	1.0000
			TOT	17	9.58823	210.382	14.5046	1.51275	3.51787	60.0000	1.0000
32217 CHLRPHYL	A	UG/L		17	35.7059	1106.72	33.2674	.931707	8.06853	120.000	3.0000

Table 6 - continued

02084570

PUNGO CK @ NC HWY 92 @SIDNEY CROSSROADS NC PEAT
37013 NORTH CAROLINA BEAUFORT
SOUTHEAST 030307
TAR-PAMLICO
21NC01WQ 811024

/TYPA/AMBNT/ESTURY

INDEX
MILES

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM
00010	WATER	TEMP	CENT		15	19.8333	46.9972	6.85545	.345653	1.77007	29.9000	10.0000
00076	TURB	TRBIDMTR	HACH FTU		16	14.8000	128.793	11.3487	.766805	2.83718	45.0000	5.00000
00094	CNDUCTVY	FIELD	MICROMHO		14	9557.14	.255E+08	5049.82	.528382	1349.62	18860.0	1580.00
00300	DO		MG/L		15	9.01999	5.46891	2.33857	.259265	.603816	15.3000	6.00000
00310	BOD	5 DAY	MG/L		14	4.98571	28.9336	5.37900	1.07888	1.43760	23.0000	1.40000
				L	1	8.60000					8.60000	8.60000
				TOT	15	5.22666	27.7378	5.26667	1.00765	1.35985	23.0000	1.40000
00400	PH		SU		14	7.49285	.549936	.741577	.098971	.198195	8.90000	6.10000
00431	T ALK	FIELD	MG/L		14	37.4000	194.672	13.9525	.373062	3.72896	60.6000	12.0000
00480	SALINITY		PPTH		15	5.86666	8.84525	2.97410	.506949	.767908	11.9000	1.00000
00500	RESIDUE	TOTAL	MG/L		6	5586.66	.122E+08	3495.62	.625707	1427.08	8950.00	540.000
00530	RESIDUE	TOT NFLT	MG/L		17	19.4706	355.265	18.8485	.968049	4.57143	80.0000	7.00000
01002	ARSENIC	AS,TOT	UG/L	K	11	10.0000	.000000	.000000		.000000	10.0000	10.0000
01027	CADMIUM	CD,TOT	UG/L	K	16	25.6250	146.250	12.0934	.471937	3.02335	50.0000	20.0000
01034	CHROMIUM	CR,TOT	UG/L	K	16	50.0000	.000000	.000000		.000000	50.0000	50.0000
01042	COPPER	CU,TOT	UG/L	K	16	23.7500	65.0000	8.06226	.339463	2.01556	40.0000	20.0000
01051	LEAD	PB,TOT	UG/L		3	133.333	3333.35	57.7352	.433014	33.3334	200.000	100.000
				K	13	100.000	.000000	.000000		.000000	100.000	100.000
				TOT	16	106.250	625.000	25.0000	.235294	6.25000	200.000	100.000
01067	NICKEL	NI,TOTAL	UG/L	K	16	100.000	.000000	.000000		.000000	100.000	100.000
01092	ZINC	ZN,TOT	UG/L		2	23.0000	18.0000	4.24264	.184463	3.00000	26.0000	20.0000
				K	14	27.1571	251.916	15.8719	.584445	4.24193	50.0000	.200000
				TOT	16	26.6375	221.543	14.8843	.558773	3.72108	50.0000	.200000
31616	FEC COLI	MFM-FCBR	/100ML		10	85.0000	10250.0	101.242	1.19108	32.0156	350.000	10.0000
				K	1	10.0000					10.0000	10.0000
				TOT	11	78.1818	9736.37	98.6730	1.26210	29.7510	350.000	10.0000
32209	CHLRPHYL	A	UG/L		15	43.0000	3503.00	59.1861	1.37642	15.2818	190.000	2.00000
32213	PHPHTN-A	FLR MTHD	UG/L		12	7.33333	26.9697	5.19324	.708169	1.49916	18.0000	2.00000
				K	3	1.00000	.000000	.000000		.000000	1.00000	1.00000
				TOT	15	6.06667	28.0667	5.29780	.873264	1.36789	18.0000	1.00000
32217	CHLRPHYL	A	UG/L		15	44.4667	2619.55	51.1816	1.15101	13.2150	160.000	5.00000

Dissolved Oxygen, Biochemical Oxygen Demand, and Fecal Coliform Bacteria

Dissolved oxygen levels were low at several stations in the study area. The Scuppernong River at SR 1105 near Columbia (02081166) had 80% of all dissolved oxygen (DO) values below the state standard of 5.0 mg/l (daily average). The low dissolved oxygen levels at this station were probably due to a combination of swampy waters (with naturally low DO's) and impact from non-point source pollution. Agricultural runoff could have had an affect on the low DO level at this station. The Alligator River above Cherry Ridge Landing near Gum Neck (0208117810) and Kendrick Creek (02081185) had approximately one third of all DO levels below the state standard. This was likely due to the swampy conditions at these locations.

Five-day biochemical oxygen demand (BOD_5) is the amount of oxygen which is utilized in 5 days in a water sample. One slightly elevated BOD_5 (5.0 mg/l) occurred at the Scuppernong River station (02081166). This value, along with the low DO values here, could have been caused by agricultural runoff. The Intracoastal Waterway station (0208455655) had two slightly elevated BOD_5 values: one greater than 7.7 mg/l and the other, 6.3 mg/l. Bath Creek at NC Hwy 92 near Bath (02084534) had four BOD_5 values that were somewhat elevated. These values were one greater than 8.4 mg/l, 6.1 mg/l, 5.0 mg/l, and 5.2 mg/l. Pantego Creek at NC Hwy 92 at Belhaven (0209455850) had several high BOD_5 values with the highest being 16 mg/l. These could have been caused by the effluent discharges from fish processing plants in the area. About one fourth of all BOD_5 values at Pungo Creek at NC Hwy 92 at Sidney Crossroads (0208457020) were elevated. The highest BOD_5 value found here was 23 mg/l.

A few elevated fecal coliform bacteria values were found in the CEIP study area. The Scuppernong River station (02081166) had one very high value of 17,000/100 ml which is above the state standard of 100/100 ml. This was probably due to runoff, as the highest turbidity value for this station (45 NTU) occurred on the same day (December 13, 1982). One elevated fecal coliform bacteria value (3900/100 ml) occurred at Kendrick Creek at Mackeys (02081185). It is likely that this elevated coliform value was also due to runoff.

Chlorophyll a Corrected

Elevated chlorophyll a values above the state standard of 40 ug/l occurred at several stations. The Scuppernong River station (02081166) had one value of 51 ug/l in 1982. The Intracoastal Waterway near Scranton (0208455655) had 3 values above the 40 ug/l standard. These values were 76 ug/l, 45 ug/l, and 58 ug/l. A single high value of 120 ug/l occurred at Bath Creek (02084534). Approximately one-third of chlorophyll a corrected values at Pantego Creek at Belhaven (0208455850) were above the state standard with the highest value being 74 ug/l. Pungo Creek at Sidney Crossroads (0208457020) had about one-fourth of all chlorophyll a values above the standard. The highest chlorophyll a corrected value found here was 190 ug/l, which was the highest value found in the study area for this parameter. It is clear from this information that waterways around the Pamlico/Albemarle peninsula have the ability to support algal populations in excess of the current state standards for chl a. It is likely that physical factors other than nutrients may be limiting potential nuisance problems.

Metals

Stations within the CEIP study area were sampled for various metals in the water column. Only zinc, lead, chromium, and mercury were found in levels above detection limits.

One zinc value of 30 ug/l was found at the Scuppernong River at SR 1105 near Columbia, NC (02081166). The value for zinc was slightly above the detection limit of 20 ug/l and probably does not indicate a problem level. A zinc value of 90 ug/l was found at Kendrick Creek at SR 1300 at Mackeys, N.C. (02081185). The American Fisheries Society (AFS), in A Review of the EPA Red Book: Quality Criteria for Water, suggests a criteria of 50 ug/l for zinc in waters with less than 150 mg/l hardness. Hardness values at this station are in this range, therefore, the positive zinc value found at this station exceeds the AFS criteria. However, it should be noted that this is only one observation and may not indicate a problem situation. A zinc value of 150 ug/l occurred at Pantego Creek at N.C. Hwy 92 at Belhaven (0208455850). In the AFS

review of the redbook publication mentioned above, a recommended level of 600 ug/l for zinc is given for waters with hardness values in the same range that existed at this station. Therefore, this zinc value is probably no cause for concern.

Two elevated lead values of 200 ug/l were found at the Intracoastal Waterway at US Hwy 264 near Scranton (0208455655). These values are above the state standard of 30 ug/l. A possible source of these elevated lead values could be leaded gasoline from boats since many boats use the Intracoastal Waterway. The Pungo River at U.S. Hwy 264 near Ponzer (0208455650) also had a lead value of 200 ug/l. A 200 ug/l lead value occurred at Pungo Creek at N.C. Hwy 92 at Sidney Crossroads (0208457020) as well.

A chromium value of 60 ug/l occurred at the Scuppernong River station (02081166). This value was well below the 100 ug/l criteria for freshwater aquatic life listed in the Quality Criteria for Water book published by the U.S. Environmental Protection Agency.

Total mercury analyses were completed on 87 water samples collected during the study period January 1, 1983 through February 1984 (Tables 8 & 9). Nine samples (10%) were above the laboratory detection limit of 0.2 ug/l for mercury. Of the nine samples greater than 0.2 ug/l, seven were equal to 0.3 ug/l, one was equal to 0.4 ug/l, and one observation was equal to 1.6 ug/l.

The evaluation of mercury concentration data in surface waters is complicated by a wide range of published criteria and standards which are listed below.

Important Mercury Criteria

MERCURY DETECTION LIMITS:	AS OF JANUARY 1982 0.2 ug/l			PRIOR TO JANUARY 1982 0.5 ug/l	
MERCURY CRITERIA AND STANDARDS FOR THE PROTECTION OF:					
ORGANIZATION AND DATE	FRESHWATER AQUATIC LIFE	SALTWATER AQUATIC LIFE	DOMESTIC WATER SUPPLY	INGESTION OF WATER AND AQUATIC ORGANISMS	INGESTION OF AQUATIC ORGANISMS ALONE
EPA "RED BOOK" (1976)	0.05 ug/l	0.10 ug/l	2.0 ug/l		
ENVIRONMENTAL MANAGEMENT (1979)	0.05 ug/l	0.05 ug/l	0.05 ug/l		
EPA QUALITY CRITERIA (1980)	0.2 ug/l 24 hour average	0.10 ug/l 24 hour average		0.144 ug/l	0.146 ug/l
	4. 1ug/l at any time	3.7 ug/l at any time			
U.S.S.R. (1963)	5.0 ug/l				
WORLD HEALTH ORGANIZATION (1971)			1.0 ug/l		

FOOD AND DRUG ADMINISTRATION ACTION LEVEL FOR MERCURY CONCENTRATIONS IN FISH TISSUE

1976 ——— 0.5 mg/kg
1978 ——— 1.0 mg/kg

It is probable that a wide range of values is a result of the difficulties in obtaining precise analytical measurements as well as the variation of effects of different forms of mercury. Prior to January of 1982, the laboratory detection capabilities of DEM prohibited the quantification of mercury samples with concentrations below 0.5 ug/l. As of January 1, 1982 this detection level was lowered to 0.2 ug/l. Prior to the use of the 0.2 ug/l detection limit, the reliability of data in the low concentration range was often suspect. Data reliability was further complicated by frequent sample contamination with mercuric chloride (used as a preservative for nutrient samples). In January of 1983, mercuric chloride preservation of nutrient samples was discontinued. Since that time, data reliability has improved.

The values above the detection limit of 0.2 ug/l encountered during this study period probably represent either contamination (in the case of the one 1.6 ug/l observation) or difficulties in analytical accuracy (standard deviation 0.07 ug/l) rather than environmental conditions. These conclusions are supported by fish tissue analyses; the best available monitoring tool to assess the potential threat of mercury pollution.

Table 7

Mercury Observations

January 1983 - February 1984

Station	# Samples	# Samples > 0.2 ug/l	# Samples = 0.3 ug/l	# Samples = 0.4 ug/l	# Samples >0.4 ug/l
02081166	12	0	0	0	0
0208117810	3	0	0	0	0
0208117820	2	1	1	0	0
0208117830	2	1	1	0	0
0208117840	2	1	1	0	0
02081185	5	1	0	0	1
02084534	11	2	2-	0	0
0208455650	16	1	0	1	0
0208455655	8	0	0	0	0
0208455850	13	0	0	0	0
0208457020	13	2	2	0	0
	87	9	7	1	1

Table 8

Mercury Data

SCUPPERNONG R @ SR 1105 NR COLUMBIA NC
NORTH CAROLINA TYRRELL

02081166

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/04/18	11 00	00.0	0.2K
83/05/23	16 00	00.0	0.2K
83/06/17	10 05	00.0	0.2K
83/06/21	16 20	00.0	0.2K
83/07/20	12 10	00.0	0.2K
83/08/30	10 40	00.0	0.2K
83/09/15	12 00	00.0	0.2K
83/10/24	10 40	00.0	0.2K
83/11/17	10 50	00.0	0.2K
83/12/15	10 30	00.0	0.2K
84/01/30	13 40	00.0	0.2K
84/02/13	09 15	00.0	0.2K

ALLIGATOR R US CHERRY RIDGE LANDING
NORTH CAROLINA TYRRELL

0208117810

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/04/18	13 45	00.0	0.2K
83/07/20	13 00	00.0	0.2K
84/01/30	11 40	00.0	0.2K

ALLIGATOR RIVER @ NEWPORT NEWS POINT
NORTH CAROLINA TYRRELL

0208117820

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/04/18	12 50	00.0	0.2K
83/09/20	13 35	00.0	0.3

ALLIGATOR RIVER 3 MILES US CATFISH POINT
NORTH CAROLINA TYRRELL

0208117830

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/04/18	12 20	00.0	0.3
83/09/20	13 15	00.0	0.2

ALLIGATOR R @ US HWY64 NR ALLIGATOR NC
NORTH CAROLINA TYRRELL

0208117840

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/04/18	12 00	00.0	0.2K
83/09/20	12 30	00.0	0.3

KENDRICKS CR @ SR1300 @ MACKEYS NC
37187 NORTH CAROLINA WASHINGTON

02081185

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/16	10 00	00.0	1.6
83/04/28	12 00	00.0	0.2K
83/07/27	13 45	00.0	0.2K
83/10/06	13 45	00.0	0.2K
84/01/30	14 20	00.0	0.2K

INTRACOASTAL WATERWAY @ US HWY264 SCRANTON
NORTH CAROLINA HYDE

0208455655

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/07	15 00	00.0	0.2
83/04/19	16 10	00.0	0.2K
83/05/17	15 00	07.9B	0.2K
83/07/19	10 20	00.0	0.2K
83/07/25	14 30	00.0	0.2K
83/08/10	17 30	00.0	0.2K
83/10/13	15 00	00.0	0.2K
84/01/26	15 45	00.0	0.2K

Table 8 cont.

BATH CREEK @ NC HWY 92 NEAR BATH NC
NORTH CAROLINA BEAUFORT

02084534

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/07	11 45	00.0	0.3
83/04/25	10 10	00.0	0.2K
83/05/26	10 30	00.0	0.2K
83/06/23	12 10	00.0	0.2K
83/07/25	11 30	00.0	0.2K
83/08/15	15 15	00.0	0.3
83/09/28	16 10	00.0	0.2K
83/10/13	12 30	00.0	0.2K
83/11/09	15 30	00.0	0.2K
83/12/14	15 00	00.0	0.2K
84/01/26	13 15	00.0	0.2K
84/02/27	13 15	00.0	0.2

FUNGO RIVER @US HWY 264 NR FONZER NC
NORTH CAROLINA BEAUFORT

0208455650

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/03	14 10	00.0	0.2K
83/03/07	15 00	00.0	0.2
83/04/19	16 45	00.0	0.2K
83/04/25	12 55	00.0	0.2K
83/05/16		04.3B	0.2K
83/05/26	13 30	00.0	0.2K
83/06/23	14 45	00.0	0.2K
83/07/19	10 45	00.0	0.2K
83/07/25	13 30	00.0	0.2K
83/08/10	16 10	00.0	0.2K
83/08/15	12 00	00.0	0.4
83/09/28	14 10	00.0	0.2K
83/10/13	14 20	00.0	0.2K
83/11/09	12 30	00.0	0.2K
83/12/14	11 15	00.0	0.2K
84/01/26	15 10	00.0	0.2K
84/02/27	15 15	00.0	0.2

Table 8 cont.

PANTEGO CREEK @ NC HWY 92 @BELHAVEN NC
NORTH CAROLINA BEAUFORT

0208455850

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/07	13 10	00.0	0.2
83/04/19	14 20		0.2K
83/04/25	11 40	00.0	0.2K
83/05/17	12 40	01.8B	0.2K
83/05/26	12 15	00.0	0.2K
83/06/23	13 55	00.0	0.2K
83/07/25	13 00	00.0	0.2K
83/08/15	13 00	00.0	0.2
83/09/28	14 50	00.0	0.2K
83/10/13	13 50	00.0	0.2K
83/11/09	13 30	00.0	0.2K
83/12/14	11 40	00.0	0.2K
84/01/26	14 35	00.0	0.2K
84/02/27	14 50	00.0	0.2K

PUNGO CK @ NC HWY 92 @SIDNEY CROSSROADS NC
NORTH CAROLINA BEAUFORT

0208457020

DATE FROM TO	TIME OF DAY	DEPTH METER	MERCURY HG,TOTAL UG/L
83/03/07	12 40	00.0	0.3
83/04/19	13 20	00.0	0.2K
83/04/25	11 05	00.0	0.2K
83/05/17	12 00	04.9B	0.2K
83/05/26	11 30	00.0	0.2K
83/06/23	13 20	00.0	0.2K
83/07/25	12 30	00.0	0.2K
83/08/15	14 20	00.0	0.3
83/09/28	15 20	00.0	0.2K
83/10/13	13 15	00.0	0.2K
83/11/09	14 20	00.0	0.2K
83/12/14	14 15	00.0	0.2K
84/01/26	14 10	00.0	0.2K

FISH ANALYSIS

Fish from seven sites in the Pamlico-Albemarle Peninsula were collected between May 17, 1983 and January 11, 1984. Tissue samples were from 113 fish (19 species) and represented several levels of the food chain; first order predators, second order predators, and omnivores. Species included american eel, black crappie, bluegill sunfish, bowfin, brown bullhead, carp, chain pickerel, chub sucker, gizzard shad, large-mouth bass, longnose gar, pumpkinseed, stripped bass, stripped mullet, warmouth, white catfish, white perch, yellow bullhead, and yellow perch.

Fish were collected at seven locations by electroshocking and by means of gill nets. The fish that were collected were wrapped in aluminum foil and then placed in large plastic bags with ice to await laboratory preparation. Each fish was identified to species level, weighed to the nearest gram, and measured to the nearest tenth of a centimeter. Each fish was scaled and fillet portions were removed. The skin was removed from the fillet and the fillet was then homogenized in a blender and wrapped in aluminum foil. If a fish was too small to obtain a sufficient quantity of fillet, a whole scaled fish sample was used. The metals analysis on the fish tissue samples was done by flameless atomic absorption.

All fish tissue results are reported in mg/kg wet weight (Table 14). Concentrations are reported as actual concentrations or as a "less than" value based on the laboratory's current detection limits which are as follows:

Mercury	0.02 mg/kg
Arsenic	0.40 mg/kg
Cadmium	0.20 mg/kg
Chromium, Total	0.05 mg/kg
Copper	0.20 mg/kg
Nickel	1.00 mg/kg
Lead	1.00 mg/kg
Zinc	0.20 mg/kg

For statistical purposes all "less than" values are taken to be the detection level, thus maximizing all metal values to represent worst case conditions. For example: less than 0.5 would be expressed as 0.5. One hundred and two samples were analyzed for mercury, 99 samples were analyzed for cadmium, chromium, nickel, lead, and zinc, and 87 samples were analyzed for arsenic. The results for mercury, cadmium, copper, lead, and zinc had a significant number of values above detection and will thus be discussed separately. The results for arsenic, chromium, and nickel were mostly below the detection level and will be discussed at this point. All arsenic values were less than the detection level. Of the 99 samples analyzed for nickel, only two were above the detection level. These two samples were 1.7 mg/kg and 1.1 mg/kg from sunfish collected at station 02081185, Kendrick Creek near Mackeys. Only 7 of the 99 samples analyzed for chromium were above the detection level. This should be of little concern since chromium is recognized as an essential trace element for humans (NAS, 1974) and chromium deficiency is a greater nutritional concern than overexposure (EPA-1976).

Mercury

Mercury is a silver-white metal which exists in hundreds of different forms. Certain microorganisms have been found to convert inorganic and organic forms of mercury to the highly toxic methyl and dimethyl mercury, thus making any form of mercury potentially available to the environment (Jensen & Jernelov, 1969). Methyl mercury has been shown to be a particular threat because of its ability to bioaccumulate with increases in body weight and trophic level (Koli, Williams, McClary, Wright, and Burrell, 1977). The current Food and Drug Administration "action level" is 1.0 mg/kg for fish tissue.

One hundred and two samples were analyzed for mercury in the Pamlico-Albemarle area. The average fish tissue concentration was 0.09 mg/kg (Table 9) with station 02081185 on Kendrick Creek having the highest average (0.21 mg/kg) and station 0208455850 on Pantego Creek having the lowest (0.02 mg/kg). This level is well below the FDA action

level of 1 mg/kg and also below the average value of 0.12 mg/kg for the North Carolina Statewide Ambient Fish Tissue Network 1980-1983. The National Pesticide Monitoring Program in 1976/1977 recorded a Nationwide Mercury Average of 0.11 mg/kg (May & McKinney, 1981). Fish from B. Everett Jordan Lake, which is in central North Carolina on the Haw River and is downriver from a considerable number of industrial dischargers, had an average mercury concentration of 0.22 mg/kg (NRCD, 1983).

In areas where mercury is a problem, the mercury levels found are much higher. In LaHontan Reservoir, Nevada, where the drainage area has been contaminated with mercury via gold and silver mining, an average concentration of 1.72 mg/kg in fish muscle tissue was found (Cooper, 1983). In the Holston River, Tennessee, 135 kilometers below an abandoned chloro-alkali plant, an average concentration in muscle was 0.85 mg/kg (Hildebrand, Andrew, and Huckabee, 1976). In North Carolina, where mercury was introduced into a stream system by a battery plant, concentrations averaged 0.59 mg/kg (NRCD unpublished). In conclusion, the mercury concentration of 0.09 mg/kg is well below the FDA action level of 1.0 mg/kg and should be of little concern environmentally.

Cadmium

Cadmium is a soft, white metal similar to zinc and lead in many properties. Biologically, cadmium is a nonessential, nonbeneficial element recognized to be of high toxic potential and able to accumulate in various body tissues (EPA-1976).

Ninety-nine samples were analyzed for cadmium in the Pamlico-Albemarle area (Table 10) and only 21 percent of the samples were above detection. An average concentration of 0.21 mg/kg was found. Station 0208455850, Pantego Creek at Highway 92, had the highest average level of cadmium (0.24 mg/kg) and the greatest percentage of samples above detection (89%).

The levels of cadmium which were found in the Pamlico-Albemarle fish are not easily interpreted because fish tissue samples were only done on fillets and whole fish. The fillets and whole fish samples are less significant because cadmium accumulates to a greater extent in the kidney,

Mercury - Table 9

# of Sampling Stations	# of Fish Sampled	# of Species Sampled	Length (cm)			Weight (gr)			Total # of Hg Samples	# of Detectable Hg Samples	Mercury Conc. (mg/kg)		
			Avg	Max	Min	Avg	Max	Min			Avg	Max	Min
7	113	19	31.3	74.0	13.3	489	3075	38	102	75	.09	1.3	.02

Station	# of Fish Sampled	# of Species Sampled	Total # of Hg Samples	# of Detectable Hg Samples	Mercury Conc. (mg/kg)		
					Avg	Max	Min
02081166	27	9	27	26	0.15	0.34	0.02
0208117810	9	3	5	5	0.06	0.19	0.03
02081195	17	7	10	10	0.21	1.30	0.04
02084534	24	9	24	14	0.06	0.16	0.02
0208455650	9	4	9	7	0.04	0.08	0.02
0208455850	9	2	9	1	0.02	0.04	0.02
0208457020	18	8	18	10	0.04	0.12	0.02

Mercury - Continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Hg Samples	# of Detectable Hg Samples	Mercury Conc. (mg/kg) Avg	Max	Min
American Eel	1	48.5	275	1	1	.05	.05	.05
Black Crappie	2	24.2	235	2	2	.10	.11	.08
Bluegill Sunfish	14	14.8	83	8	6	.04	.08	.02
Bowfin	9	49.2	1215	9	9	.31	1.30	.09
Brown Bullhead	11	31.3	436	11	8	.06	.27	.02
Carp	8	44.1	1457	8	4	.04	.09	.02
Chain Pickeral	9	42.2	609	9	8	.12	.27	.02
Gizzard Shad	1	32.1	300	1	0	.02	.02	.02
Largemouth Bass	4	29.2	395	4	4	.11	.16	.09
Longnose Gar	7	64.2	840	7	7	.13	.31	.06
Pumpkinseed	6	15.9	97	6	3	.03	.05	.02
Stripped Mullet	3	29.3	311	3	0	.02	.02	.02
Warmouth	5	17.6	144	5	5	.17	.27	.03
White Catfish	10	34.1	676	10	8	.04	.07	.02
White Perch	17	20.3	139	12	5	.03	.13	.02
Yellow Bullhead	1	31.5	463	1	1	.18	.18	.18
Yellow Pearch	3	19.6	106	2	2	.05	.05	.04
Chub Sucker	1	26.4	320	1	1	.08	.08	.08
Stripped Bass	1	27.5	247	1	0	.02	.02	.02

Cadmium - Table 10

# of Sampling Stations	# of Fish Sampled	# of Species Sampled	Length (cm)			Weight (gr)			Total # of Cd Samples	# of Detectable Cd Samples	Cadmium Conc. (mg/kg)		
			Avg	Max	Min	Avg	Max	Min			Avg	Max	Min
7	110	18	30.9	74.0	13.3	490	3075	38	99	21	0.21	.33	0.20

Station	# of Fish Sampled	# of Species Sampled	Total # of Cd Samples	# of Detectable Cd Samples	Cadmium Conc. (mg/kg)		
					Avg	Max	Min
02081166	27	9	27	0	0.20	0.20	0.20
0208117810	9	3	5	3	0.22	0.25	0.20
02081185	17	7	10	0	0.20	0.20	0.20
02084534	24	9	24	4	0.22	0.30	0.20
0208455650	6	2	6	0	0.20	0.20	0.20
0208455850	9	2	9	8	0.24	0.28	0.20
0208457020	18	8	18	6	0.23	0.33	0.20

Cadmium - continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Cd Samples	# of Detectable Cd Samples	Cadmium Conc. (mg/kg) Avg	Max	Min
Black Crappie	2	24.2	235	2	0	0.20	0.20	0.2
Bluegill Sunfish	14	14.8	83	8	1	0.21	0.30	0.2
Bowfin	9	49.2	1215	9	0	0.20	0.20	0.2
Brown Bullhead	11	31.3	436	11	2	0.22	0.31	0.2
Carp	8	44.1	1457	8	0	0.20	0.20	0.2
Chain Pickeral	9	42.2	609	9	2	0.22	0.33	0.2
Chub Sucker	1	26.4	320	1	0	0.20	0.20	0.2
Gizzard Shad	1	32.1	300	1	0	0.20	0.20	0.2
Largemouth Bass	4	29.2	395	4	1	0.23	0.30	0.2
Longnose Gar	6	63.5	831	6	0	0.20	0.20	0.2
Punpkinseed	6	15.9	97	6	1	0.21	0.28	0.2
Stripped Bass	1	27.5	247	1	0	0.20	0.20	0.2
Stripped Mullet	3	29.3	311	3	1	0.20	0.20	0.2
Warmouth	4	17.1	142	4	0	0.20	0.20	0.2
White Catfish	10	34.1	676	10	4	0.22	0.30	0.2
White Perch	17	20.3	139	12	8	0.22	0.28	0.2
Yellow Bullhead	1	31.5	463	1	0	0.20	0.20	0.2
Yellow Perch	3	19.6	106	2	0	0.20	0.20	0.2

liver, and gill tissues and to a lesser extent in the muscle tissue (Benoit, Leonard, Christensen, & Fiandt, 1976). With this in mind, the levels of cadmium recorded in the Pamlico-Albemarle area, particularly in Pantego Creek, may be of some environmental significance since the levels of cadmium in the kidneys, gills, and livers of these are probably greater than the values we recorded.

Copper

Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher (EPA-1980A).

In the Pamlico-Albemarle study, 99 samples were analyzed for copper (Table 11) with an average concentration of 1.09 mg/kg. Station 0208455850, Pantego Creek at Hwy. 92, had the highest average concentration, 4.74 mg/kg and station 02081185 Kendrick Creek near Mackeys had the lowest (0.55 mg/kg). The highest concentration of copper was in a white perch (11.0 mg/kg).

The N.C. Statewide Ambient Fish Tissue Network, comprising 196 copper samples from 42 different stations, showed copper concentrations averaging 2.1 mg/kg with a maximum of 33 mg/kg and a minimum of less than 0.2 mg/kg. In the National Pesticide Monitoring Program (NPMP) 1980 study, of 24 samples, a mean of 0.78 mg/kg was reported (NPMP, 1980). In fish from B. Everett Jordan Lake during 1982 and 1983, an average concentration of 0.53 mg/kg was found (NRCD, 1983).

The copper concentration of 1.09 mg/kg in the Pamlico-Albemarle area is below the North Carolina statewide average of 2.1 mg/kg and should be of little concern. The average concentration at station 0208455850, Pantego Creek at Hwy. 92, however, at 4.74 mg/kg is over twice the statewide average.

Lead

Lead is a toxic metal that tends to accumulate in the tissue of man and animals (EPA, 1976). It is ubiquitous in nature being a part of the earth's crust, but the largest portion of lead which contaminates the environment comes from airborne particles (EPA, 1980).

Copper - Table 11

# of Sampling Stations	# of Fish Sampled	# of Species Sampled	Length (cm)			Weight (gr)			Total # of Cu Samples	# of Detectable Cu Samples	Copper Conc. (mg/kg)		
			Avg	Max	Min	Avg	Max	Min			Avg	Max	Min
7	110	18	30.9	74.0	13.3	490	3075	38	99	93	1.09	11.0	.20

Station	# of Fish Sampled	# of Species Sampled	Total # of Cu Samples	# of Detectable Cu Samples	Copper Conc. (mg/kg)		
					Avg	Max	Min
02081166	27	9	27	26	0.63	2.50	0.20
0208117810	9	3	55	4	1.40	4.10	0.20
02084534	24	9	24	24	0.87	4.20	0.40
0208455650	6	2	6	6	0.94	3.50	0.33
0208455850	9	2	9	9	4.74	11.0	2.10
0208457020	18	8	18	15	0.49	1.10	0.20
02081185	17	7	10	9	0.55	0.96	0.20

Copper - continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Cu Samples	# of Detectable Cu Samples	Copper Conc. (mg/kg) Avg	Max	Min
Black Crappie	2	24.2	235	2	2	0.50	0.51	0.48
Bluegill Sunfish	14	14.8	83	8	8	0.72	1.20	0.37
Bowfin	9	49.2	1215	9	8	0.28	0.35	0.20
Brown Bullhead	11	31.3	436	11	11	0.78	2.50	0.35
Carp	8	44.1	1457	8	8	0.76	1.10	0.29
Chain Pickeral	9	42.2	609	9	6	0.39	0.89	0.20
Chub Sucker	1	26.4	320	1	1	1.00	1.00	1.00
Gizzard Shad	1	32.1	300	1	1	1.10	1.10	1.10
Largemouth Bass	4	29.2	395	4	4	0.54	0.74	0.42
Longnose Gar	6	63.5	831	6	5	0.96	3.50	0.20
Pumpkinseed	6	15.9	97	6	5	0.45	0.88	0.20
Stripped Bass	1	27.5	247	1	1	0.55	0.55	0.55
Stripped Mullet	3	29.3	311	3	3	1.66	2.20	0.69
White Catfish	10	34.1	676	10	10	.52	1.10	.28
Warmouth	4	17.1	142	4	4	.49	0.82	0.31
White Perch	17	20.3	139	12	12	4.28	11.00	1.7
Yellow Perch	3	19.6	106	2	2	0.76	0.81	0.71
Yellow Bullhead	1	31.5	463	1	1	0.94	0.94	0.94

Lead Table 12

# of Sampling Stations	# of Fish Sampled	# of Species Sampled	Length (cm)			Weight (gr)			Total # of Pb Samples	# of Detectable Pb Samples	Lead Conc. (mg/kg)		
			Avg	Max	Min	Avg	Max	Min			Avg	Max	Min
7	110	18	30.9	74.0	13.3	490	3075	38	99	36	1.47	5.3	1.0

Station	# of Fish Sampled	# of Species Sampled	Total # of Pb Samples	# of Detectable Pb Samples	Lead Conc. (mg/kg)		
					Avg	Max	Min
02081166	27	9	27	2	1.14	2.1	1.0
0208117810	9	3	5	3	2.80	5.3	1.0
02081185	17	7	10	7	2.01	3.1	1.0
02084534	24	9	24	7	1.40	2.8	1.0
0208455650	6	2	6	1	1.02	1.1	1.0
0208455850	9	2	9	9	2.14	3.1	1.3
0208457020	18	8	18	7	1.43	2.8	1.0

Lead – continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Pb Samples	# of Detectable Pb Samples	Lead Conc. (mg/kg) Avg	Max	Min
Black Crappie	2	24.2	235	2	2	1.95	2.1	1.8
Bluegill Sunfish	14	14.8	83	8	8	2.33	3.1	1.6
Bowfin	9	49.2	1215	9	0	1.00	1.0	1.0
Brown Bullhead	11	31.3	436	11	2	1.15	1.9	1.0
Carp	8	44.1	1457	8	0	1.00	1.0	1.0
Chain Pickeral	9	42.2	609	9	0	1.00	1.0	1.0
Chub Sucker	1	26.4	320	1	0	1.00	1.0	1.0
Gizzard Shad	1	32.1	300	1	1	1.80	1.8	1.8
Largemouth Bass	4	29.2	395	4	0	1.00	1.0	1.0
Longnose Gar	6	63.5	831	6	1	1.02	1.1	1.0
Pumpkinseed	6	15.9	97	6	6	2.30	2.8	1.9
Stripped Bass	1	27.5	247	1	1	1.80	1.8	1.8
Stripped Mullet	3	29.3	311	3	2	1.73	2.8	1.0
Warmouth	4	17.1	142	4	0	1.0	1.0	1.0
White Catfish	10	34.1	676	10	1	1.21	3.1	1.0
White Perch	17	20.3	139	12	10	2.40	5.3	1.0
Yellow Bullhead	1	31.5	463	1	0	1.0	1.0	1.0
Yellow Perch	3	19.6	106	2	1	1.8	2.6	1.0

Lead - continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Pb Samples	# of Detectable Pb Samples	Lead Conc. (mg/kg) Avg	Max	Min
Black Crappie	2	24.2	235	2	2	1.95	2.1	1.8
Bluegill Sunfish	14	14.8	83	8	8	2.33	3.1	1.6
Bowfin	9	49.2	1215	9	0	1.00	1.0	1.0
Brown Bullhead	11	31.3	436	11	2	1.15	1.9	1.0
Carp	8	44.1	1457	8	0	1.00	1.0	1.0
Chain Pickeral	9	42.2	609	9	0	1.00	1.0	1.0
Chub Sucker	1	26.4	320	1	0	1.00	1.0	1.0
Gizzard Shad	1	32.1	300	1	1	1.80	1.8	1.8
Largemouth Bass	4	29.2	395	4	0	1.00	1.0	1.0
Longnose Gar	6	63.5	831	6	1	1.02	1.1	1.0
Pumpkinseed	6	15.9	97	6	6	2.30	2.8	1.9
Stripped Bass	1	27.5	247	1	1	1.80	1.8	1.8
Stripped Mullet	3	29.3	311	3	2	1.73	2.8	1.0
Warmouth	4	17.1	142	4	0	1.0	1.0	1.0
White Catfish	10	34.1	676	10	1	1.21	3.1	1.0
White Perch	17	20.3	139	12	10	2.40	5.3	1.0
Yellow Bullhead	1	31.5	463	1	0	1.0	1.0	1.0
Yellow Perch	3	19.6	106	2	1	1.8	2.6	1.0

Ninety-nine samples were analyzed for lead in the Pamlico-Albemarle area (Table 12). A mean concentration of 1.49 mg/kg was found. Station 0208117810, Alligator River near Gum Neck, had the highest average concentration (2.80 mg/kg).

The N.C. Statewide Ambient Fish Tissue Network found an average lead concentration of 1.23 mg/kg. A mean lead level of 0.39 mg/kg has been reported in the National Pesticide Monitoring Program 1976/1977 (May & McKinney, 1981).

The levels of lead as an average are not very significant because of the high detection level , 1.0 mg/kg. Of all the samples analyzed for lead, only 36 percent were above detection. Only at station 0208455850, Pantego Creek at Hwy 92, were all samples above detection, which in itself may be of some concern.

Zinc

Zinc is a common trace constituent of natural waters and is a required trace element in the metabolism of most organisms (EPA, 1980s).

Ninety-nine samples were analyzed for zinc in fish tissue in the Pamlico-Albemarle area (Table 13). The average zinc concentration was 8.93 mg/kg with station 02081185, Kendrick Creek near Mackeys, having the highest mean (16.05 mg/kg).

The N.C. Statewide Ambient Fish Tissue Network 1980-1982 reported an average zinc level of 14.6 mg/kg. A level of 24.5 mg/kg for meats, poultry, and fish was provided by Mahaffey, et. al. (1975).

Since the zinc levels in the Pamlico-Albemarle region are below the N.C. statewide average, and below that suggested for fish, meats, and poultry, they appear to pose no problem.

Zinc Table 13

# of Sampling Stations	# of Fish Sampled	# of Species Sampled	Length (cm)			Weight (gr)			Total # of Zn Samples	# of Detectable Zn Samples	Zinc Conc. (mg/kg)		
			Avg	Max	Min	Avg	Max	Min			Avg	Max	Min
7	110	18	30.9	74.0	13.3	490	3075	38	99	99	8.93	35	2.1

Station	# of Fish Sampled	# of Species Sampled	Total # of Zn Samples	# of Detectable Zn Samples	Zinc Conc (mg/kg)		
					Avg	Max	Min
02081166	27	9	27	27	4.54	10.0	2.1
0208117810	9	3	5	5	13.10	27.0	3.2
02081185	17	7	10	10	16.05	35.0	2.4
02084534	24	9	24	24	8.01	19.0	2.9
0208455650	6	2	6	6	6.50	8.1	4.7
0208455850	9	2	9	9	15.70	26.0	9.9
0208457020	18	8	18	18	9.10	16.0	3.6

Zinc - continued

Common Name	# of Fish Sampled	Avg Ln (cm)	Avg Wt (gr)	Total # of Zn Samples	# of Detectable Zn Samples	Zinc Conc. (mg/kg) Avg	Max	Min
Black Crappie	2	24.2	235	2	2	12.05	15.0	9.1
Bluegill Sunfish	14	14.8	83	8	8	17.38	33.0	12.0
Bowfin	9	49.2	1215	9	9	2.49	3.3	2.1
Brown Bullhead	11	31.3	436	11	11	5.82	12.0	2.8
Carp	8	44.1	1457	8	8	9.38	15.0	7.3
Chain Pickeral	9	42.2	609	9	9	6.38	19.0	3.0
Chub Sucker	1	26.4	320	1	1	4.30	4.3	4.3
Gizzard Shad	1	32.1	300	1	1	10.00	10.0	10.0
Largemouth Bass	4	29.2	395	4	4	4.80	9.1	3.2
Longnose Gar	6	63.5	831	6	6	3.97	8.1	2.5
Pumpkinseed	6	15.9	97	6	6	18.17	35.0	11.0
Stripped Bass	1	27.5	247	1	1	12.0	12.0	12.0
Stripped Mullet	3	29.3	311	3	3	8.97	12.0	2.9
Warmouth	4	17.1	142	4	4	4.63	6.3	3.6
White Catfish	10	34.1	676	10	10	6.08	12.0	3.2
White Perch	17	20.3	139	12	12	15.37	27.0	3.5
Yellow Bullhead	1	31.5	463	1	1	2.90	2.9	2.9
Yellow Perch	3	19.6	106	2	2	8.6	13.0	4.2

Table 14
Fish
Tissue
Data

SAMPLE#	DATE	STATION #	SP.	L(CM)	W(GR)	TYPE	HG MG/KG	AS MG/KG	CD MG/KG	CR.T MG/KG	CU MG/KG	NI MG/KG	PB MG/KG	ZN MG/
001411	830608	02081185	BF	58.0	1985	F	1.3		0.2K	0.50K	0.26	1.0K	1.0K	2.4
001412	830608	02081185	LG	74.0	1131	F	0.12		0.2K	0.50K	0.22	1.0K	1.0K	2.5
001413	830608	02081185	BKS	27.4	310	W	0.08		0.2K	0.50K	0.51	1.0K	1.8	15
001414	830608	02081185	CHP	39.6	430	F	0.27		0.2K	0.50K	0.20K	1.0K	1.0K	9.6
001415	830608	02081185	YP	17.3	57	WC2	0.05		0.2K	0.50K	0.71	1.0K	2.6	13
001415	830608	02081185	YP	18.0	64									
001416	830608	02081185	BGS	18.9	116	W	0.05		0.2K	0.50K	0.67	1.0K	2.1	17
001417	830608	02081185	BGS	18.6	112	W	0.08		0.2K	0.50K	0.56	1.0K	2.1	13
001418	830608	02081185	BGS	15.0	115	WC4	0.04		0.2K	0.59	0.96	1.0K	3.0	20
001418	830608	02081185	BGS	16.0	81									
001418	830608	02081185	BGS	15.7	76									
001418	830608	02081185	BGS	14.9	55									
001419	830608	02081185	BGS	14.3	55	WC4	0.04		0.2K	0.59	0.83	1.7	3.1	33
001419	830608	02081185	BGS	14.4	54									
001419	830608	02081185	BGS	13.4	45									
001419	830608	02081185	BGS	13.3	41									
001420	830608	02081185	SF	16.7	85	W	0.05		0.2K	0.50K	0.53	1.1	2.4	35
001576	840110	02084534	SF	16.3	129	W	0.02K	0.4K	0.2K	0.50K	0.43	1.0K	2.2	17
001577	840110	02084534	SF	15.7	126	W	0.02K	0.4K	0.28	0.50K	0.88	1.0K	2.8	18
001578	840110	02084534	BGS	16.6	98	W	0.02K	0.4K	0.2K	0.50K	0.59	1.0K	1.6	13
001579	840110	02084534	BGS	17.3	126	W	0.04	0.4K	0.30	0.50K	1.2	1.0K	2.0	15
001580	840110	02084534	BGS	16.5	115	W	0.03	0.4K	0.2K	0.50K	0.61	1.0K	1.9	12
001581	840110	02084534	WP	22.1	220	W	0.04	0.4K	0.2K	0.50K	2.1	1.0K	1.9	9.
001582	840110	02084534	BRB	26.3	232	W	0.02K	0.4K	0.2K	0.50K	0.79	1.0K	1.0K	8.
001583	840110	02084534	BRB	29.2	296	W	0.02K	0.4K	0.2K	0.50K	0.78	1.0K	1.8	12
001584	840110	02084534	BRB	30.4	401	F	0.05	0.4K	0.2K	0.50K	0.60	1.0K	1.0K	4.
001585	840110	02084534	BRB	29	295	F	0.02K	0.4K	0.2K	0.50K	1.0	1.0K	1.0K	4
001586	840110	02084534	BRB	28.7	327	F	0.03	0.4K	0.29	0.50K	0.52	1.0K	1.0K	5
001587	840110	02084534	SMU	31.9	378	F	0.02K	0.4K	0.2K	0.50K	0.69	1.0K	1.0K	2.
001588	840110	02084534	YP	23.4	198	F	0.04	0.4K	0.2K	0.50K	0.81	1.0K	1.0K	4.
001589	840110	02084534	CHP	36.3	426	F	0.02K	0.4K	0.2K	0.50K	0.89	1.0K	1.0K	1
001590	840110	02084534	CHP	41.6	497	F	0.11	0.4K	0.2K	0.50K	0.52	1.0K	1.0K	3
001591	840110	02084534	CHP	46	759	F	0.08	0.4K	0.2K	0.50K	0.42	1.0K	1.0K	3.
001592	840110	02084534	CHP	46.3	853	F	0.13	0.4K	0.2K	0.50K	0.40	1.0K	1.0K	3.
001593	840111	02084534	CHP	48.8	984	F	0.11	0.4K	0.2K	0.50K	0.42	1.0K	1.0K	3.
001594	840111	02084534	CHP	48.8	984	F(D)	0.13	0.4K	0.2K	0.50K	0.64	1.0K	1.0K	3.
001595	840111	02084534	CCS	26.4	320	F	0.08	0.4K	0.2K	0.50K	1.0	1.0K	1.0K	4.
001596	840111	02084534	LMB	28.6	298	W	0.09	0.4K	0.30	0.50K	0.74	1.0K	1.0K	9.
001597	840110	02084534	LMB	27.1	333	F	0.09	0.4K	0.2K	0.50K	0.42	1.0K	1.0K	3.
001598	840111	02084534	LMB	28.6	434	F	0.16	0.4K	0.2K	0.50K	0.53	1.0K	1.0K	3.
001599	840110	02084534	LMB	32.6	515	F	0.11	0.4K	0.2K	0.50K	0.45	1.0K	1.0K	3.
001610	840110	02084534	WP	23.8	267	W	0.03	0.4K	0.2K	0.50K	4.2	1.0K	1.0K	10

Table 14 cont.

SAMPLE#	DATE	STATION #	SP.	L(CM)	W(GR)	TYPE	HG MG/KG	AS MG/KG	CD MG/KG	CR.T MG/KG	CU MG/KG	NI MG/KG	PB MG/KG	ZN MG/K
001403	830608	02081166	GSH	32.1	300	W	0.02K		0.2K	0.50K	1.1	1.0K	1.8	10
001404	830608	02081166	BKS	21.0	160	W	0.11		0.2K	0.50K	0.48	1.0K	2.1	9.1
001405	830608	02081166	LG	71.0	895	F	0.31		0.2K	0.50K	0.20K	1.0K	1.0K	2.7
001519	831208	02081166	BF	45.7	813	F	0.11	0.4K	0.2K	0.50K	0.29	1.0K	1.0K	2.3
001520	831208	02081166	BF	59.2	1885	F	0.31	0.4K	0.2K	0.50K	0.33	1.0K	1.0K	2.5
001521	831208	02081166	BF	44.2	802	F	0.14	0.4K	0.2K	0.50K	0.35	1.0K	1.0K	2.4
001522	831208	02081166	BF	40.7	652	F	0.09	0.4K	0.2K	0.50K	0.31	1.0K	1.0K	2.7
001523	831208	02081166	BF	51	1259	F	0.34	0.4K	0.2K	0.50K	0.25	1.0K	1.0K	3.1
001524	831208	02081166	BF	43.8	776	F	0.17	0.4K	0.2K	0.50K	0.27	1.0K	1.0K	2.3
001525	831208	02081166	BF	42.7	765	F	0.17	0.4K	0.2K	0.50K	0.29	1.0K	1.0K	2.4
001526	831208	02081166	C	58.5	3075	F	0.08	0.4K	0.2K	0.50K	0.65	1.0K	1.0K	9.1
001527	831208	02081166	C	48	1684	F	0.09	0.4K	0.2K	0.50K	0.98	1.0K	1.0K	9
001528	831208	02081166	C	51.4	2043	F	0.06	0.4K	0.2K	0.50K	0.75	1.0K	1.0K	7.8
001529	831208	02081166	C	49.8	1625	F	0.04	0.4K	0.2K	0.50K	1.1	1.0K	1.0K	9.5
001530	831208	02081166	LG	62.5	725	F	0.11	0.4K	0.2K	0.50K	0.52	1.0K	1.0K	3
001531	831208	02081166	LG	68.7	1053	F	0.17	0.4K	0.2K	0.50K	0.85	1.0K	1.0K	4.1
001532	831208	02081166	LG	55.8	830	F	0.08	0.4K	0.2K	0.64	0.48	1.0K	1.0K	3.3
001533	831208	02081166	BRB	36.3	602	F	0.04	0.4K	0.2K	0.50K	0.60	1.0K	1.0K	2.8
001534	831208	02081166	BRB	34	533	F	0.09	0.4K	0.2K	0.50K	0.52	1.0K	1.0K	2.8
001535	831208	02081166	BRB	33.1	483	F	0.27	0.4K	0.2K	0.50K	0.56	1.0K	1.0K	4.2
001536	831208	02081166	BRB	31.5	420	F	0.06	0.4K	0.2K	1.4	2.5	1.0K	1.0K	3.6
001537	831208	02081166	YEB	31.5	463	F	0.18	0.4K	0.2K	0.50K	0.94	1.0K	1.0K	2.9
001538	831208	02081166	WP	20.7	170	F	0.13	0.4K	0.2K	0.50K	0.83	1.0K	1.0K	3.5
001539	831208	02081166	W	18	160	F	0.19	0.4K	0.2K	0.50K	0.36	1.0K	1.0K	3.6
001540	831208	02081166	W	17	144	F	0.27	0.4K	0.2K	0.50K	0.31	1.0K	1.0K	3.8
001541	831208	02081166	W	16.5	130	F	0.24	0.5K	0.2K	0.58	0.82	1.0K	1.0K	6.1
001542	831208	02081166	W	17	135	F	0.14	0.4K	0.2K	0.50K	0.48	1.0K	1.0K	4.8
001406	830616	0208117810	BF	57.5	1996	F	0.19		0.2K	0.50K	0.20K	1.0K	1.0K	3.3
001407	830616	0208117810	WHC	32.0	554	F	0.04		0.2K	0.50K	0.23	1.0K	1.0K	3.1
001408	830616	0208117810	WHC	21.0	125	W	0.03		0.25	0.50K	0.79	1.0K	3.1	12
001409	830616	0208117810	WP	18.0	73	WC3	0.03		0.22	0.57	4.1	1.0K	3.6	27
001409	830616	0208117810	WP	17.2	63									
001409	830616	0208117810	WP	17.0	61									
001410	830616	0208117810	WP	15.7	39	WC3	0.03		0.25	0.50K	1.7	1.0K	5.3	20
001410	830616	0208117810	WP	15.6	38									
001410	830616	0208117810	WP	15.8	48									

Table 14 cont.

SAMPLE#	DATE	STATION #	SP.	L(CM)	W(GR)	TYPE	HG MG/KG	AS MG/KG	CD MG/KG	CR.T MG/KG	CU MG/KG	NI MG/KG	PB MG/KG	ZN MG/
001354	830615	0208455650	LG	49.0	350	W	0.08		0.20K	0.53	3.5	1.0K	1.1	8.1
001355	830615	0208455650	WHC	38.0	832	F	0.03		0.20K	0.50K	0.38	1.0K	1.0K	6.3
001356	830615	0208455650	WHC	37.5	703	F	0.03		0.20K	0.50K	0.42	1.0K	1.0K	6.4
001357	830615	0208455650	WHC	33.8	598	F	0.02K		0.20K	0.50K	0.33	1.0K	1.0K	4.7
001358	830615	0208455650	WHC	31.9	480	W	0.02K		0.20K	0.50K	0.47	1.0K	1.0K	6.2
001359	830615	0208455650	WHC	28.2	285	W	0.02		0.20K	0.50K	0.52	1.0K	1.0K	7.9
001360	830517	0208455650	AME	48.5	275	F	0.05							
001361	830517	0208455650	W	19.5	149	F	0.03							
001362	830517	0208455650	LG	68.5	895	F	0.06							
001343	830615	0208455850	WP	23.1	203	W	0.02K		0.28	0.50K	5.2	1.0K	3.1	18
001344	830615	0208455850	WP	23.8	125	W	0.02K		0.23	0.50K	2.7	1.0K	2.6	9.
001345	830615	0208455850	WP	22.8	201	W	0.02K		0.21	0.50K	2.3	1.0K	1.3	11
001346	830615	0208455850	WP	22.1	174	W	0.02K		0.28	0.50K	7.3	1.0K	2.7	17
001347	830615	0208455850	WP	23.3	209	W	0.02K		0.23	0.50K	11.0	1.0K	1.9	26
001348	830615	0208455850	WP	22.3	176	W	0.02K		0.26	0.50K	3.7	1.0K	1.4	18
001349	830615	0208455850	WP	21.6	164	W	0.04		0.26	0.50K	6.2	1.0K	2.1	17
001350	830615	0208455850	SMU	30.0	286	W	0.02K		0.20K	0.50K	2.2	1.0K	1.4	12
001351	830615	0208455850	SMU	26.0	268	W	0.02K		0.20	0.50K	2.1	1.0K	2.8	12
001352	830616	0208457020	WP	20.6	138	W	0.02K		0.20K	0.50K	0.88	1.0K	1.9	13
001353	830616	0208457020	STB	27.5	247	W	0.02K		0.20K	0.50K	0.55	1.0K	1.8	12
001560	840111	0208457020	C	33.4	657	F	0.02K	0.4K	0.2K	0.50K	0.29	1.0K	1.0K	9.9
001561	840111	0208457020	C	44.2	1285	F	0.02K	0.4K	0.2K	0.50K	0.81	1.0K	1.0K	15
001562	840111	0208457020	C	36.4	707	F	0.02K	0.4K	0.2K	0.50K	0.76	1.0K	1.0K	7.4
001563	840111	0208457020	C	31.2	578	F	0.02K	0.4K	0.2K	0.50K	0.75	1.0K	1.0K	7.3
001564	840111	0208457020	WHC	40.8	1270	F	0.05	0.4K	0.23	0.50K	0.28	1.0K	1.0K	4.-
001565	840111	0208457020	WHC	38.6	930	W	0.07	0.4K	0.30	0.50K	0.69	1.0K	1.0K	6.3
001566	840111	0208457020	WHC	39.6	980	F	0.06	0.4K	0.24	0.50K	1.1	1.0K	1.0K	3.8
001567	840111	0208457020	BRB	40.2	982	F	0.05	0.4K	0.31	0.50K	0.35	1.0K	1.0K	4
001568	840111	0208457020	CHP	43.1	553	F	0.12	0.4K	0.33	0.50K	0.20K	1.0K	1.0K	4.5
001569	840111	0208457020	CHP	40.6	513	F	0.12	0.4K	0.25	0.50K	0.30	1.0K	1.0K	7.7
001570	840111	0208457020	CHP	37.7	467	F	0.11	0.4K	0.2K	0.50K	0.20K	1.0K	1.0K	3.-
001571	840111	0208457020	BRB	25.7	229	W	0.02	0.4K	0.2K	0.50K	0.40	1.0K	1.9	10
001572	840111	0208457020	BGS	14.7	72	W	0.02K	0.4K	0.2K	0.50K	0.37	1.0K	2.8	16
001573	840111	0208457020	SF	15.6	87	W	0.02K	0.4K	0.2K	0.50K	0.36	1.0K	2.5	15
001574	840111	0208457020	SF	15.1	67	W	0.02	0.4K	0.2K	0.50K	0.20K	1.0K	1.9	13
001575	840111	0208457020	SF	16.1	89	W	0.02	0.4K	0.2K	0.50K	0.30	1.0K	2.0	11

Table 14 cont.

SAMPLE#	DATE	STATION #	SP.	L(CM)	W(GR)	TYPE	HG MG/KG	AS MG/KG	CD MG/KG	CR.T MG/KG	CU MG/KG	NI MG/KG	PB MG/KG	ZN MG/
001354	830615	0208455650	LG	49.0	350	W	0.08		0.20K	0.53	3.5	1.0K	1.1	8.1
001355	830615	0208455650	WHC	38.0	832	F	0.03		0.20K	0.50K	0.38	1.0K	1.0K	6.3
001356	830615	0208455650	WHC	37.5	703	F	0.03		0.20K	0.50K	0.42	1.0K	1.0K	6.4
001357	830615	0208455650	WHC	33.8	598	F	0.02K		0.20K	0.50K	0.33	1.0K	1.0K	4.7
001358	830615	0208455650	WHC	31.9	480	W	0.02K		0.20K	0.50K	0.47	1.0K	1.0K	6.2
001359	830615	0208455650	WHC	28.2	285	W	0.02		0.20K	0.50K	0.52	1.0K	1.0K	7.9
001360	830517	0208455650	AME	48.5	275	F	0.05							
001361	830517	0208455650	W	19.5	149	F	0.03							
001362	830517	0208455650	LG	68.5	895	F	0.06							
001343	830615	0208455850	WP	23.1	203	W	0.02K		0.28	0.50K	5.2	1.0K	3.1	18
001344	830615	0208455850	WP	23.8	125	W	0.02K		0.23	0.50K	2.7	1.0K	2.6	9.
001345	830615	0208455850	WP	22.8	201	W	0.02K		0.21	0.50K	2.3	1.0K	1.3	11
001346	830615	0208455850	WP	22.1	174	W	0.02K		0.28	0.50K	7.3	1.0K	2.7	17
001347	830615	0208455850	WP	23.3	209	W	0.02K		0.23	0.50K	11.0	1.0K	1.9	26
001348	830615	0208455850	WP	22.3	176	W	0.02K		0.26	0.50K	3.7	1.0K	1.4	18
001349	830615	0208455850	WP	21.6	164	W	0.04		0.26	0.50K	6.2	1.0K	2.1	17
001350	830615	0208455850	SMU	30.0	286	W	0.02K		0.20K	0.50K	2.2	1.0K	1.4	12
001351	830615	0208455850	SMU	26.0	268	W	0.02K		0.20	0.50K	2.1	1.0K	2.8	12
001352	830616	0208457020	WP	20.6	138	W	0.02K		0.20K	0.50K	0.88	1.0K	1.9	13.
001353	830616	0208457020	STB	27.5	247	W	0.02K		0.20K	0.50K	0.55	1.0K	1.8	12
001560	840111	0208457020	C	33.4	657	F	0.02K	0.4K	0.2K	0.50K	0.29	1.0K	1.0K	9.9
001561	840111	0208457020	C	44.2	1285	F	0.02K	0.4K	0.2K	0.50K	0.81	1.0K	1.0K	15
001562	840111	0208457020	C	36.4	707	F	0.02K	0.4K	0.2K	0.50K	0.76	1.0K	1.0K	7.4
001563	840111	0208457020	C	31.2	578	F	0.02K	0.4K	0.2K	0.50K	0.75	1.0K	1.0K	7.3
001564	840111	0208457020	WHC	40.8	1270	F	0.05	0.4K	0.23	0.50K	0.28	1.0K	1.0K	4.-
001565	840111	0208457020	WHC	38.6	930	W	0.07	0.4K	0.30	0.50K	0.69	1.0K	1.0K	6.3
001566	840111	0208457020	WHC	39.6	980	F	0.06	0.4K	0.24	0.50K	1.1	1.0K	1.0K	3.8
001567	840111	0208457020	BRB	40.2	982	F	0.05	0.4K	0.31	0.50K	0.35	1.0K	1.0K	4
001568	840111	0208457020	CHP	43.1	553	F	0.12	0.4K	0.33	0.50K	0.20K	1.0K	1.0K	4.2
001569	840111	0208457020	CHP	40.6	513	F	0.12	0.4K	0.25	0.50K	0.30	1.0K	1.0K	7.2
001570	840111	0208457020	CHP	37.7	467	F	0.11	0.4K	0.2K	0.50K	0.20K	1.0K	1.0K	3.-
001571	840111	0208457020	BRB	25.7	229	W	0.02	0.4K	0.2K	0.50K	0.40	1.0K	1.9	10
001572	840111	0208457020	BGS	14.7	72	W	0.02K	0.4K	0.2K	0.50K	0.37	1.0K	2.8	16
001573	840111	0208457020	SF	15.6	87	W	0.02K	0.4K	0.2K	0.50K	0.36	1.0K	2.5	15
001574	840111	0208457020	SF	15.1	67	W	0.02	0.4K	0.2K	0.50K	0.20K	1.0K	1.9	13
001575	840111	0208457020	SF	16.1	89	W	0.02	0.4K	0.2K	0.50K	0.30	1.0K	2.0	11

Sediment Discussion

Sediment at nine of the eleven stations within the study area was sampled for metals. Metals sampled for were cadmium, chromium, copper, mercury, nickel, lead, and zinc. In "A 96-hour bioassay of Otter Creek, Ohio", an article in the Journal of Water Pollution Control, October 1977, Bayliss L. Prater and Max A. Anderson suggested sediment criteria for polluted waters from data taken from several harbors. Two parameters sampled during this study, arsenic and lead, indicated values that are considered heavily polluted according to these criteria. The high arsenic value occurred at station # 0208455650 (Pungo River at U.S. Hwy 264 near Ponzer, N.C.). This arsenic value was 8.6 mg/kg. The high lead value occurred at station # 02081166 (Scuppernong River at SR 1105 near Columbia, N.C.). The lead value here was 140 mg/kg. Sediment mercury values were fairly low at all stations with a maximum value of 0.1 mg/kg. Values for sediment metals at the nine stations are found in table 15.

TABLE 15

SEDIMENT METALS (MG/KG)
(K refers to "less than" values)

STATION #	DATE	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
02081166	820921	3.9K	.50K	11	8.8	.1	6.5	140	59
	830609	5.3K	.97	34	11	.1	17	25	93
0208117810	820921	6.1K	.50K	17	3.1	.05	6.8	13	21
	830616	6.7K	.20K	18	5	.05	8.6	17	26
0208117820	820921	5.8K	.50K	19	3.9	.05	6.7	13	28
0208117830	820921	2.8K	.50K	8.9	.97	.04	4.4	39	17
02081185	830609	4.2K	.73	39	15	.1	16	32	97
82084534	820107	6.1	.95	27	15	.02K	11	32	94
	830623	7.9	.75	38	13	.1	15	40	78
0208455650	830303					.1			
	830420					.02			
	830615	7.9K	.41	22	8.90	.1	12	19	40
	830810	8.6	.80	23	10	.02K	13	26	45
0208455850	830615	6.4	.58	32	15	.1	20	36	100
0208457020	830613	6.2K	.46	35	12	.1	17	38	80

PHYTOPLANKTON AND CHLOROPHYLL a ANALYSIS

Phytoplankton and chlorophyll a data was analyzed for several rivers and creeks associated with the CEIP study including Bath Creek, Pungo Creek, Pantego Creek, Pungo River, Scuppernong River, and the Alligator River. Results indicated very different levels of phytoplankton standing crops and dominant species in these waters (Figure 11).

The creeks and rivers on the south side of the peninsula had intrusions of saline waters during the last few months of 1983 (Figure 12). All stations sampled in these creeks and rivers were dominated totally, or in part, in the late summer and fall by flagellates common to brackish or saline waters. Species dominant in the spring and early summer were more indicative of waters with little or no salinity. Bath Creek, Pungo Creek, and Pantego Creek exhibited the potential for high levels of phytoplankton growth as well as ideal conditions for dominance of phytoplankton by blue-greens. Total inorganic nitrogen concentrations were reduced to low levels (<.01 mg/l) in these creeks by early summer and an adequate supply of other nutrients was available (Figure 10). Colonial blue-green algae dominated the phytoplankton at these sites until salinities increased in late summer. With continued nutrient loading and proper environmental conditions, any of these creeks appear to be capable of supporting surface blooms of flagellated greens, Euglena sp., or blue-greens during the spring or summer. These creeks also seem capable of maintaining high numbers of dinoflagellates in the fall.

The Pungo River supported less phytoplankton biomass than the creeks described above. There was no major spring pulse of algal growth, therefore, reduction of total inorganic nitrogen in the water column was much more gradual during the summer at the Pungo River site. Fall phytoplankton species composition was similar at the Pungo River and at Bath, Pungo, and Pantego Creeks but phytoplankton density was 1-2 orders of magnitude less at the Pungo River site. Shallow light penetration and more dynamic flow and mixing patterns at the Pungo River site might have accounted for this difference, but no flow or light data was available.

Two stations on the north side of the peninsula on the Alligator and Scuppernong Rivers did not have a strong intrusion of saline water during late summer and fall (Figure 15). Algal populations in these rivers were not strongly dominated by one taxa or class of phytoplankton in any of the observed samples. Inorganic nutrients in the water column on the Scuppernong River were never reduced to extremely low levels during the study period and were probably influenced more by productivity of aquatic macrophytes than by phytoplankton. The relatively low concentrations of chlorophyll a, in the presence of available nutrients, indicated that algal growth was limited by factors other than nutrients. Light penetration or chelation of trace metals due to humics in these dark waters may have helped limit phytoplankton production.

Bath Creek 02084534

Seasonal increases in phytoplankton growth, as indicated by chlorophyll a, began in March. This growth reduced inorganic nitrogen concentrations to low levels by May. Spring phytoplankton were dominated by diatoms (Bacillariophyceae) and greens (Chlorophyceae). Small filamentous blue-green algae dominated phytoplankton density during the summer but dinoflagellates dominated algal biomass during that period. The maximum chlorophyll concentration (40 ug/l) was recorded in July. Chlorophyll a levels declined in the fall, as did phytoplankton density, but maximum phytoplankton biomass was measured in December. A brackish water dinoflagellate (Heterocapsa triquetra) was responsible for 60% of the biomass measured in Bath Creek at that time (8.5 mg/l). Intrusion of saline water in Bath Creek in the last 6 months of 1983 was indicated by the dominance of brackish water species.

Pungo Creek 0208457020

A spring pulse in phytoplankton growth occurred in May in Pungo Creek. Although phytoplankton density and biomass were not measured in May, a chlorophyll a concentration of 63 ug/l was recorded. A green flagellate (Chlamydomonas sp.) was responsible for this bloom. Chlamydomonas sp. often responds to warming temperatures and high levels of nutrients avail-

able in the spring in fresh waters of North Carolina. The growth of phytoplankton in May reduced total inorganic nitrogen concentrations to low levels in Pungo Creek. A second, smaller peak of chlorophyll a (32 ug/l) occurred in July. A rather large dinoflagellate (Gymnodinium nelsonii) constituted 94% of algal biomass (14.4 mg/l) at that time. Small filamentous blue-green algae (Phormidium sp. and Anabaenopsis circularis) dominated phytoplankton density during the summer when units/ml approached 100,000 (August) in Pungo Creek. As salinity increased and temperatures decreased in the fall and winter, brackish water flagellates (Cryptophyceae, Chrysophyceae, Prasinophyceae, and Dinophyceae) were abundant in the algal samples analyzed.

Pantego Creek 0208455850

Phytoplankton in Pantego Creek responded to high nutrients and warming temperatures in May of 1983. An assortment of fresh water green algae (Chlorophyceae) were responsible for a chlorophyll a maximum of 74 ug/l in May. Elevated total inorganic nitrogen concentrations (3.53 mg/l) present in March were reduced to very low levels (.03 mg/l) by May. Summer phytoplankton populations were dominated by blue-green algae, and inorganic nutrients remained low during the summer. The introduction of saline water in the late summer and fall was accompanied by a shift in phytoplankton populations to brackish water flagellates. Flagellates dominated the December phytoplankton biomass and density. Heterocapsa triquetra dominated algal biomass (5.59 mg/l) at this time and chlorophyll a levels rose to 36 ug/l.

Pungo River 0208455650

Chlorophyll a measurements in the Pungo River at Ponzer did not indicate a major pulse of phytoplankton growth in the spring of 1983. Decreases in total inorganic nitrogen concentrations were much more gradual in the river than in nearby creeks. The maximum chlorophyll a concentration recorded was 9 ug/l in both September and October when flagellates in the Dinophyceae and Cryptophyceae dominated phytoplankton biomass and density. Salinity measurements of 5-10 ppth were recorded during this period, which would favor the brackish water flagellates observed.

Scuppernong River 02081166

There was a steady decline in total inorganic nitrogen in the Scuppernong River during the late spring of 1983. However, this decline did not correlate well with phytoplankton growth as indicated by chlorophyll a measurements. Phytoplankton standing crops were relatively low throughout 1983 as indicated by a maximum phytoplankton density of 2218 units/ml, a maximum phytoplankton biomass of 1.34 mg/l; and a maximum chlorophyll a concentration of 11 ug/l in July. No particular group of algae totally dominated phytoplankton in the Scuppernong River in the samples analyzed. Inorganic nutrients were not reduced to undetectable levels throughout the growing season, and total inorganic nitrogen increased to high levels (2.16 mg/l) in December. This increase may not have been associated with reduced phytoplankton growth, but rather with reductions in the productivity of aquatic macrophytes.

Alligator River at Cherry Ridge Landing 0208117810

Samples procured from this station in the spring and summer of 1983 indicated that phytoplankton were probably not the major primary producer. The chlorophyll a concentrations in April, July and September were <1, <1, and 4.0 ug/l respectively. Total inorganic nitrogen concentrations remained above detectable levels in all samples, as did total phosphorus. Apparently something other than nutrients is limiting phytoplankton growth in the Alligator River.

Figure 10

NITROGEN AND PHOSPHORUS CONCENTRATIONS IN BATH CREEK, PUNGO CREEK, PANTEGO CREEK, PUNGO RIVER, AND SCUPPERNONG RIVER (MG/L), 1983

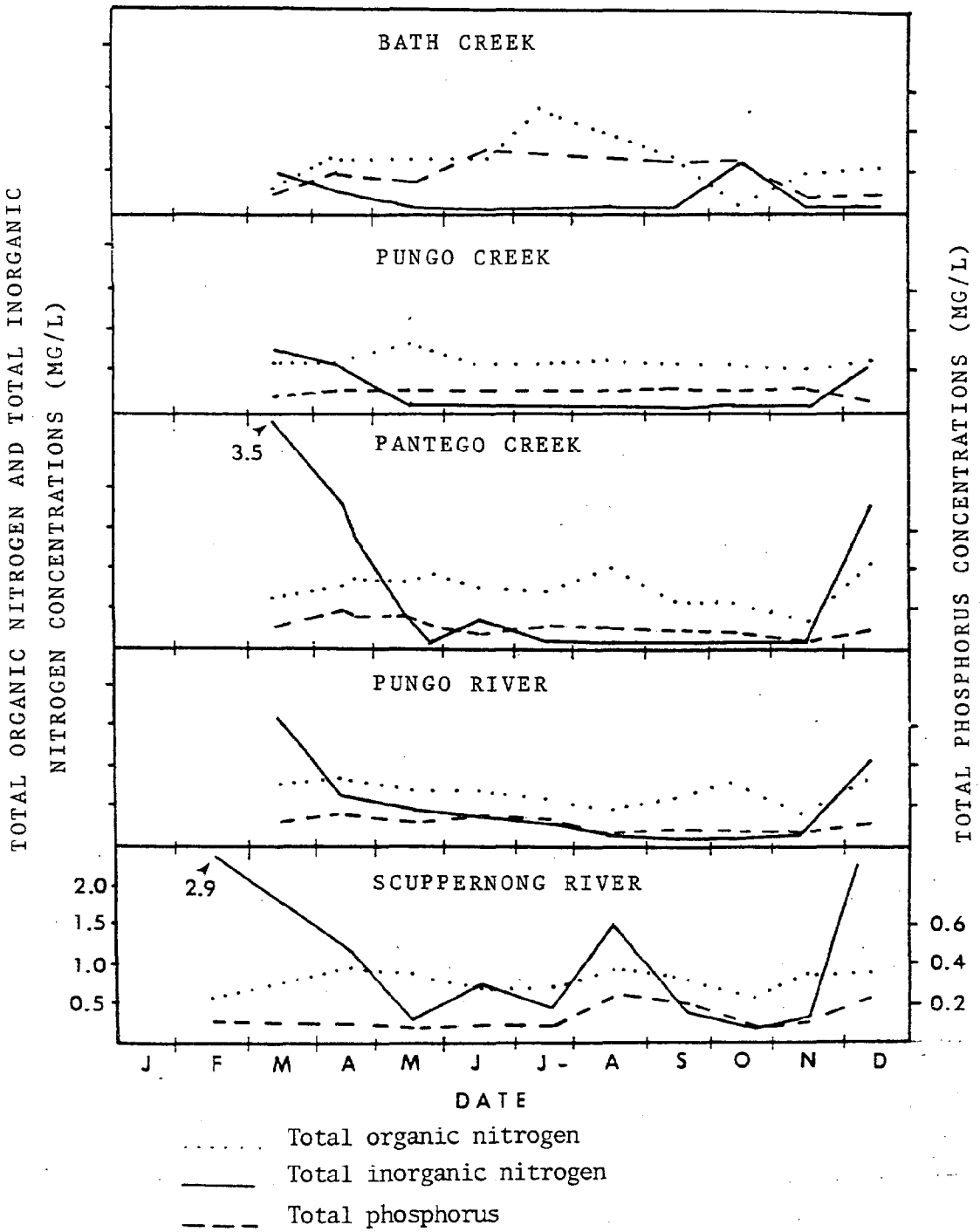


Figure 11

CHLOROPHYLL-a, PHYTOPLANKTON BIOMASS, AND PHYTOPLANKTON DENSITY AT BATH CREEK, PUNGO CREEK, PANTEGO CREEK, PUNGO RIVER, AND SCUPPERNONG RIVER, 1983

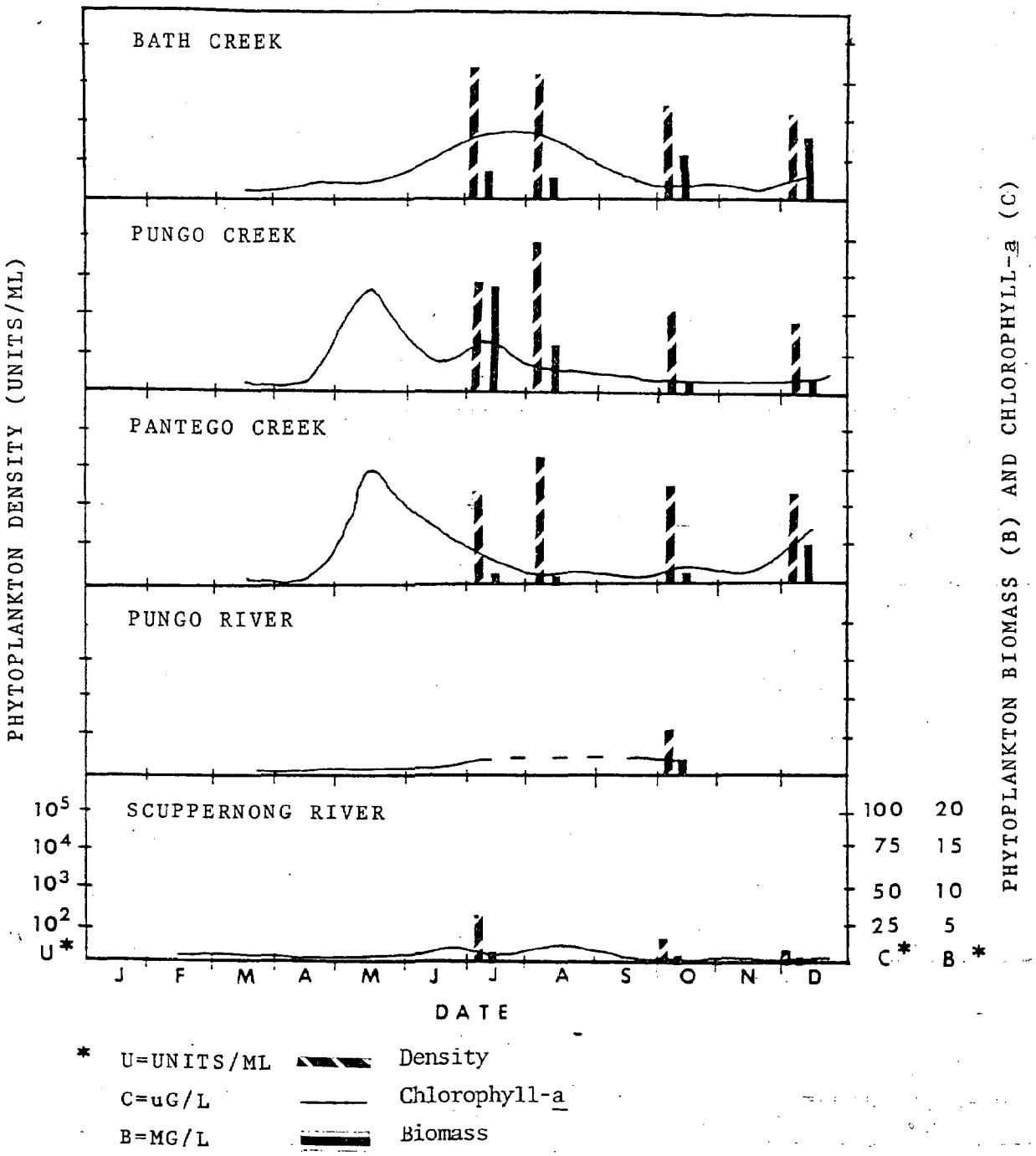
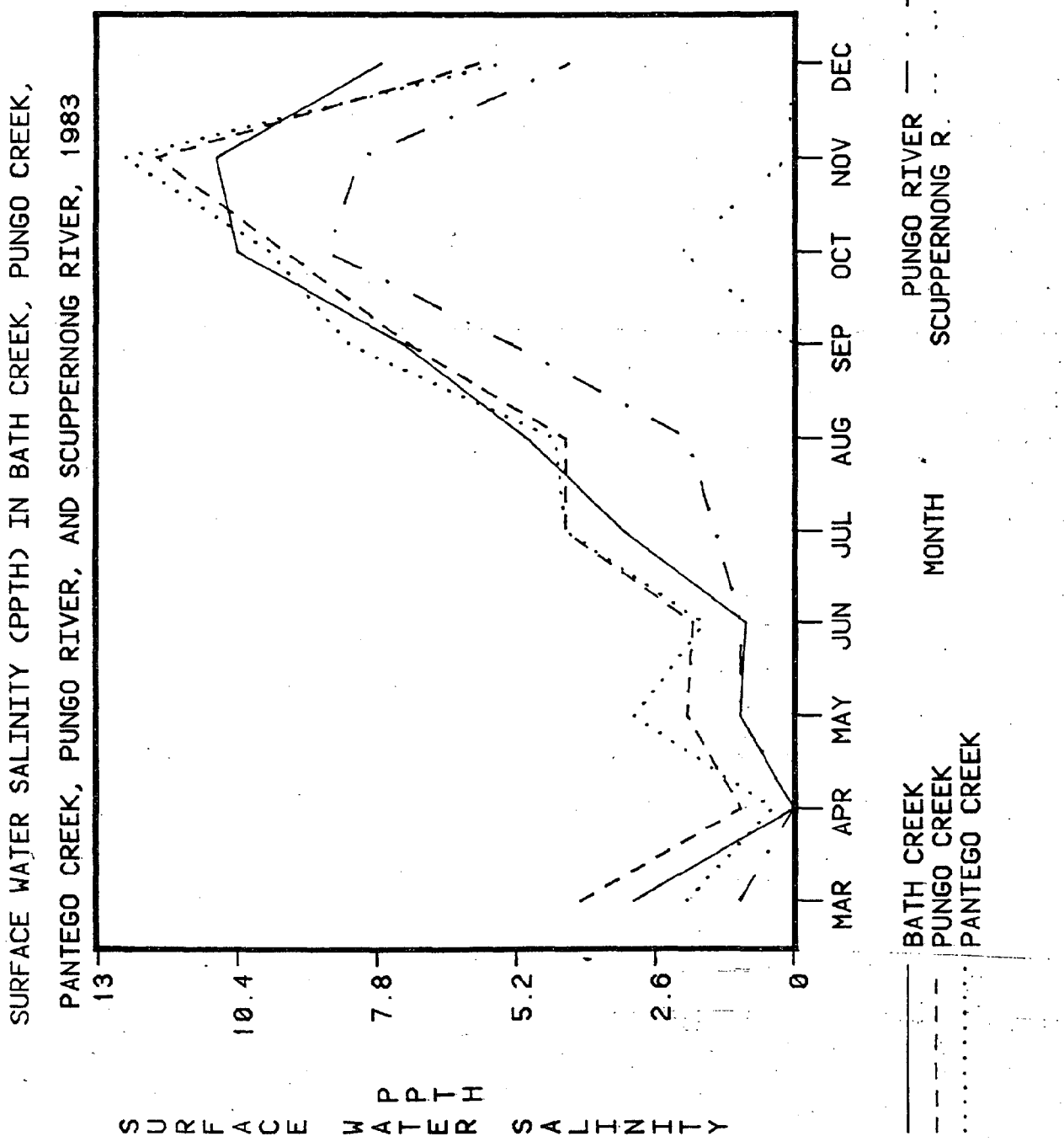


Figure 12


SURFACE WATER SALINITY (PPTH) IN BATH CREEK, PUNGO CREEK,
PANTEGO CREEK, PUNGO RIVER, AND SCUPPERNONG RIVER, 1983
SURFACE WATER SALINITY (PPTH)
13
10.4
7.8
5.2
2.6
0
MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
BATH CREEK
PUNGO CREEK
PANTEGO CREEK
PUNGO RIVER
SCUPPERNONG R.

BENTHIC MACROINVERTEBRATE ANALYSIS

Benthic macroinvertebrates were collected using a standardized qualitative technique (DEM, 1983). This collection method is directed at a complete inventory of all species present with some indication of relative abundance. Two crews worked simultaneously, one working at shore areas and the other taking dredge samples in deeper water.

Table 16 presents taxa richness, by group, at all sites. Maximum taxa richness (46) was low, as expected for this area. The Albemarle-Pamlico peninsula is an area with low aquatic macroinvertebrate diversity. This is due, in part, to low current velocities, low dissolved oxygen values, and variable salinities. This area has been so extensively modified by man (agriculture, silviculture) that undisturbed "control" areas are largely absent.

Salinity values are the most important factors regulating taxa richness at the Albemarle-Pamlico sites. Most freshwater species are oligohaline; intolerant of salinities greater than 0.5% (Kendall, 1983). Overall salinities are lowest on the north side of the peninsula, as the Albemarle Sound is much fresher than the Pamlico Sound. Only two sites (Kendrick Creek and Scuppernong River) are freshwater sites (Table 17). These two sites had the highest taxa richness with estuarine species being rare or absent. At both sites, the macroinvertebrate fauna was abundant only at bank areas. In midstream areas, only Chaoborus punctipennis and Limnodrilus were common. This distribution pattern indicates that very low dissolved oxygen concentrations are present for long periods in deeper water.

A similar distribution of species was noted at the Alligator River, but overall taxa richness was lower (31). This decline can be attributed to the occasional intrusion of brackish water (Table 17). Note that the number of estuarine species is higher at this site (3) than at either Kendrick Creek or the Scuppernong River. Therefore, the reduced taxa richness at this site cannot be attributed to a decline in water quality.

In fact, the higher number of Trichoptera at this site suggests better water quality.

When taxa richness for June 1983 is combined with taxa richness for August 1983, values increase at all sites. However, a large increase is seen only at Kendricks Creek. This indicates better water quality at this station (Table 18).

The number of estuarine species per site is much greater at Pamlico sites (13-20) than at Albemarle sites (0-3). These species are primarily in the groups Polychaeta, Crustacea and Mollusca (Table 16). The higher salinity is associated, as expected, with lower taxa richness (22-33 taxa). There are few between-station differences in total taxa richness at tributary sites. Taxa richness declines at Pamlico River sites as higher salinities eliminate almost all freshwater species. Note that the normal diversity of true estuarine organisms, at salinities of 5-10%, is very low (McLusky 1981). Table 16 gives only a few clues to suggest any between-station differences in water quality at Pamlico sites. Note the higher than expected taxa richness for estuarine organisms (especially Crustacea) at Pungo Creek. This suggests more stable salinities for this stream. The Pungo River has the highest number of freshwater species suggesting greater input of freshwater after heavy rains.

Other indications of water quality differences can be found in the distribution of chironomid (midge) species (Table 19). The high organic group is abundant in midstream samples at Pungo Creek, Pantego Creek, and Bath Creek, particularly at the first two sites. The dominance of this group indicates low (but not zero) dissolved oxygen conditions, and high input of particulate organic carbon (POC).

This POC probably originates as phytoplankton. It is likely that normal estuarine mixing and/or wind mixing prevents the extended periods of near anoxia deduced for some Albemarle sites.

The "Enrichment Group" includes 2 chironomids collected as epifauna at shore areas. These species were abundant at 2 Albemarle sites (Scuppernong River, Alligator River) and 3 Pamlico sites (Bath Creek, Pungo Creek, and the Pungo River)

The benthic macroinvertebrate data can be used to rank stations according to overall water quality. No attempt is made, however, to compare Albemarle sites with Pamlico sites due to marked salinity differences.

Within the Albemarle area, Kendrick Creek clearly had the best water quality. This is based on higher taxa richness (1982 + 1983) and the rarity of species indicating enrichment and/or organic loading. The Scuppernong River appears to have the poorest water quality based on low numbers of intolerant species and the abundance of "enrichment" indicators. Unpublished data shows extensive deoxygenation at this site.

Within the Pamlico area, the stations with poorest water quality were Pantego Creek and Pungo Creek. Fish kills have been reported at both stations. This rating is based primarily on the abundance of "enrichment" and "high organic" indicators. Pungo Creek may be marginally better, as data indicates more stable salinities at this site. Pungo River also has similar water quality problems, but the abundance of "high organic" indicators is less. Note, however, that August 1982 samples found similar communities at Pantego Creek and the Pungo River. Both sites were dominated by a capitellid polychaete, Mediomastus, indicating a high organic loading.

Data from Bath Creek indicates similar problems, but not to the same degree. The abundance of organic indicator species was consistently less at this site in 1982 and 1983.

Table 16. Taxa Richness, by group, June 1983

Basin:	Albemarle			Pamlico					
Site	Kendrick Cr.	Scuppernong River	Alligator River	Bath Cr.	Pungo Cr.	Pantego Cr.	Pungo River	Pamlico River Hickory Pt.	Pamlico River Great Island
Group									
Ephemeroptera	2	1	-	-	-	2	2	-	-
Trichoptera	1	-	4	-	-	-	-	-	-
Coleoptera	5	4	-	-	-	1	-	-	-
Odonata	3	4	2	1	1	1	1	-	1
Hemiptera	3	4	3	-	-	-	1	-	-
Diptera: Misc.	2	3	2	1	2	1	1	-	-
Diptera: Chiron.	9	12	9	13	7	10	9	3	2
Oligochaeta	3	6	1	2	1	3	-	1*	-
Hirudinea	2	2	-	-	-	-	-	-	-
Polychaeta	-	-	-	3*	2*	2*	4*	4*	4*
Crustacea	4	3	6	8*	12*	9*	8*	8*	12*
Mollusca	5	5	3	2*	5*	3*	3*	5*	4*
Other	3	2	1	1*	1*	1*	1*	1*	-
Total	42	46	31	31	31	33	29	22	23
# Estuarine species	0	1	3	15	20	13	14	19	20
# Freshwater species	42	45	28	16	11	20	15	3	3
# Unique Species**	10	14	8	3	3	3	1	3	5
Rating (From Assessment Document)	G-F	G-F	G-F	G-F	G-F	F	F	F/G-F	G

* Primarily estuarine species

** Collected at only 1 site

Table 17. Average Salinity %/Dissolved Oxygen (mg/l)

	N	DO Surface	DO Bottom*	Measured Salinity (Surface)	Predicted Salinity+
Kendrick Cr.	8	6.1	-	0.1	<2
Scuppernong R.	17	3.1	3.2**	0.2 (0-2.1)	<2
Alligator R.	4	6.3	6.1	3.3 (0-7.0)	<2
Bath Cr.	14-15	8.8	-	4.9 (0-10.8)	3-9
Pungo Cr.	14	9.0	-	5.9 (1.0-11.9)	5-11
Pantego Cr.	14	9.0	-	5.4 (0.4-12.5)	5-11
Pungo R.	13	7.1	-	4.0 (0-9.0)	5-11
Pamlico (Hickory Pt.)					5-11
Pamlico (Great Island)					14-17

* Based on very limited data

** May be <1.0

\+ From Giese et al. (1979)

Table 18. Taxa Richness, by group, August 82 & June 83

Basin:	Albemarle			Pamlico		
Station:	Kendrick	Scuppernong	Alligator	Bath	Pantego	Pungo R.
Group						
Ephemeroptera	4	1	-	-	2	2
Trichoptera	2	-	4	-	-	-
Coleoptera	6	4	-	-	1	-
Odonata	4	4	2	1	1	1
Hemiptera	3	4	3	-	-	1
Diptera: Misc.	5	3	3	1	1	2
Diptera: Chiron.	16	12	12	14	13	9
Oligochaeta	7	8	1	2	4	2
Hirudinea	3	2	-	-	-	-
Polychaeta	-	-	2	3	5	4
Crustacea	4	3	7	9	10	8
Mollusca	8	5	6	4	5	4
Other	6	2	1	1	1	2
Total	68	48	41	35	43	35

Table 19. Distribution of Abundant Chironomid Taxa, July 1983

Basin:	Albemarle			Pamlico			
Station:	Kendrick	Scuppernong	Alligator	Bath	Pungo Cr.	Pantego	Pungo R.
Taxa							
High Organic Group							
Chironomus spp.	*	*		X	$\underline{X}$	$\underline{X}$	
Procladius sp.		*		X	$\overline{X}$	$\overline{X}$	X
Enrichment Group							
Dicrotendipes spp. (2)	*	X	X	X	X	*	X
Glyptotendipes sp.		X		*			
Other							
Ablabesmyia peleensis	X	*					*
A. parajanta	*		X				X
Larsia	X	*					
Parachironomus monochromus		*	*	X	*	X	
Polypedilum illinoense	X	X	X	X	X	X	X
Phaenopsectra sp. 3			X				
Stenochironomus sp.	*		X				
Tanytarsus spp.		X		*	*	*	

$\underline{X}$ Very abundant
$\overline{X}$ Abundant
* Rare or common

REFERENCES

American Public Health Association. 1980. Standard Methods for the Examination of Water and Wastewater, 15th edition.

Benoit, D.A., E.N. Leonard, G.M. Christensen, and J.T. Fiandt. 1976. Toxic Effects of Cadmium on Three Generations of Brook Trout (Salvelinus Fontinalis). Trans. Amer. Fish. Soc. 105:550-560.

Cooper, James J. 1983. Total Mercury in Fishes and Selected Biota in Lahontan Reservoir, Nevada. 1981, Bull. Environ. Contam. Toxicol. 31, 9-17.

Division of Environmental Management. 1983. Biological Series #108. Qualitative Sampling of Benthic Macroinvertebrates: A Reliable, Cost Effective, Biomonitoring Technique.

Giese, G.L., H.B. Wilder, and G.G. Parker, Jr. 1979. Hydrology of Major Estuaries and Sounds of North Carolina. U.S.G.S. Open-File Report 79-46.

Hildebrand, S.G., A.W. Andren, and J.W. Huckabee, 1976. Distribution and Bioaccumulation of Mercury in Biotic and Abiotic Compartments of a Contaminated River-Reservoir System. In Andres, R.W., P.V. Hodson, and D.E. Konasewich (Eds.) Toxicity to Biota of Metal Forms in Natural Waters. Great Lakes Res. Adv. Bd., Stand. Comm. Sci. Basis Water Qual. Criteria Inter. JT. Comm. Res. Adv. Bd.: 211-232.

Jensen, S. and A. Jernelov. 1969. Biological Methylation of Mercury. Nature 23, 753.

Kendall, D.R. 1983. "The Role of Physical - Chemical Factors in Structuring Subtidal Marine and Estuarine Benthos". Tech. Report EL-83-2. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Koli, A.K., W.R. Williams, E.B. McClary, E.L. Wright, and J.M. Burrell. 1977. Mercury Levels in Freshwater Fish of the State of South Carolina. Bull. Environ. Contam. Toxicol. 17- 82-89.

Krauskopf, K.B. 1967. Introduction to Geochemistry. McGraw-Hill, N.Y.

Mahaffey, K.R., et. al. 1975. Heavy Metal Exposure From Food. Environ. Health Perspec., 12:63.

May, Thomas W. and G. L. McKinney. 1981. Cadmium, Lead, Mercury, Arsenic, and Selenium Concentrations in Freshwater Fish, 1976-1977, - National Pesticide Monitoring Program. Pesticide Monitoring Journal 15:1.

McLusky, Donald S. 1981. The Estuarine Ecosystem. Halsted Press, N.Y.

National Academy of Sciences. 1978. An Assessment of Mercury in the Environment. Panel of Mercury, Washington, D.C.

NRCD, 1983. Mercury and Other Metals in the Fish of B. Everett Jordan Lake, N.C. N.C. Dept. of Natural Resources and Community Development, Raleigh.

Prater, B.L. and Max A. Anderson. 1977. "A 96-Hour Bioassay of Otter Creek, Ohio." Journal of the Water Pollution Control Federation. Washington, D.C.

US EPA. 1976. Quality Criteria for Water, U.S. Environmental Protection Agency, Washington, D.C.

US EPA. 1980A. Ambient Water Quality Criteria for Copper, EPA-440/5-80-057, U.S. Environmental Protection Agency, Washington, D.C.

US EPA. 1980B. Ambient Water Quality Criteria for Lead, EPA 440/5-80-057, U.S. Environmental Protection Agency, Washington, D.C.

US EPA. 1980. Ambient Water Quality Criteria for Mercury, EPA 440/5-80-058 U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 1980C. Ambient Water Quality Criteria for Zinc, EPA-440/5-80-079, U.S. Environmental Protection Agency, Washington, D.C.

Walker, Patrick N. 1962 (revised 1965). Drainage Areas of Selected Sites on Streams in North Carolina. U.S.G.S. Open-File Report.