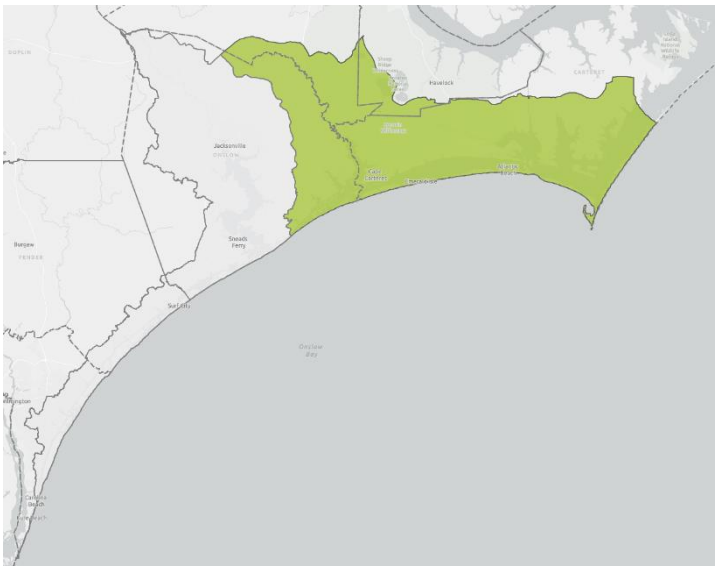
Contents

Chapter 3 2
3.1 General Description 2
3.2 Population and Land Use 2
3.3 Permits 4
3.4 Biological Health 5
3.5 Ambient Water Quality 7
3.6 Shellfish Growing Areas 8
3.7 Water Quality on the Watershed Scale (HUC 10) 9
3.7.1 Headwaters White Oak River Watershed (HUC 0302030101) 9
3.7.2 Outlet White Oak River Watershed (HUC 0302030102) 11
3.6.3 Bogue Banks-Bogue Sound (HUC 0302030103) 13
3.6.4 Newport River Watershed (HUC 0302030104) 15
3.6.5 North River Watershed (HUC 0302030105) 21
3.6.6 Oyster Creek – Jarrett Bay (HUC 0302030106) 23
3.6.7 Bogue Banks – Shackleford Banks (HUC 0302030107) 25
3.8 White Oak River TMDLs 26
3.10 Protecting Water Resources in the White Oak River Subbasin 26
References 28

Chapter 3
White Oak Subbasin
Hydrologic Unit Code (HUC): 03020301

3.1 General Description

The White Oak (Northeast) subbasin is on the eastern end of the White Oak River basin. Most of the subbasin lies within Carteret County, but portions of Craven and Jones county are also located in the subbasin. Municipalities in the subbasin include Atlantic Beach, Beaufort, Bogue, Cape Carteret, Emerald Isle, Harkers Island, Indian Beach, Maysville, Morehead City, Newport, Pine Knoll Shores, Salter Path, and Swansboro. Rural residential properties and communities are also scattered throughout the basin.



The White Oak subbasin is located in EPA IV ecoregions designated as Nonriverine Swamps and Wetlands, Carolina Flatwoods, and Carolina Barrier Islands and Coastal Marshes (Griffith et al., 2002). Major tributaries include the White Oak River, Starkys Creek, Hunters Creek, Pettiford Creek, Queen Creek, Bear Creek, Newport River, Calico Creek, North River, Oyster Creek – Jarrett Bay, and Bogue Banks – Shackleford Banks. Significant natural heritage areas include the Croatan National Forest and Pocosin Wilderness Area.

3.2 Population and Land Use

Based on the 2010 Census data, population in the White Oak subbasin is estimated to be 89,727 (Table 3-1). The largest municipalities in the subbasin are Morehead City and Newport. Each of these municipalities experienced a small net increase in population over the 2000 to 2010 time-period.

Table 3-1 Estimated population of the watershed boundary scale (HUC 10) (2010 Census) (OSBM, 2014)

HUC 10 Name	HUC 10	Land Area (mi^2)	Population 2010	Population 2020	Population 2030
Headwaters White Oak River	0302030101	142.4	3,793	3,878	3,917
Outlet White Oak River	0302030102	131.0	7,927	8,376	8,659
Bogue Banks - Bogue Sound	0302030103	104.9	22,874	24,145	24,956
Newport River	0302030104	148.7	26,333	28,093	29,187

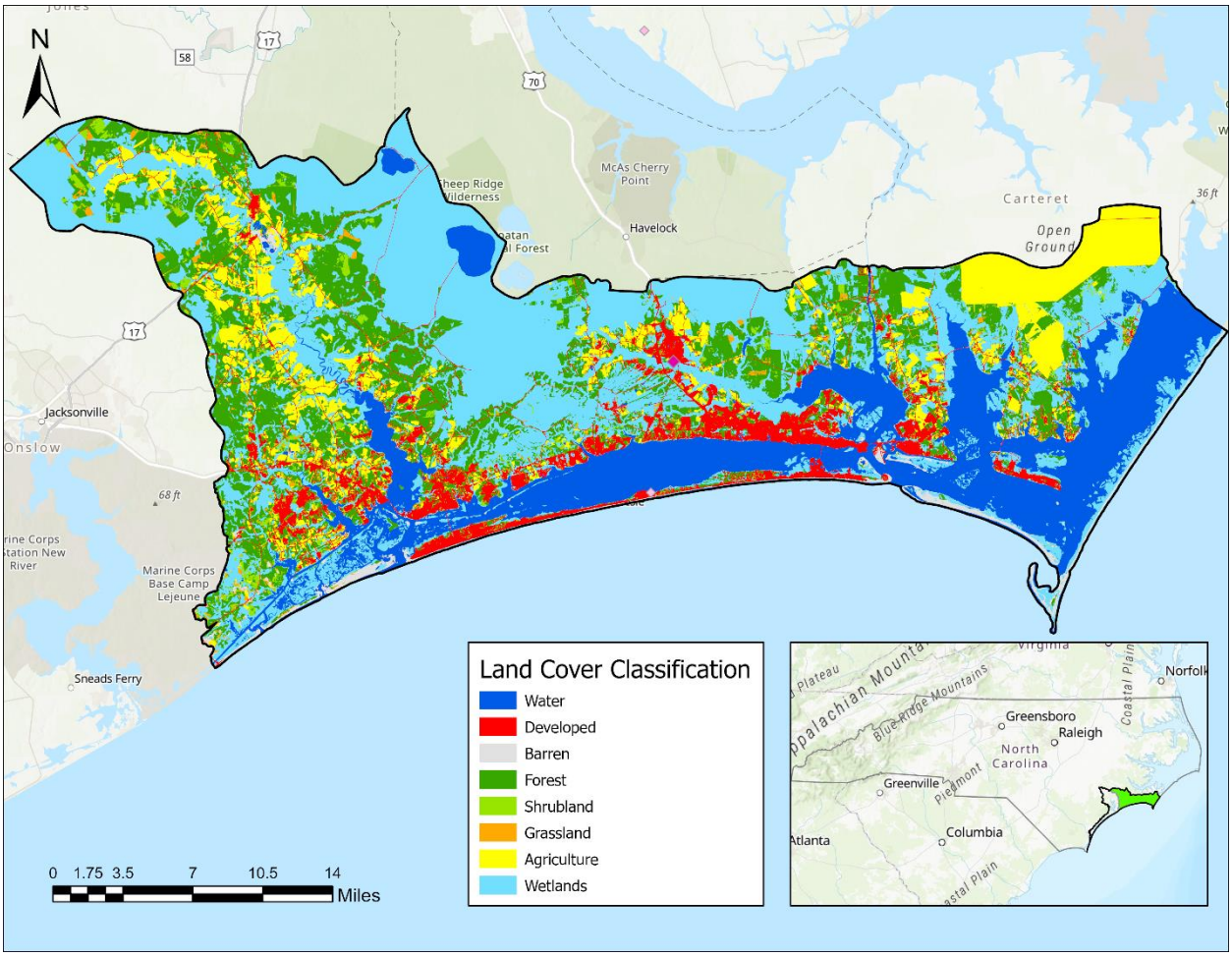
HUC 10 Name	HUC 10	Land Area (mi^2)	Population 2010	Population 2020	Population 2030
North River	0302030105	68.5	6,482	6,915	7,184
Oyster Creek - Jarrett Bay	0302030106	83.5	1,987	2,119	2,202
Bogue Banks - Shackleford Banks	0302030107	78.5	16,342	17,434	18,113

The White Oak subbasin drains approximately 757 mi^2. In 2016, land cover within the White Oak Subbasin was predominantly wetlands (36%). Open water comprised 20% and forest land accounted for 17%. Agricultural comprises an additional 11%, and only 4% is classified as developed (Table 3-2; Figure 3-1) (NLCD, 2016).

Table 3-2 Land cover of White Oak subbasin (NLCD, 2016)

Land Cover	2001	2004	2006	2008	2011	2013	2016
Agriculture	10.85%	10.81%	10.65%	10.62%	10.51%	10.51%	10.50%
Barren	1.50%	1.49%	1.47%	1.46%	1.45%	1.43%	1.42%
Developed	7.37%	7.37%	7.72%	7.72%	7.73%	7.73%	8.0%
Forest	16.96%	16.75%	16.19%	15.8%	15.61%	16.24%	17.5%
Water	20.41%	20.48%	20.48%	20.53%	20.55%	20.56%	20.50%
Shrubland	2.81%	2.98%	2.83%	3.64%	3.49%	3.7%	2.38%
Grassland	1.93%	1.96%	2.54%	2.12%	2.34%	1.42%	1.27%
Wetland	36%	35.95%	35.95%	35.92%	35.89%	35.91%	35.97%

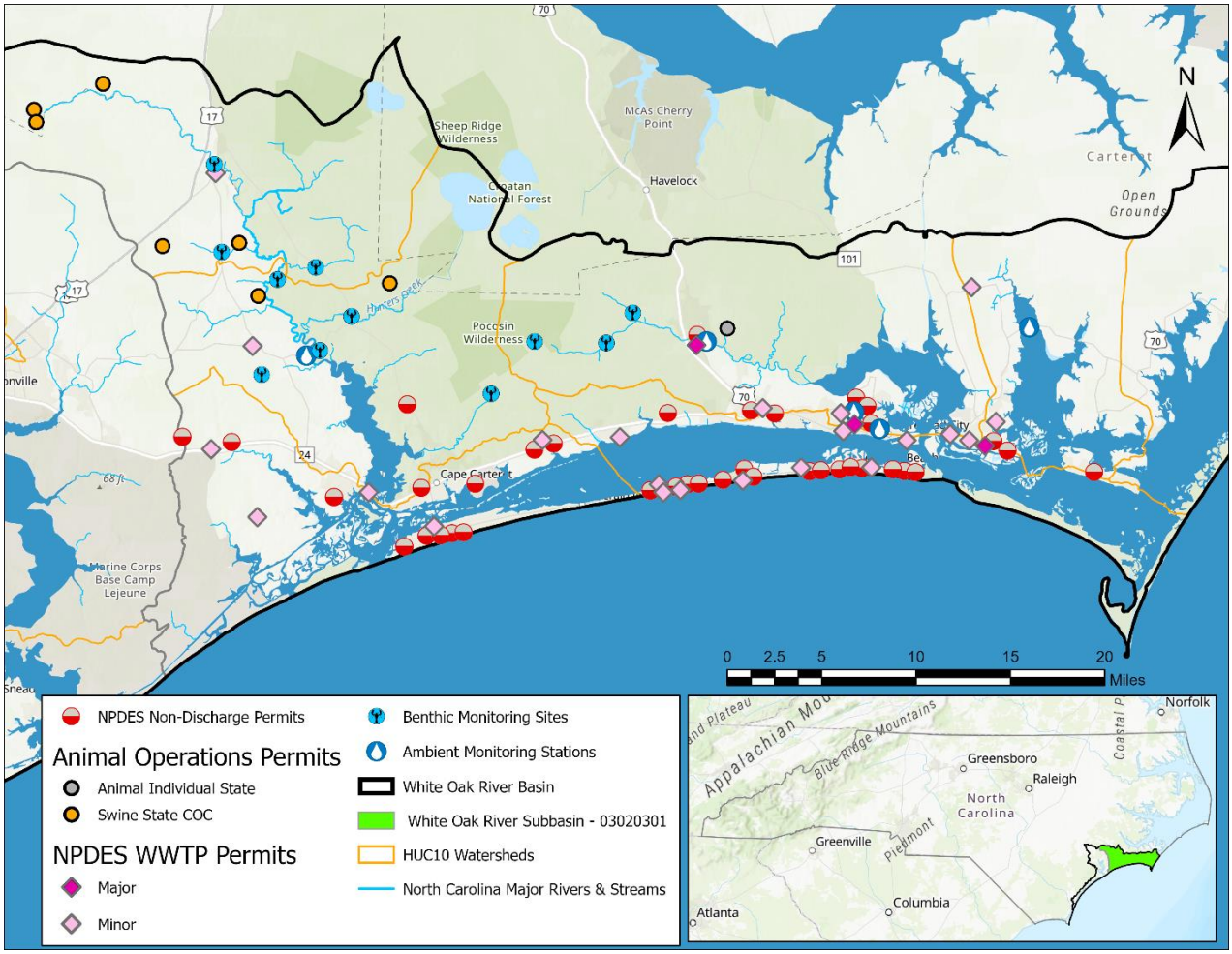
Figure 3-1 Land Cover in the White Oak Subbasin (NLCD, 2016)



3.3 Permits

There are 23 NPDES wastewater permits, 38 non-discharge permits, and 9 permitted animal feeding operations issued in the White Oak Subbasin. A list of permitted facilities can be found in Appendix III. Figure 3-2 shows the location of the permitted facilities.

Figure 3-2: NPDES Wastewater, NPDES Non-Discharge, and Animal Operations Permits in the White Oak subbasin



3.4 Biological Health

Benthic macroinvertebrate communities (also referred to as aquatic benthic communities) are composed of aquatic insects and crustacean species such as crayfish, mollusk-like mussels, clams, snails, and aquatic worms. They respond to a wide array of potential pollutants, and their sedentary nature helps identify and accurately capture local conditions, exposure to a pollutant and/or stress in the environment. Benthic communities allow for the comparison of sites over time and changes in water quality.

Biologists in DWR's Biological Assessment Branch (BAB) incorporate species richness, abundance, composition, and pollution indicator species into the benthic biocriteria used to calculate Index of Biological Integrity (IBI) scores and bioclasssification ratings. Certain species of benthos, like mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), referred to in combination as EPT, are typically sensitive to pollution and their presence or absence can be an indicator of water quality condition. Biocriteria, bioclassification assignment, and sampling methodology can vary with region and stream conditions. In the White Oak subbasin, two assessment methodologies were used: Swamp and Full Scale.

Waterbodies that have an Excellent, Good, Natural or Moderate bioclassification rating consistently contain diverse, stable, and pollution-sensitive communities of aquatic benthic macroinvertebrates and are considered supporting their designated use for aquatic habitat. Waterbodies that have a Fair, Poor, or Severe bioclassification usually contain a number of pollution-tolerant species and are considered "impaired" and not meeting their designated use for aquatic habitat.

A total of three benthic sites were sampled between 2003 and 2010. No sites were sampled between 2011 and 2015, and two sites were sampled in 2019. White Oak River (PB1) appears to have improved between 2004 and 2010 but was not resampled in 2015. PB1 was, however, resampled in 2019 and the data is going through quality assurance and quality control review and is currently unavailable for this report. The Pettiford Creek (PB3) site received a Natural rating in both 2004 and 2008, but was Not Rated in 2019. The Not Rated bioclassification could be contributed to low pH swamp water conditions at the time of sampling. Figure 3-2 shows the location and bioclassification of the most recent sampling event. Table 3-3 also includes the bioclassification by sampling methodology and year. Numerous sites sampled between 2003 and 2010 were not resampled between 2011 and 2019 due to reductions in staff.

Figure 3-2. Benthic Monitoring Sites in the White Oak Subbasin (HUC 03020301)

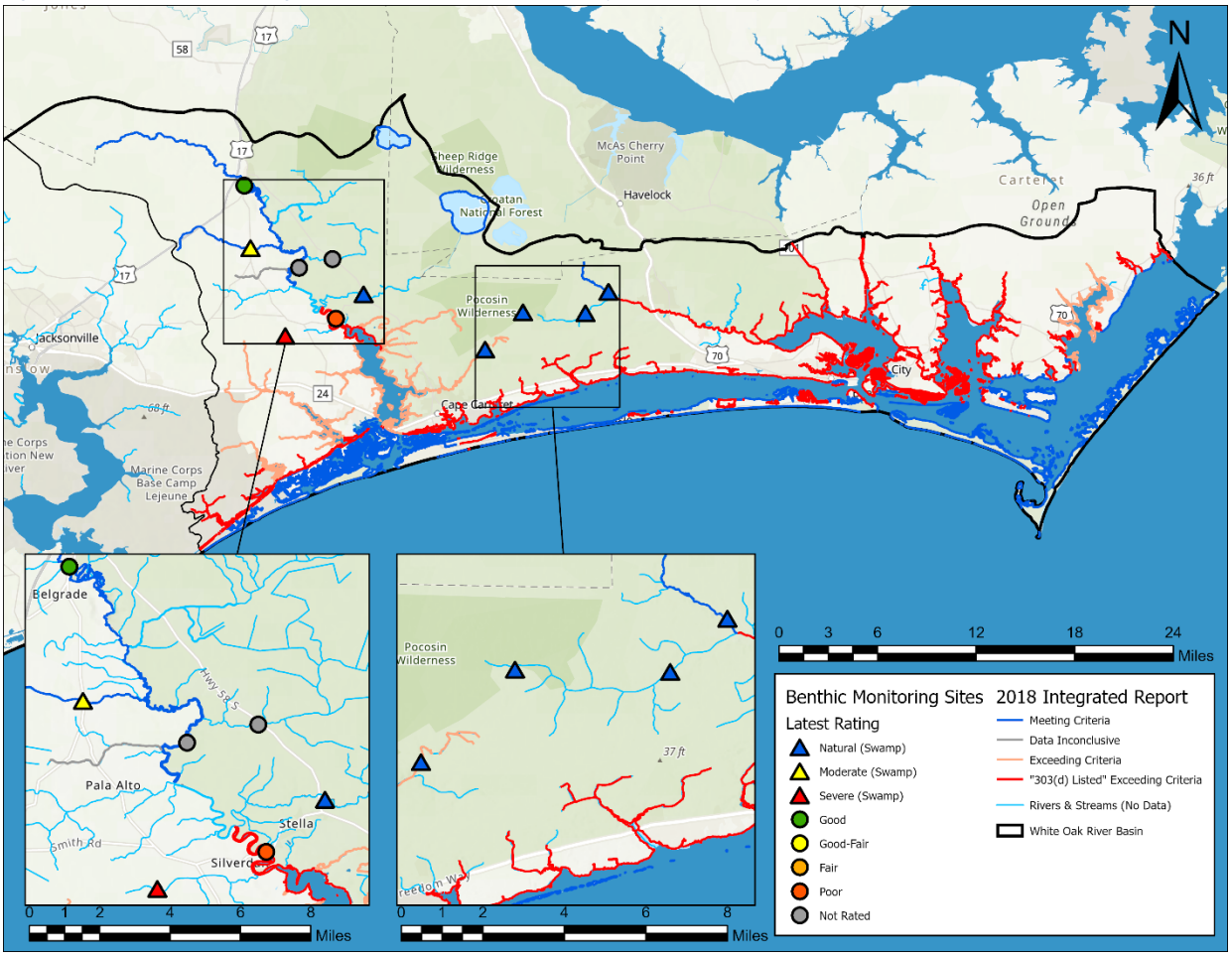


Table 3-3. Biological monitoring stations in the White Oak subbasin

Site ID	Water Body	Assessment Unit #	Drainage Area (mi^2)	Assessment Method	Sample Date	Bioclassification
PB1	White Oak River	20-(1)	66.7	Full Scale	6/30/2004	Good-Fair
					6/9/2010	Good
				Not Available	2019	Not Available
PB2	Starkeys Creek	20-10	15.7	Swamp	3/2/2004	Moderate
PB3	Pettiford Creek	20-29-1	3.5	Swamp	3/2/2004	Natural
					2/20/2008	Natural
					2/27/2019	Not Rated

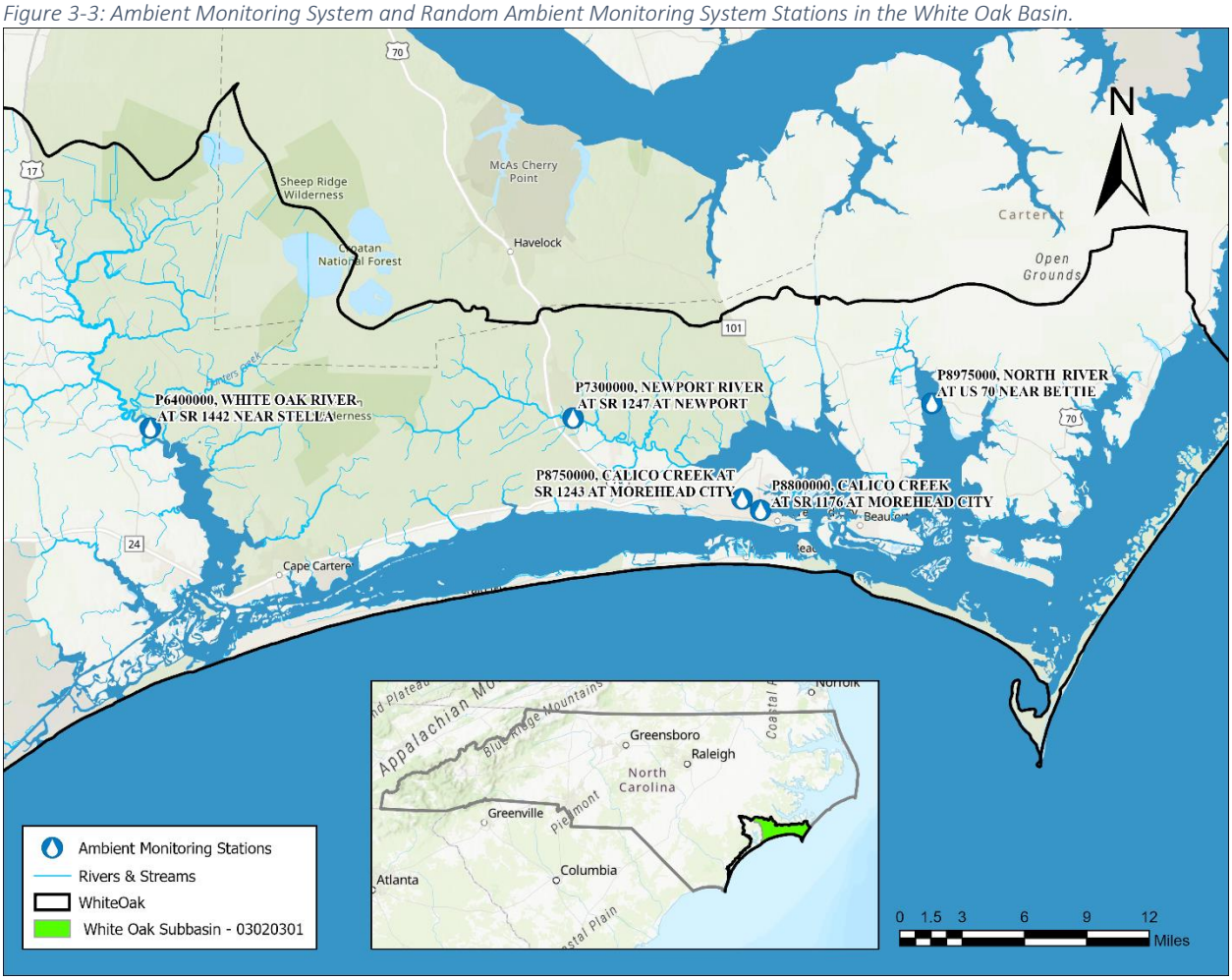
3.5 Ambient Water Quality

Monthly chemical and physical samples are taken by DWR through the Ambient Monitoring System (AMS) stations. Many of the ambient stations are associated with waterbody locations where potential pollution could occur from known land use activities in the subbasin. There are also portions of the subbasin where no water quality data are collected; therefore, water quality in those areas cannot be evaluated. Parameters collected depend on the waterbody classification, but typically include conductivity, dissolved oxygen, pH, temperature, turbidity, nutrients and fecal coliform. Each classification has an associated set of standards the parameters must meet in order to be considered supporting the waterbody's designated uses. Ten sample results are required within the five-year data collection window in order to evaluate the water quality parameter and compare it to the water quality standards. Stressors are either chemical parameters or physical conditions that at certain levels prevent waterbodies from meeting the standards for their designated use. There are five ambient monitoring stations in the White Oak subbasin (Figure 3-3; Table 3-4). Ambient monitoring station sampling results are discussed in detail in Section 3.7.

Table 3-4: Ambient monitoring stations in the White Oak subbasin (HUC 03020301)

Station ID	Station Location	County	Stream AU#	Stream Classification
P6400000	WHITE OAK RIV AT SR 1442 NR STELLA	ONSLOW	20-(18)	SA HQW
P7300000	NEWPORT RIV AT SR 1247 AT NEWPORT	CARTERET	21-(1)	C
P8750000	CALICO CRK AT SR 1243 AT MOREHEAD CITY	CARTERET	21-32	SC HQW
P8800000	CALICO CRK AT SR 1176 AT MOREHEAD CITY	CARTERET	21-32	SC HQW
P8975000	NORTH RIV AT US 70 NR BETTIE	CARTERET	21-35-1	SA HQW

Figure 3-3: Ambient Monitoring System and Random Ambient Monitoring System Stations in the White Oak Basin.



3.6 Shellfish Growing Areas

The Shellfish Sanitation and Recreational Water Quality Section of the DEQ's Division of Marine Fisheries (DMF) is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption. Shellfish growing areas are classified as Approved, Conditionally Approved, Restricted, or Prohibited. Approved areas are consistently open, while Prohibited areas are permanently closed. Conditionally Approved areas can be open to harvest under certain conditions, such as dry weather when stormwater runoff is not having an impact on surrounding water quality. Restricted waters can be used for harvest at certain times as long as the shellfish are subjected to further cleansing before they are made available for consumption.

The Shellfish Sanitation Section completes a Sanitary Survey for each shellfish growing area every three years that includes a shoreline survey of all existing or potential pollution sources, a hydrographic and meteorological survey, and a bacteriological survey of the shellfish growing waters. Shoreline surveys assess the impacts of potential pollution sources like marinas, multi-slip docks, agricultural areas, subdivisions, septic tanks, wastewater treatment plants or ditching on surrounding water quality. The hydrographic and meteorological survey is used to evaluate the factors that may affect the distribution of pollutants within a growing area, such as prevailing winds, tidal amplitude and type, water circulation

patterns, and the amount of freshwater. Rainfall patterns and intensity can also affect the distribution of pollutants by increasing volume and duration of pollutant delivery and flooding.

For water quality assessment purposes, shellfish growing areas that are conditionally approved (open or closed), restricted, or prohibited are considered impaired and not meeting their designated use. To target resources and the development of watershed action plans, conditionally approved (open) shellfish growing areas and the waterbodies associated with each are included in this subbasin chapter. For a complete list of water quality assessments for shellfish growing areas, refer to the Integrated Reports.

Stormwater, wastewater treatment plants, marinas, subdivisions, golf courses, and animals were identified as potential pollution sources in several of the shellfish growing areas in the New River subbasin. On-site wastewater management is also a potential pollution source identified throughout the subbasin. All the sanitary surveys conducted in the subbasin reported that the county health departments were notified prior to the surveys being conducted. Each county health department agreed to provide corrective action and follow-up for any malfunctioning septic systems or illegal on-site wastewater discharges discovered during the survey. Copies of the sanitary survey are available in the NC Digital Collections Library. Current, or more recent, surveys are available upon request from DMF.

Several divisions and agencies within DEQ have jurisdiction over marine fisheries, water quality and coastal management. Representatives from these agencies, develop and implement the Coastal Habitat Protection Plan (CHPP). The CHPP source document is a guidance document that addresses habitat and water quality efforts needed to protect, enhance, and restore fish habitat along North Carolina's coasts (NCDEQ 2016). It supports the Albemarle-Pamlico National Estuary Program's (APNEP) Comprehensive Conservation and Management Plan (CCMP). More information about the CHPP can be found in Chapter 5.

3.7 Water Quality on the Watershed Scale (HUC 10)

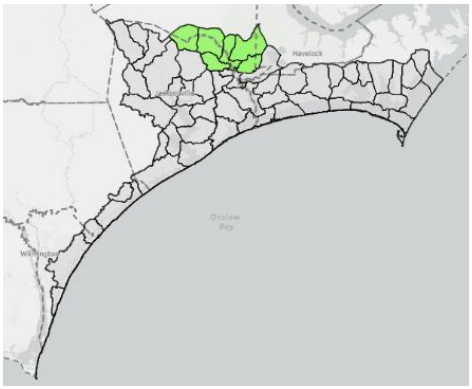
To determine the source of pollutants in a watershed, it is useful to evaluate them on a smaller scale. Smaller-scale evaluations can also help identify where monitoring and restoration is needed or being conducted. North Carolina assigns numbers to surface waterbodies. For water quality assessment purposes, these numbers are referred to as assessment unit numbers (AU#). A letter attached to the end of the AU# indicates that the assessment unit has been segmented, or broken into smaller pieces, to target the water quality assessment and the data associated with it. AU#'s that have water quality data associated with them are discussed here on a watershed (HUC 10) scale. Not all stream segments are monitored by DWR. DWR does, however, value qualitative information from stakeholders throughout the basin to understand that is impacting water quality in a particular area. Information provided by stakeholders are incorporated into each watershed along with recommendations to protect and improve water resources in the watershed.

3.7.1 Headwaters White Oak River Watershed (HUC 0302030101)

This watershed encompasses 91,136 acres (142 mi^2) and had an estimated 2010 population of 3,793 people. Fifty percent (50%) of the watershed is wetlands, followed by forests (25%) and agriculture (11%) (NLCD, 2016). Five permitted animal feeding operations, one NPDES wastewater, and three stormwater permits have been issued in this subbasin.

The White Oak River [AU# 20-(1)] (C) drains a primarily agricultural area, with Maysville as the only municipality in the watershed. Maysville's WWTP discharges into the White Oak River and has had ongoing permit violations, but planned improvements and upgrades at the facility should bring the plant into compliance. Belgrade Quarry also has a stormwater permit that drains into the White Oak River.

Benthic macroinvertebrates (PB1) were last sampled in 2019, but the results are being reviewed and were not available for this report. In 2010, PB1 rated Good, which was an improvement over the Good-Fair rating it received in 2004. Biologists noted an abundant amount of both emergent macrophytes and non-emergent macroalgaes, indicating possible high nutrient loads. Riparian vegetation was also limited along the streambanks.



Continued development, road building, wetland ditching and draining, and de-snagging practices have the potential to cause degradation of aquatic habitats and water quality in the White Oak River, as well as increase the potential for eutrophication problems in the estuary. Land use practices should implement appropriate best management practices to reduce water quality impacts.

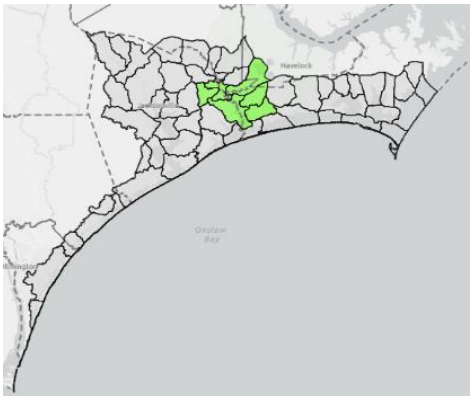
Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	10.6%	15.03
Barren Land	0.4%	0.62
Developed	2.3%	3.24
Forest	29.0%	41.29
Grassland/Shrub	6.0%	8.52
Open Water	1.4%	1.97
Wetland	50.4%	71.73

Catfish Lake [AU# 20-9-1](C) is a natural blackwater Carolina Bay Lake in the Croatan National Forest. Although the lake is large (950 acres), it is uniformly shallow with a maximum depth of approximately 1.5 meters. Having no feeder stream, the lake level is maintained by rainfall and groundwater recharge. The land surrounding the lake is flat, swampy and forested. The lake was sampled by DWR in the summer months of 2009 and no water quality concerns were detected; the lakes condition remains similar to conditions first documented in 1981. The lake drains into Black Swamp Creek [AU#20-9] (C), which is not monitored by DWR. More information about lake sampling data in the White Oak River basin is available in DWR's 2019 Lake Assessment Report.

Starkeys Creek [AU# 20-10] (C) was last sampled at PB2 in 2004 for benthic macroinvertebrates. It was rated a Moderate based on swamp water methodologies. Much of the watershed is agricultural and the stream at this site had good riparian and instream habitat. Deppe Asphalt Plant (NCG160097) has a stormwater permit within the Starkeys Creek catchment. Stormwater is collected in two discharge ponds, but it is not discharged except for extreme storm events. To improve the quality of runoff entering the ponds, it is suggested that the facility maintain constant vegetation to stabilize the inlet swale.

3.7.2 Outlet White Oak River Watershed (HUC 0302030102)

This watershed encompasses 83,819 acres (130 mi^2) and had an estimated 2010 population of 7,927 people. Wetlands comprise most of the watershed (42%), followed by forest (27%) and agriculture (12%). Only 6% of the land area is considered developed (NLCD, 2016). Three permitted animal feeding operations are located in the watershed along with two non-discharge, one NPDES wastewater and one stormwater permit. In addition, the Town of Beaufort (WQ0006017) and Morehead City (WQ006018) both hold non-discharge permits for land application of residual solids. The solids are land applied to 158 acres within the watershed. A list of permitted facilities can be found in Appendix III.



Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	11.6%	15.17
Barren Land	0.1%	0.11
Developed	5.8%	7.62
Forest	27.62%	36.21
Grassland/Shrub	2.9%	3.79
Open Water	9.7%	12.64
Wetland	42.3%	55.42

A TMDL for managing fecal coliform bacteria in the White Oak River and tributaries was completed in 2010 with an addendum added in 2012. Data through 2012 show fecal coliform bacteria levels exceeding water quality standards 45% of the time. The TMDL required a 75% reduction from nonpoint sources and identified the NC Department of Transportation (DOT) as a potential partner in achieving the reduction goal.

Great Lake [AU# 20-17a] is a natural blackwater lake located within the Croatan National Forest. Like other Carolina Bay Lakes, it is a large shallow body of water with acidic tannic water. Great Lake has no major tributaries and lake level is maintained by rainfall and groundwater recharge. The lake was sampled most recently in the summer of 2014 by DWR. Water quality data indicates elevated phosphorus, nitrogen, and chlorophyll *a* levels, but the levels were within the same ranges previously observed. More information about lake sampling data in Great Lake is available in DWR's 2014 Lakes Assessment Report.

Hunters Creek [AU# 20-17b] (C) drains Great Lake and was last sampled in 1999 when it received a Natural bioclassification.

Pettiford Creek [20-29-1] (SA;HQW) is impaired for shellfish harvesting. Biological samples have been collected in the upper reach of this stream since 1998 and show a stable minimally disturbed swamp habitat. In 2019, PB3 was Not Rated because the naturally occurring low pH levels.

There is one ambient monitoring station P6400000 on the White Oak River [AU# 20-(18)a1] (SA;HQW). Low pH and low dissolved oxygen (DO) occurrences are associated with natural conditions attributed to swamp drainage. A review of the last 19 years of pH and DO data indicates there has been little to no change in this segment of the river (Figure 3-4; Figure 3-5).

Figure 3-4. Yearly median values of pH measured at ambient monitoring station P6400000 (White Oak River) (2000-2019). Numbers on bars represent the number of samples collected in that year.

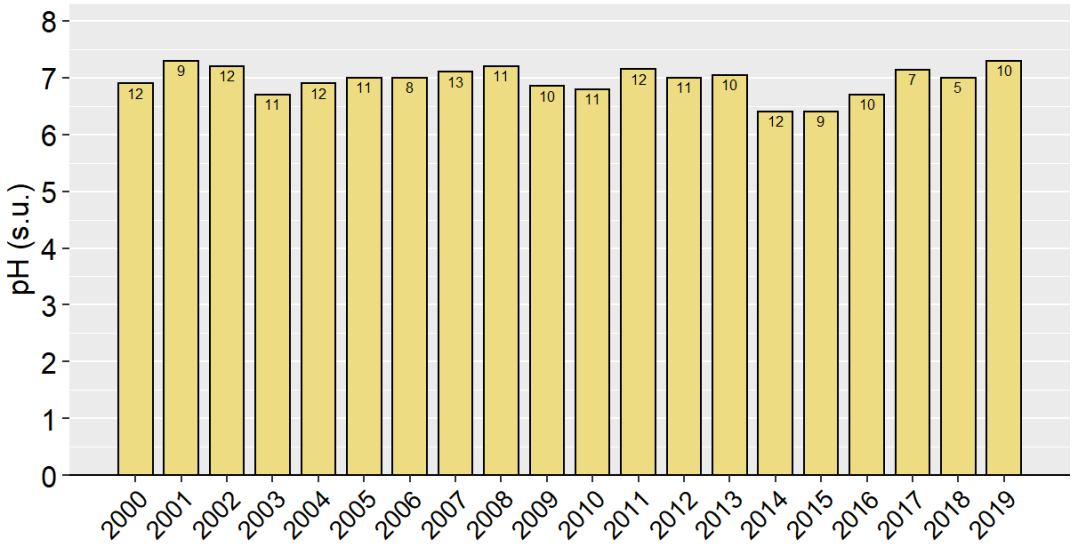
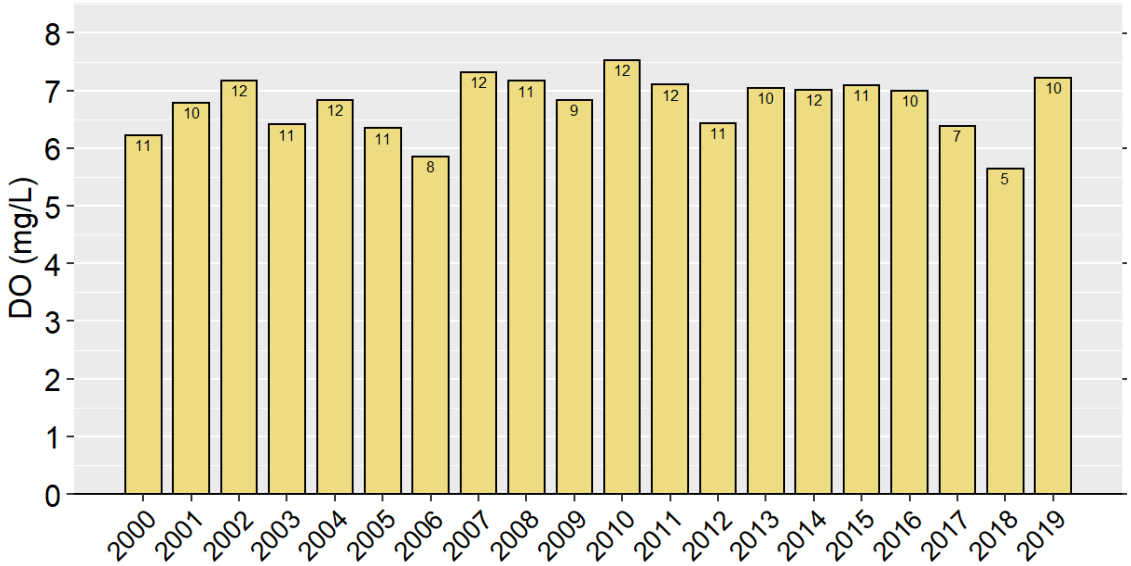


Figure 3-5. Yearly median values of DO measured at ambient monitoring station P6400000 (White Oak River) (2000-2019). Numbers on bars represent the number of samples collected in that year.



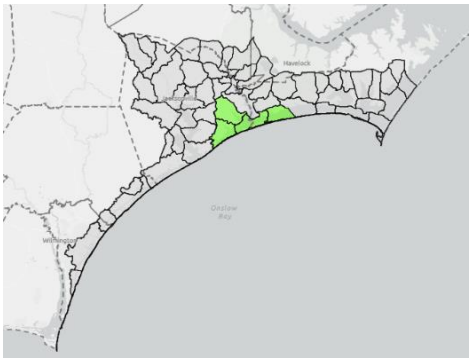
Based on the most current shellfish sanitary surveys, D-3 White Oak River Area is located in this watershed. More information about the shellfish growing areas, new closures associated with the most current shellfish sanitary surveys, and potential pollution sources can be found in Chapter 5. Five waterbodies are located in conditionally approved open shellfish growing areas (Table 3-5).

Table 3-5. Conditionally Approved - Open shellfish growing areas in Outlet White Oak River (HUC 0302030102)

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
20-(18)c3	WHITE OAK RIVER	1849.8	White Oak River Area	D-3	1409.2
20-(18)c5	WHITE OAK RIVER	28.1	White Oak River Area	D-3	0.6
20-(18)e1	WHITE OAK RIVER	755.5	White Oak River Area	D-3	683.6
20-27	Hampton Bay	82.1	White Oak River Area	D-3	1367.2
20-29	Pettiford Creek Bay	239.3	White Oak River Area	D-3	683.6

3.6.3 Bogue Banks-Bogue Sound (HUC 0302030103)

Bogue Banks-Bogue Sound encompasses 67,110 acres (105 mi^2) and had an estimated 2010 population of 22,874 people. Wetlands and open water make up approximately 50% of the land use followed by forest (20%) and developed/urban areas (16%). One NPDES wastewater, 11 non-discharge, and 17 stormwater permits have been issued in the watershed.



Queen Creek [AU# 19-41-16a] (SA;HQW) is Impaired for Shellfish Harvesting. A TMDL for fecal coliform bacteria was approved for Queen Creek and tributaries in 2011. Reductions in fecal coliform bacteria loading were required for Upper Queens Creek, Pasture Branch and Bells Swamp at 63%, Parrot Swamp at 11%, and Halls Creek at 87%.

Nonpoint source pollution was identified as a major concern in the Queen Creek drainage area because of steep grades along the shoreline and runoff conveyed rapidly via ditches, pipes, and lawns to the shellfish waters. The majority of stormwater runoff is from residential neighborhoods and roadways. There are several stormwater, discharge and non-discharge permits in the catchment. None have had major compliance issues.

Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	5.1%	5.31
Barren Land	3.6%	3.72
Developed	16.2%	16.99
Forest	19.7%	20.64
Grassland/Shrub	6.8%	7.17
Open Water	24.7%	25.88
Wetland	24.0%	25.15

Bear Creek [AU# 19-41-11a1, 19-41-11a2, 19-41-11a3, 19-41-11b1, 19-41-11b2] (SA;HQW) is also Impaired for Shellfish Harvesting. A TMDL for fecal coliform bacteria was approved in 2011. The results indicated that there needed to be a 69% reduction in bacterial loading from Upper Bear Creek. Stormwater from agriculture lands, residential areas, and roadways are likely contributing to the bacterial loads.

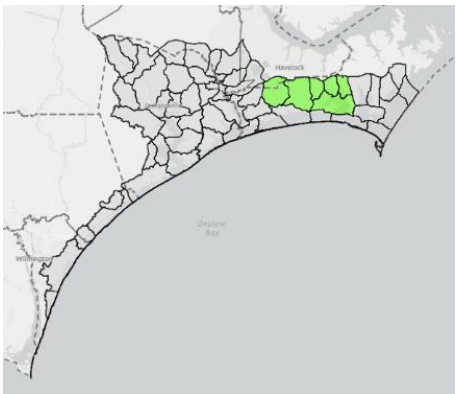
Based on the most current shellfish sanitary surveys, this watershed falls into DMF Shellfish Sanitation Growing Areas D-4 Deer Creek Area, D-3 White Oak River Area, D-2 Queens Creek Area, and D-1 Bear Creek Area (Table 3-6). Potential sources of pollution that may be affecting the growing area are discussed in detail in Chapter 5.

Table 3-6 Conditionally approved open shellfish growing areas in the Bogue Banks-Bogue Sound watershed (HUC 0302030103)

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
19-41-(0.5)c1	Intracoastal Waterway	145.2	Hurst Beach Area	C-4	128.2
19-41-(0.5)d	Intracoastal Waterway	276.9	Hurst Beach Area	C-4	246.1
19-41-5	Freeman Creek	65.4	Hurst Beach Area	C-4	129.0
19-41-(0.5)d	Intracoastal Waterway	276.9	Bear Creek Area	D-1	30.9
19-41-(0.5)e	Intracoastal Waterway	57.0	Bear Creek Area	D-1	100.6
19-41-11a1	Bear Creek	88.1	Bear Creek Area	D-1	9.2
19-41-11a2	Bear Creek	8.2	Bear Creek Area	D-1	9.2
19-41-11a3	Bear Creek	19.2	Bear Creek Area	D-1	1.9
19-41-11b1	Bear Creek	12.1	Bear Creek Area	D-1	9.4
19-41-11b2	Bear Creek	179.8	Bear Creek Area	D-1	57.8
19-41-(14.5)a	Intracoastal Waterway	108.4	Queens Creek Area	D-2	2.0
19-41-(15.5)a	Intracoastal Waterway	162.6	Queens Creek Area	D-2	1.1
19-41-16c	Queen Creek	283.8	Queens Creek Area	D-2	12.1
20-(18)e1	WHITE OAK RIVER	755.5	White Oak River Area	D-3	3.4
20-36-(0.5)a1	Bogue Sound (Including Intracoastal Waterway)	9281.0	Deer Creek Area	D-4	1221.4
20-36-(0.5)a2	Bogue Sound (Including Intracoastal Waterway)	1750.1	Deer Creek Area	D-4	4069.9
20-36-(0.5)a4	Bogue Sound (Including Intracoastal Waterway)	1.6	Deer Creek Area	D-4	586.9
20-36-(0.5)a6	Bogue Sound (Including Intracoastal Waterway)	4.6	Deer Creek Area	D-4	586.9
20-36-(0.5)b1	Bogue Sound	44.2	Deer Creek Area	D-4	586.9
20-36-(0.5)c	Bogue Sound	33.6	Deer Creek Area	D-4	406.6
20-36-3	Taylor Bay	81.9	Deer Creek Area	D-4	2.0
20-36-4b	Goose Creek	128.8	Deer Creek Area	D-4	7.5
20-36-(0.5)a2	Bogue Sound (Including Intracoastal Waterway)	1750.1	Broad Creek Area	E-1	539.8

3.6.4 Newport River Watershed (HUC 0302030104)

This watershed encompasses 95,140 acres (149 mi^2) and had an estimated 2010 population of 26,333 people. The majority of the land use is designated as wetlands (48%) followed by forest (22%) and developed/urban area (11%) (NLCD, 2016). Four NPDES wastewater permits including the Morehead City WWTP and Newport WWTP are located in the watershed along with five non-discharge, 29 stormwater, and one animal feeding operation. Newport's WWTP discharges into the Newport River and Morehead City's WWTP discharges into Calico Creek.



Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	6.8%	10.11
Barren Land	0.3%	0.38
Developed	11.1%	16.57
Forest	21.62%	32.14
Grassland/Shrub	3.1%	4.62
Open Water	9.0%	13.44
Wetland	48.0%	71.40

Three ambient monitoring stations (P7300000, P8750000, P8800000) are located in this watershed. Water quality data has been collected at P7300000 in the Newport River [AU# 21-(1)] since 1980. The most recent data at this site does show incidences of low pH and high fecal coliform bacteria levels (Figure 3-6; Figure 3-7). Based on new data, the Newport River [AU# 21-(17)e2] is proposed to be listed for an enterococcus impairment in the 2020 draft IR.

Calico Creek [AU# 21-32a, AU# 21-32b]

Calico Creek is a highly eutrophic tidal estuarine creek located in Morehead City and has been listed on the North Carolina 303(d) list since 2008 for nutrient related impairments. Two segments, or assessment units (AU 21-32a and 21-32b), of Calico Creek and its tributaries are included in the most recent 2018 North Carolina 303(d) list of impaired waters. The upper part of Calico Creek (AU 21-32a) was listed as impaired for chlorophyll *a*, DO, and turbidity, while the lower part (AU 21-32b) was listed for chlorophyll *a*. Based on new data, AU 21-32b also moved from Category 1 to Category 3b in the draft 2020 Integrated Report for DO.

In addition to the long-term ambient monitoring program, DWR's Intensive Survey Branch (ISB) conducted intensive surveys from May 2017 to April 2019 to collect extra physical and biogeochemical data at additional sampling sites within Calico Creek. Cross-channel depth profiles were collected in February 2018 along 6 transects and again between July and August 2019 along 7 transects (Figure 3-8). The study was conducted as part of a data collection effort to aid in the development of a dynamic nutrient response model that is needed to assess the impact of nutrient loadings to the water quality conditions in the Calico Creek Estuary. A data report summarizing major physical and biogeochemical features in Calico Creek is available online (DWR, 2020).

Figure 3-6. Yearly median values of pH measured at ambient monitoring station P7300000 (Newport River) (2000-2019). Numbers on bars represent the number of samples collected in that year.

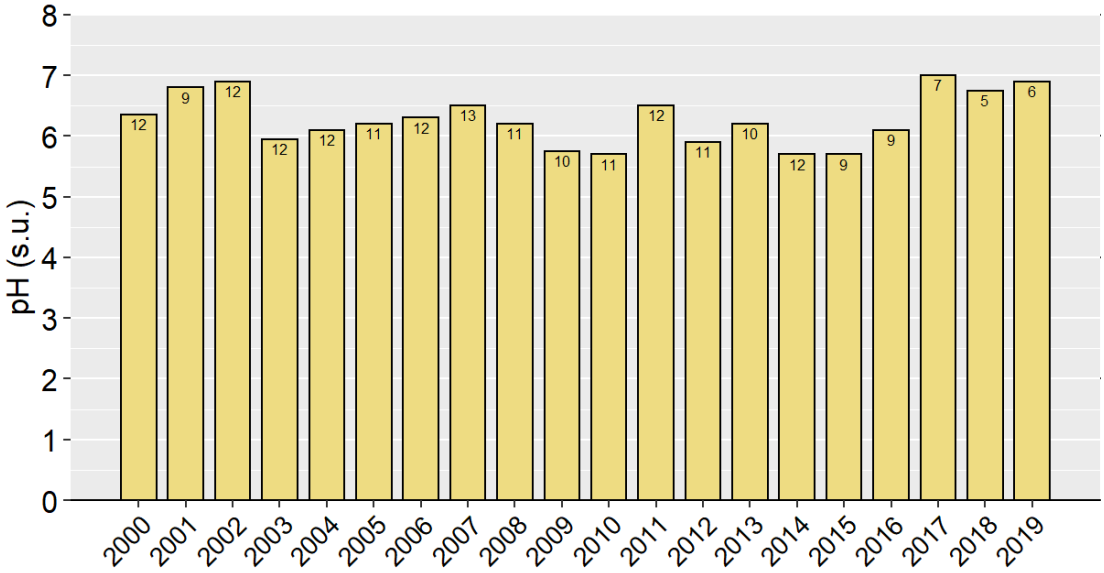


Figure 3-7. Yearly geometric mean values of fecal coliform measured at ambient monitoring station P7300000 (Newport River) (2000-2019). Numbers on bars represent the number of samples collected in that year.

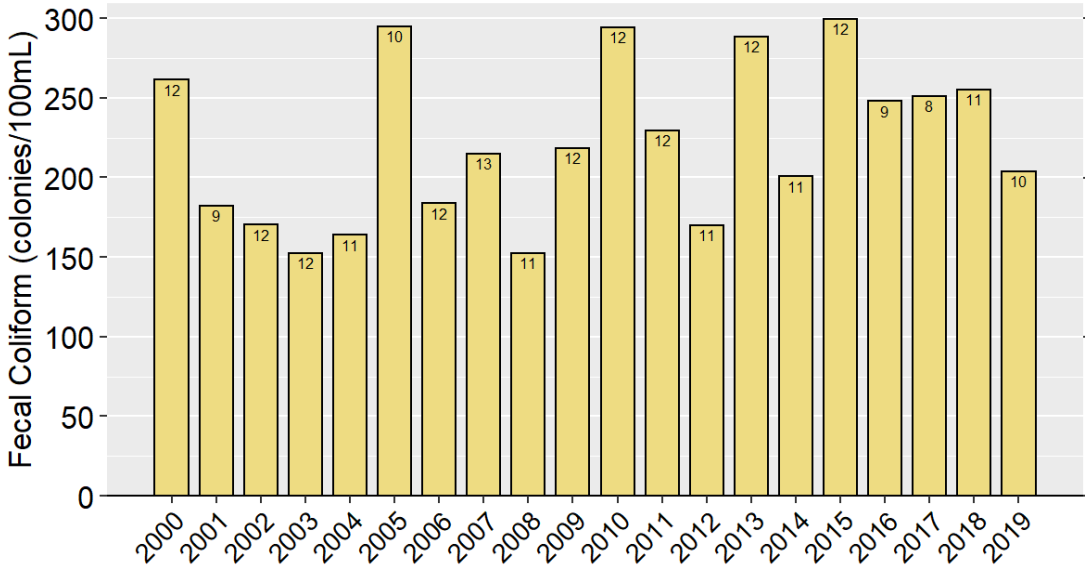
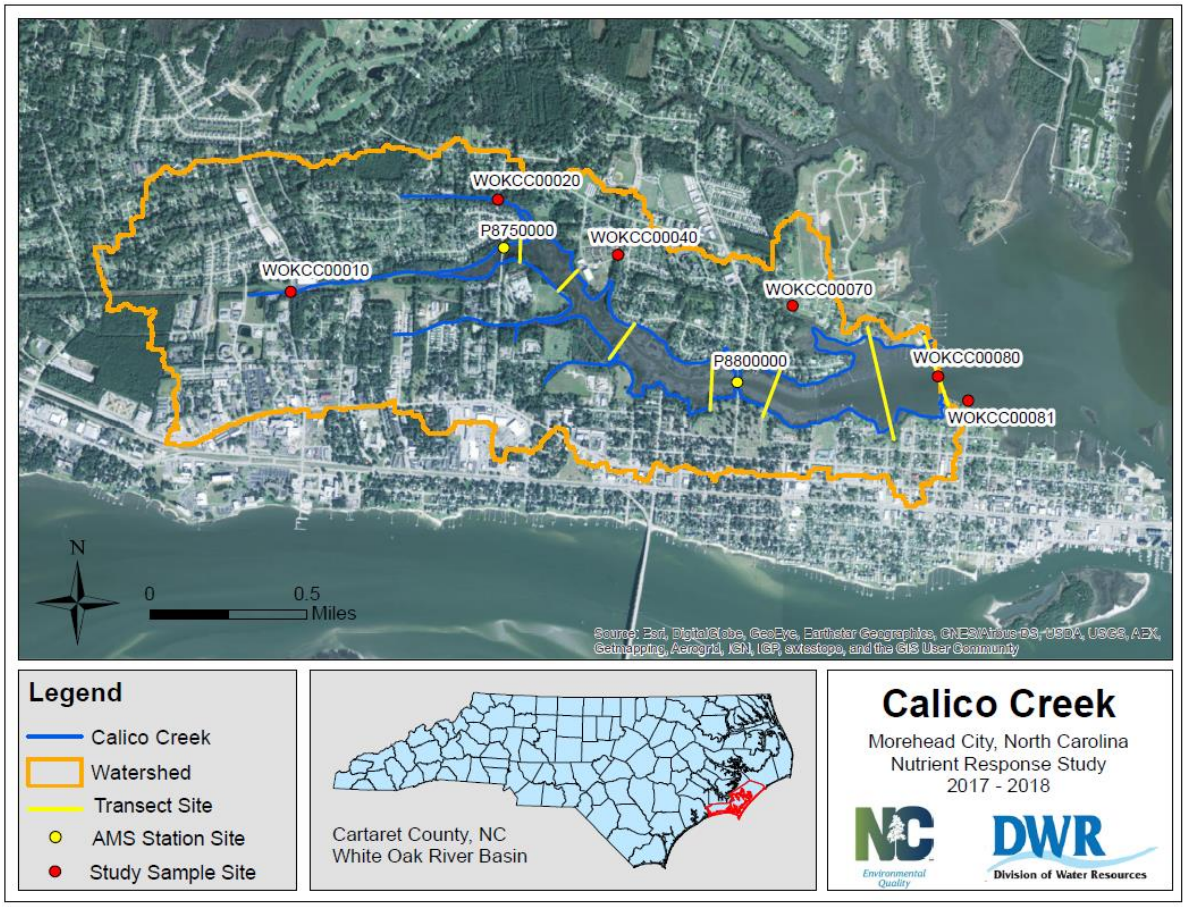


Figure 3-8. Calico Creek watershed and monitoring stations (Modeling and Assessment Branch (MAB), 2020)



Chlorophyll a concentrations were measured within the Calico Creek estuary at station P8750000 and P8800000 (Figure 3-8). Very high Chlorophyll a values, up to 1000 µg/L, were observed during growing seasons (April to September). Algal data also suggest that diatom dominates especially during summer (DWR, 2020).

Nutrient concentrations appear to be higher during warmer months, especially April to August, at the upper estuary station P8750000, and in recent years (2011-2018), at P8800000. During 2002 to 2011, before the Morehead City WWTP upgrade was complete, high nutrient concentrations were observed almost year-round at P8800000 (Figure 3-9; Figure 3-10).

Figure 3-9. Monthly distributions of nutrient concentrations (in mg/L) during 2002-2010 and 2011-2018 periods at Calico Creek station P8750000 (DWR, 2020).

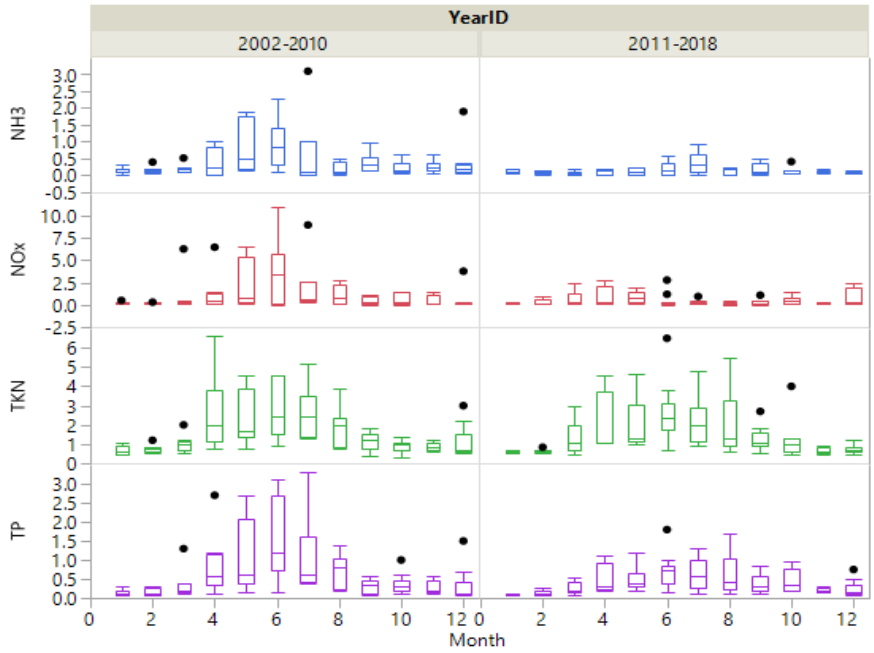
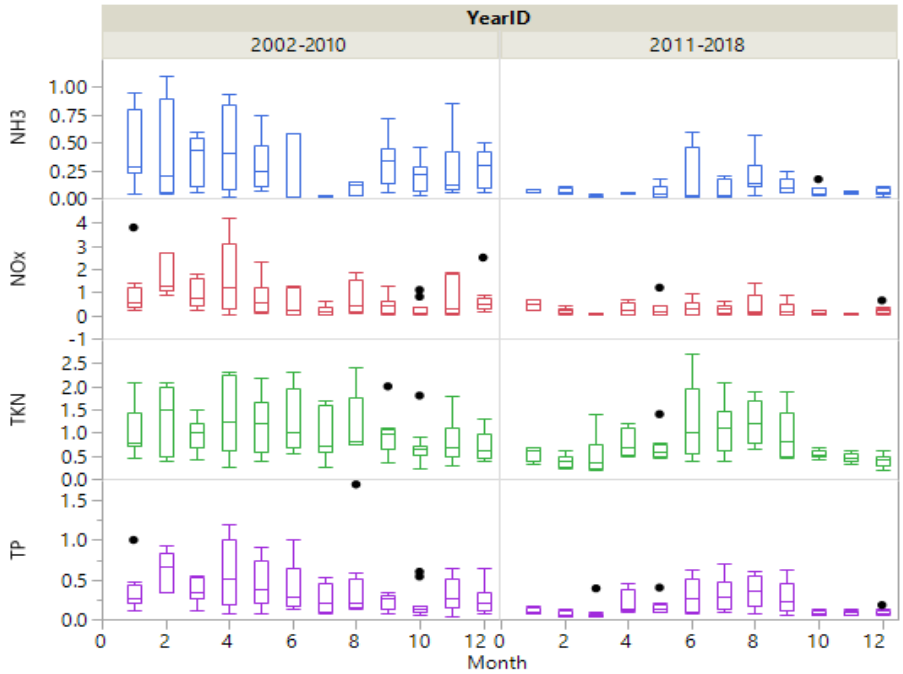


Figure 3-10. Monthly distributions of nutrient concentrations (in mg/L) during 2002-2010 and 2011-2018 periods at station Calico Creek station P8800000 (DWR, 2020).



Year-round nutrient concentrations at P8800000 were significantly lower during 2011-2018 than during 2002-2010 for all the nutrient forms mentioned above. However, there are no significant differences in mean nutrient concentrations between the summers of the two time periods. At station P8750000, lower NH_3 and NO_x concentrations were observed during most recent years (2011-2018). During summer months, significantly lower NOx and TP concentrations were observed in recent years.

Morehead City WWTP is the single point source discharging directly into the estuary. The drainage basin is heavily developed. Stormwater runoff also delivers nutrients to the estuary. An upgrade to the Morehead City WWTP facility happened between 2008 and 2010 with permitted flow increased from 1.7 to 2.5 MGD and with tertiary treatment and UV disinfectant installed. The effluent NH3, BOD5, and TSS concentrations appear to be lower in recent years than before the upgrade, but pH values are about 0.5 higher.

Algal blooms occurred most often in summers in Calico Creek and were primarily dominated by diatoms (Appendix III). Algal blooms were generally more severe in the upstream part of the estuary, and no significant differences were found in algal unit density or biovolume before and after the Morehead City WWTP upgrade. Chlorophyll *a* concentrations are significantly higher in recent years, but no significant differences in chlorophyll *a* concentrations were found during summer when compared to other seasons. Significantly lower nutrient concentrations were observed at both estuary monitoring stations (for NH3 and NOx at upstream station P8750000 and for NH3 NOx, TKN and TP at downstream station P8800000) during recent years. NOx and TP concentrations were significantly lower during recent summers at P8750000 but no significant differences were found during summers at P8800000. In short, nutrient concentrations were in general lower in recent years especially during non-summer seasons (DWR, 2020).

Long-term records show that sea level at Beaufort appears to have risen more than 0.1 m since 2000. Air temperature has also increased from 2002 to 2019, up around 2 °F. Calico Creek appears to be partially mixed, vertical stratifications were often observed at station P8800000. Observed freshwater inflow appears to be very low in most cases, except when rainfall events occurred during and before the day of the measurement. The salinity and water temperature records also suggest warm and dry winters and springs in recent years. The influence by freshwater inflow in Calico Creek appears to be limited to rainfall events in the basin. Tide gauge and ADCP measurement suggests that hydrodynamics in Calico Creek is likely mainly controlled by semidiurnal tide (DWR, 2020).

Based on the most recent shellfish sanitary surveys, this watershed primarily falls into DMF Shellfish Sanitation Growing Area E-4 Newport River Area. Potential sources of pollution that may be affecting the growing area 6 are discussed in detail in Chapter 5.

Table 3-6. Conditionally approved open shellfish growing areas in the Newport River watershed (HUC 0302030104)

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
21-(17)c	Newport River	2701.408	Newport River Area	E-4	465.5534
21-(17)d1a	Newport River	3194	Newport River Area	E-4	59072.53
21-(17)d3	Newport River	0.405421	Newport River Area	E-4	10.86691
21-(17)e1	Newport River	19.65465	Newport River Area	E-4	20.04508
21-(17)e2	Newport River	671.0596	Newport River Area	E-4	13.80008
21-(17)g1	Newport River	30.7708	Newport River Area	E-4	5063.197
21-(17)g2	Newport River	136.8807	Newport River Area	E-4	15194.93
21-22c	Harlowe Creek	99.7022	Newport River Area	E-4	280.952
21-24-2b	Bell Creek	46.22124	Newport River Area	E-4	279.8383
21-24b2	Core Creek (Intracoastal Waterway - Adams Creek Canal)	14.87985	Newport River Area	E-4	279.8383
21-24c	Core Creek (Intracoastal Waterway - Adams Creek Canal)	196.3677	Newport River Area	E-4	559.6767
21-28a	Gable Creek	35.41187	Newport River Area	E-4	2531.598
21-28b	Gable Creek	10.93477	Newport River Area	E-4	5069.98

3.6.5 North River Watershed (HUC 0302030105)

This watershed encompasses 43,830 acres and had an estimated 2010 population of 6,482 people. There are 11,054 saltwater acres of which 2,723 Support Shellfish Harvesting and 8,331 are Impaired for Shellfish Harvesting. Potential sources of pollution that may be affecting the growing area are discussed in detail in Chapter 5.

There is one active ambient monitoring station (P8975000). Data from this site in the North River have been collected since 1984. Station P8976000, in Ward Creek, was deactivated in 2007.

Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	24.3%	16.66
Barren Land	0.4%	0.27
Developed	5.6%	3.86
Forest	16.9%	11.54
Grassland/Shrub	2.1%	1.44
Open Water	26.2%	17.98
Wetland	24.4%	16.74

Ward Creek [AU# 21-35-1-7a] (SA;HQW) and North River [AU# 21-35-1b4] (SA;HQW) are Impaired because of turbidity standard violations (Fig. 3-13). North River [AU# 21-35-1b4] is conditionally approved open for shellfish harvesting. The draft 2020 IR proposes a change from Category 1 to Category 5 in Westmouth Bay [AU#'s 21-35-1-12-3a2, 21-35-1-12-3a3] (SA; HQW) for shellfish harvesting because of fecal impairments.
Located in this watershed is The NC Coastal Federation's North River Wetland Preserve, a 6,000 acre restoration project located on former farmland. It is one of the largest wetland restoration sites in North Carolina at 6,000 acres; 3,000 acres have been restored, and another 1,200 acres of existing forested wetlands and marshes have been preserved in perpetuity, and restoration of the remaining 1,800 acres of wetlands is ongoing. The site lies between Open Ground Farms, a current 60,000-acre farm, and the North River and is open to the public (NC Coastal Federation, n.d.).

Fig. 3-13. Yearly average values of turbidity measured at ambient monitoring station P8975000 (North River) (2000-2019). Numbers on bars represent the number of samples collected in that year.

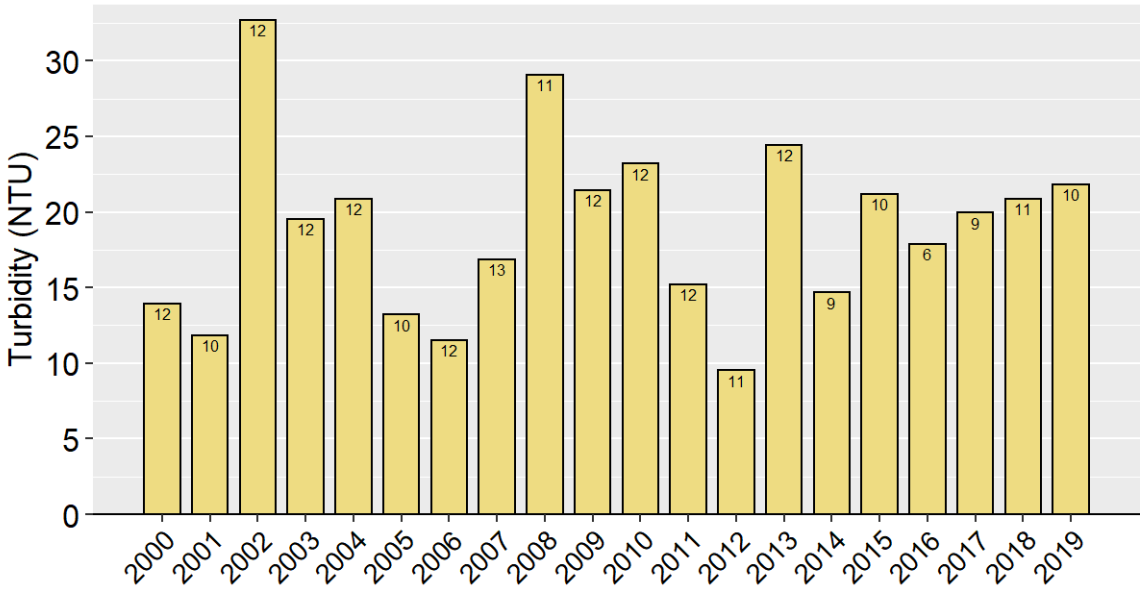
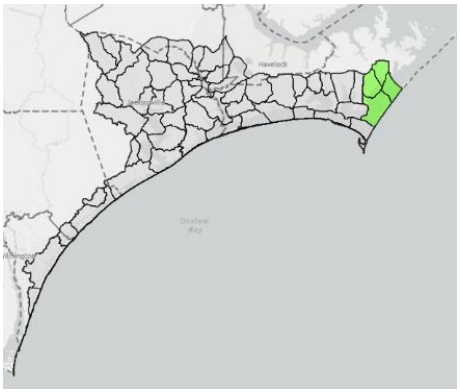


Table 3-7. Conditionally Approved - Open Shellfish Harvesting Waters HUC 0302030105

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
21-35-1b4	North River	5898.1	Beaufort Area	E-5	28.9207
21-35-1d1	North River	50.71285	Beaufort Area	E-5	3.656732
21-35-1-10	Gibbs Creek	65.43672	North River Area	E-6	1.29601
21-35-1-12-1a	Sleepy Creek	144.0607	North River Area	E-6	0.787037
21-35-1-12-2a	Whitehurst Creek	80.65293	North River Area	E-6	21.20804
21-35-1-12b	The Straits	94.09227	North River Area	E-6	76.22278
21-35-1-5a	Thomas Creek	4.05289	North River Area	E-6	260.8231
21-35-1-6a1	Fulcher Creek	2.263523	North River Area	E-6	12.25708
21-35-1-6a2	Fulcher Creek	7.226027	North River Area	E-6	12.25708
21-35-1-6a3	Fulcher Creek	3.886957	North River Area	E-6	45.73799
21-35-1-6b1	Fulcher Creek	0.26006	North River Area	E-6	130.4115
21-35-1-6b2	Fulcher Creek	0.7399	North River Area	E-6	68.60699
21-35-1-7-2b	North Leopard Creek	86.59014	North River Area	E-6	127.2491
21-35-1-7b	Ward Creek	366.4311	North River Area	E-6	20.83956
21-35-1-9	Goose Bay	260.0914	North River Area	E-6	158.5447
21-35-1a2	North River	114.4257	North River Area	E-6	636.9033
21-35-1b3	North River	12.42867	North River Area	E-6	130.4115
21-35-1b4	North River	5898.1	North River Area	E-6	2048.97
21-35-1b7	North River	1	North River Area	E-6	415.8125
21-35-1c1	North River	49.39922	North River Area	E-6	26.39987
21-35-1d1	North River	50.71285	North River Area	E-6	29.3413
21-35-1d2	North River	138.5404	North River Area	E-6	3.678213

3.6.6 Oyster Creek – Jarrett Bay (HUC 0302030106)

This watershed encompasses 53,448 acres and had an estimated 2010 population of 1,987 people. There are 4,920 saltwater acres, of which, 1,257 support shellfish harvesting and 3,662 acres are Impaired for shellfish harvesting. Potential sources of pollution that may be affecting the growing area are discussed in detail in Chapter 5.



Jarrett Bay and its tributaries are Impaired for Shellfish Harvesting. A **TMDL** for managing the fecal coliform bacteria impairment was completed in 2007, resulting in an 74% reduction in bacteria loading in Williston Creek, 88% reduction in Wade Creek and a 91%

reduction in Smyrna Creek. The estimated sources of fecal coliform bacteria in this watershed are from nonpoint sources including: wildlife, pets, failing septic systems, and livestock.

Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	20.2%	16.89
Barren Land	1.2%	1.00
Developed	1.4%	1.18
Forest	6.5%	5.40
Grassland/Shrub	1.1%	0.92
Open Water	45.8%	38.23
Wetland	23.8%	19.89

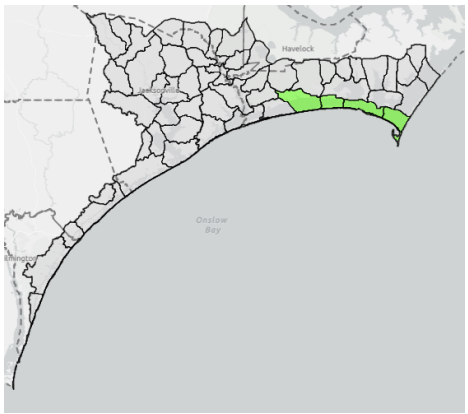
3-8. Conditionally Approved - Open Shellfish Harvesting Waters HUC 0302030106

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
21-35-7a1	Core Sound	21202.1	Core Sound - Jarrett Bay Area	E-8	**1342.821**
21-35-7-21	Spit Bay	37.60803	Core Sound - Jarrett Bay Area	E-8	2422.701
21-35-7-22-2	Ditch Cove	32.06483	Core Sound - Jarrett Bay Area	E-8	7662.488
21-35-7-22-3	Broad Creek (Jarrett Bay)	36.58261	Core Sound - Jarrett Bay Area	E-8	4028.463
21-35-7-22-4	Great Creek	71.85791	Core Sound - Jarrett Bay Area	E-8	7662.488
21-35-7-22-5	Howland Creek	26.29643	Core Sound - Jarrett Bay Area	E-8	5371.284
21-35-7-22-7a	Wade Creek	25.93182	Core Sound - Jarrett Bay Area	E-8	1342.821
21-35-7-22-7b	Wade Creek	117.7733	Core Sound - Jarrett Bay Area	E-8	8127.06
21-35-7-22a	Jarrett Bay	38.67026	Core Sound - Jarrett Bay Area	E-8	3765.504
21-35-7-22b	Jarrett Bay	1110.774	Core Sound - Jarrett Bay Area	E-8	10406.34
21-35-7-22c2	Jarrett Bay	27.68796	Core Sound - Jarrett Bay Area	E-8	17.52478
21-35-7-24b	Middens Creek	112.5341	Core Sound - Jarrett Bay Area	E-8	0.809186
21-35-7-25	Tush Creek	42.79841	Core Sound - Jarrett Bay Area	E-8	6.424579

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
21-35-7-26a	Great Marsh Creek	123.9807	Core Sound - Jarrett Bay Area	E-8	42.56071
21-35-7b	Core Sound	1251.68	Core Sound - Jarrett Bay Area	E-8	6562.917
21-35-7-13-1	Maria Creek	39.80395	Core Sound - Atlantic Area	E-9	1917.611
21-35-7-13-2	Fork Creek	18.33458	Core Sound - Atlantic Area	E-9	1117.56
21-35-7-13a	Brett Bay	161.4117	Core Sound - Atlantic Area	E-9	609.4774
21-35-7a2	Core Sound	20.29859	Core Sound - Atlantic Area	E-9	254.0411

3.6.7 Bogue Banks – Shackleford Banks (HUC 0302030107)

This watershed encompasses 50,210 acres and had an estimated 2010 population of 16,342 people. Non-discharge high rate infiltration wastewater treatment facilities are the predominant permitted facility in this watershed.



There are 69,232 saltwater acres, of which 63,342 support shellfish harvesting and 5,407 acres are Impaired for shellfish harvesting. Bogue Sound [AU# 20-36-(8.5)] is proposed to be moved from Category 5 to Category 1 in the 2020 draft IR. Back Sound [AU#'s 21-35-(0.5)a2, 21-35-(0.5)b] is proposed in the 2020 draft IR to be listed for shellfish harvesting due to fecal impairments. Potential sources of pollution that may be affecting the growing area are discussed in detail in Chapter 5.

Land Use (2016)	% Land Cover	Square Miles (mi^2)
Agriculture	0.6%	0.46
Barren Land	5.7%	4.49
Developed	14.2%	11.10
Forest	5.3%	4.14
Grassland/Shrub	1.5%	1.19
Open Water	57.2%	44.90
Wetland	15.5%	12.17

3-9. Conditionally Approved - Open Shellfish Harvesting Waters HUC 0302030107

AU #	Stream Name	Area (Saltwater Acres)	Growing Area Name	Growing Area ID	Growing Area Acres
20-36-(0.5)a2	Bogue Sound (Including Intracoastal Waterway)	1750.121	Broad Creek Area	E-1	1619.451
20-36-(0.5)d1	Bogue Sound	3.819402	Broad Creek Area	E-1	539.817
20-36-(8.5)a2	Bogue Sound (Including Intracoastal Waterway)	1180.542	Bogue Sound Area	E-2	554.5126
20-36-(8.5)c1	Bogue Sound (Including Intracoastal Waterway to Beaufort Inlet	373.1364	Bogue Sound Area	E-2	277.2563

3.8 White Oak River TMDLs

The Total Maximum Daily Load (TMDL) Program is a Federal program authorized under the Clean Water Act to address waters that are not meeting water quality standards. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. The TMDL is then used to establish limits on sources of the pollutant which are classified as either point sources (waste load allocation), and nonpoint sources (load allocation). The TMDL must account for seasonal variation in water quality and include a margin of safety to ensure that the TMDL allocations will be adequate to protect the body of water (NCDEQ, n.d.).

TMDL's developed for the White Oak River basin are listed in the table below.

TMDL Name	TMDL Type	Date Approved	Link Full TMDL
Bear Creek	Fecal Coliform	Sept. 20, 2011	Bear Creek TMDL
Jarrett Bay and it's Embayment	Fecal Coliform	Aug. 7, 2007	Jarrett Bay TMDL
Queens Creek	Fecal Coliform	Aug. 18, 2011	Queens Creek TMDL
Southeast White Oak Embayments	Fecal Coliform	Apr. 10, 2009	Southeast White Oak Embayments TMDL
White Oak River	Fecal Coliform	Sept. 8, 2010	White Oak River TMDL
Addendum to White Oak River	Fecal Coliform	Aug. 31, 2012	Addendum to White Oak River TMDL
Mercury Statewide TMDL	Mercury	Oct. 12, 2012	Mercury Statewide TMDL

3.10 Protecting Water Resources in the White Oak River Subbasin

The Basin Planning Branch (BPB) continually work with the Nonpoint Source Planning Branch (NPSPB), Soil and Water Conservation Districts (SWCD), Natural Resources Conservation Service (NRCS), and various stakeholders throughout the region to improve our understanding of point and nonpoint sources of pollution and encourage continued efforts to implement best management practices (BMPs) and restoration activities that reduce nutrients, sediment loads, and flow volume to the receiving waterbodies.

Stormwater, wastewater treatment plants, on-site wastewater management systems (septic systems), marinas, subdivisions, golf courses, and animals were identified as potential pollution sources in the White Oak subbasin. Several division within DEQ have jurisdiction over water quality, marine fisheries, and coastal management. Representatives from these divisions develop and implement the Coastal Habitat Protection Plan (CHPP), with DMF as the lead agency. The CHPP is a guidance document that addresses habitat and water quality efforts needed to protect, enhance, and restore fish habitat along North Carolina's coasts. It supports the Albemarle-Pamlico National Estuary Program's (APNEP) Comprehensive Conservation and Management Plan (CCMP). More information about the CHPP can be found in Chapter 5.

Key recommendations for protecting water quality and the shellfish growing areas in the White Oak subbasin include:

- Continue to improve strategies to reduce nonpoint source pollution and minimize cumulative losses. This can be done through voluntary programs, actions, and assistance, and includes reevaluating the existing NSW strategy for the New River watershed and improving methods to control stormwater runoff from agriculture, forestry, and urban areas.

- To prevent additional shellfish closures and swimming advisories, conduct targeted water quality restoration activities.

- Prohibit new or expanded stormwater outfalls to coastal beaches and shellfish growing areas except during times of emergency when public safety and health may be threatened, and continue to phase out existing outfalls by implementing alternative stormwater management strategies.

- Enhance coordination and provide financial and technical support to local governments to effectively manage and improve stormwater and wastewater infrastructure.

- Maintain effective regulatory strategies throughout the river basins to reduce nonpoint pollution and minimize cumulative losses of fish habitat, including use of vegetated buffers and established stormwater controls.

- Maintain adequate water quality conducive to the support of present and future mariculture in public trust waters.

- Reduce nonpoint source pollution from large-scale animal operations by ensuring proper oversight and management of animal waste management systems, and certified operator compliance with permit and operator requirements and management plan for animal waste management systems.

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