Contents

Chapter 2 Monitoring Data and Water Quality Assessments

Water quality is assessed every two years to fulfill the reporting requirements of Section 303(d) and 305(b) of the Federal Clean Water Act (CWA). To determine how well waterbodies are meeting their best-intended use, chemical, physical and biological parameters are regularly assessed by the Division of Water Resources (DWR). Where enough samples exist, waterbodies are determined to be meeting or exceeding criteria based on a five-year dataset, assigned waterbody classification, and existing water quality standards. Impaired waters are waterbodies where water quality samples are exceeding water quality standards for a particular parameter. Procedures used to evaluate water quality and assign categories are explained in detail in the Integrated Report (IR) methodology. For the purposes of this report, the 2018 methodology was used.

2.1 Surface Water Classifications and Water Quality Standards

North Carolina's (NC) Water Quality Standards Program adopted classifications and water quality standards for all the state's river basins in 1963. The program remains consistent with the CWA and its amendments. Water quality classifications and standards can be modified and supplemented during the triennial review process to provide improved protection of water uses including water supply waters, high quality waters (HQW), and unique waters with outstanding resource value (ORW).

2.1.1 Statewide Water Quality Standards

Each primary and supplemental classification is assigned a set of water quality standards that establish the level of water quality that must be maintained to support the uses associated with each classification (Table 2-1). The standards for C and SC waters establish the basic protection level for all state freshwater and tidal saltwater surface waters, respectively. The remaining primary and supplemental classifications modify or add to the standards in class C and SC to provide appropriate protections for specific uses. Some of these additional classifications, such as the water supply primary classification, establish higher levels of protection while others, such as the swamp supplemental classification, take into account naturally occurring conditions in certain surface waters. Sources of water pollution that preclude any of the best uses of waters on either a short-term or long-term basis shall be deemed to violate a water quality standard. These standards include the following components:

- *Designated uses represent the best usage for waters in the State that are to be protected. North Carolina's designated uses include aquatic life and recreation. Other designated uses are recognized in the State's water quality standards such as drinking water supply, trout, and shell fishing.*
- *Numeric values and narrative statements are established for chemical, physical, and biological parameters to protect the best usage of surface water bodies from pollution for each classification.*
- *Land management strategies aimed at controlling point and nonpoint source pollution such as setbacks and density limits, also are established to protect the best usage of waters.*
- *The State's anti-degradation policy is implemented by the NPDES permitting section which allows for protection of water quality above the minimum required for a classification of a waterbody if deemed necessary.*

A full description of surface water quality standards program is available online through the Rules Review Classification & Standards Branch website. To view the surface water quality standards rules, see 15A NCAC 02B .0200 and .0300.

Table 2-1 Classifications and designated use in the Pasquotank River basin.

Primary Classifications	
Class	**Designated Uses**
C	**Freshwater** Aquatic life propagation, survival, and maintenance of biological integrity (including fishing and fish); wildlife; secondary contact recreation; and agriculture.
B	Primary contact recreation and Class C uses.
WS-I through WS-V	Drinking, culinary or food processing uses and Class C uses. WS-I and WS-II waters are also HQW.
SC	**Saltwater** Aquatic life propagation, survival, and maintenance of biological integrity (including fishing, fish, and Primary Nursery Areas (PNAs)); wildlife; and secondary contact recreation.
SB	Primary contact recreation and protected for SC uses.
SA	Market shellfishing and Class SC and Class SB uses. SA waters are also HQW.
Supplemental Classifications	
NSW	Waters experiencing or subject to excessive growths of microscopic or macroscopic vegetation.
ORW	Waters of exceptional State or national recreational or ecological significance that require additional protection to maintain existing uses. ORW waters are a subset of HQW waters.
HQW	Waters rated excellent based on biological and physical/chemical characteristics through monitoring or special studies; or primary nursery areas (PNA) and other functional nursery areas designated by the Marine Fisheries Commission or the Wildlife Resources Commission.
Sw	Waters that have natural characteristics due to topography, such as low velocity, dissolved oxygen, or pH, that are different from streams draining steeper topography.
UWL	Wetlands of exceptional state or national ecological significance. These wetlands may include wetlands that have been documented as habitat essential for the conservation of state or federally listed threatened or endangered species.

Primary Classifications

Class C

Aquatic life propagation, survival, and maintenance of biological integrity (including fishing and fish); wildlife; secondary contact recreation; and agriculture.

This classification provides the basic protection level for all state freshwater surface waters.

Class B Primary Contact Recreation

Waters classified as Class B are protected for primary contact recreation which includes swimming, diving and similar uses involving human body contact with water where such activities take place in an organized or on a frequent basis must meet water quality standards for fecal coliform bacteria. Sewage and all discharged wastes into Class B waters must be treated to avoid potential impacts to the existing water quality.

Class WS-I – Water Supply I

This classification is restricted to waters used as a source of water supply for drinking, culinary, or food processing purposes and protects for all Class C uses. WS-I waters are generally located on land in public ownership and in undeveloped watersheds. Class I waters are also classified HQW.

Class WS-II – Water Supply II

This classification is restricted to waters used as a source of water supply for drinking, culinary, or food processing purposes where a WS-I classification is not feasible as determined by the Environmental Management Commission and protects for all Class C uses. Class II waters are also classified HQW.

Class WS-III – Water Supply III

This classification is restricted to waters used as a source of water supply for drinking, culinary, or food processing purposes where a more WS-I or WS-II classification is not feasible as determined by the Environmental Management Commission and protects for all Class C uses.

Class WS-IV – Water Supply IV

This classification is restricted to waters used as a source of water supply for drinking, culinary, or food processing purposes where a more WS-I, WS-II or WS-III classification is not feasible as determined by the Environmental Management Commission and protects for all Class C uses.

Class WS-V – Water Supply V

This classification is restricted to waters that are protected as water supplies which are generally upstream and draining to Class WS-IV waters; waters previously used for drinking water supply purposes; or waters used by industry to supply their employees, but not for municipalities or counties, with a raw drinking water supply source, although this use is not restricted to WS-V classification, and protects for all Class C uses.

WS Critical Area (CA)

A WS Critical Area (CA) is designated within one-half mile and draining to a WS intake or WS reservoir within WS-II, WS-III and WS-IV watersheds. The water supply restrictions applied in the CA are more stringent than the water supply restrictions applied in the remainder of the watershed draining to a WS intake or WS reservoir. For a WS-IV watershed, the remainder of the watershed is called a Protected Area, and is defined as 5 miles and draining to the normal pool elevation of a reservoir, or 10 miles upstream of and draining to a river intake. For the WS-II and WS-III watersheds, the remainder of the watershed is called the Balance of the Watershed (BW), and is comprised of all lands and waters draining to an intake or reservoir outside of the CA. No land management restrictions are associated with the WS-V classification, and given the same land management restrictions apply throughout the entirety of the area draining to a WS-I intake or reservoir, there is no CA, PA, or BW associated with WS-I classification.

Class SC -Tidal Saltwaters

Aquatic life propagation, survival, and maintenance of biological integrity (including fishing, fish, and Primary Nursery Areas (PNAs)); wildlife; secondary contact recreation.

This classification provides the basic protection level for all salt waters in the State.

Class SB - Tidal Saltwaters Primary Contact Recreation

Waters classified as Class SB are tidal saltwaters protected for primary contact recreation. Primary contact recreation activities include swimming, diving and similar uses involving human body contact with water where such activities take place in an organized or on a frequent basis. Class SB waters are also protected for Class SC uses.

Class SA - Tidal Saltwaters Shellfish Marketing

Waters classified as SA are tidal saltwaters that are used for shellfishing for marketing purposes. They are also protected for all Class SC and Class SB uses. All SA waters also carry the supplemental classification of High Quality Waters (HQW).

Supplemental Classifications

Nutrient Sensitive Waters - NSW

The Nutrient Sensitive Waters supplemental classification is intended for waters needing additional nutrient management due to excessive growths of microscopic or macroscopic vegetation.

High Quality Waters - HQW

The High Quality Waters (HQW) supplemental classification is intended to protect waters which are rated excellent based on biological and physical/chemical characteristics through monitoring or special studies; or primary nursery areas (PNA) and other functional nursery areas designated by the Marine Fisheries Commission and the Wildlife Resources Commission. Also waters classified as Class WS-I, WS-II, SA, or ORW are HQW.

Outstanding Resource Waters - ORW

The Outstanding Resource Waters (ORW) supplemental classification is intended to protect waters of exceptional State or national recreational or ecological significance that require additional protection to maintain existing uses. ORW is a subset of HQW.

Swamp Waters -Sw

The Swamp (Sw) supplemental classification is intended to recognize those waters that have natural characteristics due to topography, such as low velocity, dissolved oxygen, or pH, that are different from streams draining steeper topography.

Unique Wetlands – UWL

The Unique Wetland (UWL) supplemental classification is intended for unique wetlands that are of exceptional State or national ecological significance which require special protection to maintain existing uses. Class UWL wetlands may include wetlands that have been documented as habitat essential for the conservation of State or federally listed threatened or endangered species. Nags Head Woods in Dare County and Phelps Lake Shoreline in Washington County are designated UWL in the Pasquotank River basin.

2.2 Interpreting Data

In NC, criteria are established to protect the surface water classification, or designation, of a waterbody. The criteria define the maximum pollutant concentrations, goals, conditions or other requirements in order for a waterbody to maintain or attain its designation. In the Pasquotank River basin, water quality was assessed for aquatic life, recreation, and fish consumption on a monitored or evaluated basis. Waters are assessed based on the parameter of interest and are found to be:

- Meeting Criteria (meeting standards)
- Exceeding Criteria (exceeding standards, also referred to as impaired)
- Data Inconclusive (data does not allow for an assessment to be made)

Biological (benthic and fish community) samples are given a bioclassification based on the data collected at the site by DWR biologists. Different benthic macroinvertebrate criteria have been developed for different ecoregions (mountains, piedmont, coastal plain, and swamp). They include measurements for diversity, abundance and the number of pollution tolerant or intolerant species found within a particular waterbody. Most wadeable, flowing stream sites are assigned a bioclassification of Excellent, Good, Good-Fair, Not Impaired, Not Rated, Fair or Poor. Swamp stream bioclassification fall into three categories: Natural, Moderate and Severe.

For the Integrated Report, ambient monitoring data are analyzed based on the percent of samples exceeding the state standard for individual parameters for each site within a five-year period. In general, if more than 10% of the samples exceed the standard for a water quality parameter with 90% statistical confidence, the stream segment is Exceeding Criteria, or impaired, for that parameter. The standard for fecal coliform bacteria (FCB) is the exception to the rule as it relies of a 5-in-30 sampling regime which is the collection of 5 samples within a 30-day period.

Each biological parameter (benthic and fish) and each ambient parameter is assessed independently and assigned a category based on its rating or percent exceedance. Each monitored stream segment is given an overall category number. Table 2-2 illustrates how bioclassifications for biological samples and ambient data are translated into categories. For example, if the ambient data is meeting criteria for all parameters but the bioclassification is exceeding the criteria established for fish, the waterbody will be assigned to Category 5 for fish community.

Category 4 is assigned when a parameter is exceeding criteria, but (1) the development of a Total Maximum Daily Load (TMDL) is not required, (2) a TMDL or management strategy is already in place, and/or (3) a variance is in place. The development of a TMDL includes a study of the watershed to identify the sources of the pollutant of interest, calculations and modeling to identify the pollutant contributions, and reductions needed from point and nonpoint sources of pollution. Category 5 is assigned when a parameter is exceeding criteria, and a TMDL is required. Category 5 assessments are the 303(d) list, which has historically been referred to as the impaired waters list. More detailed information about each category can be found in the IR methodology. The a summary of the impaired waters in the Pasquotank River basin is below (Table 2-3 and Figure 2-1).

Table 2-2 Water quality assessments and categories (2016)

Biological Ratings (Bioclassifications)	Water Quality Assessment (EPA Categories)	Ambient Monitoring Data
Excellent/Natural	Meeting Criteria (Categories 1 and 2)	Numerical standard exceeded in ≤ 10% of the samples collected
Good		
Good-Fair/Moderate		
Not Impaired		
Not Rated	Data Inconclusive (Category 3)	Less than 10 samples were collected
Fair	Exceeding Criteria (Categories 4 and 5)	Numerical standard exceeded in ≥ 10% of samples collected with a 90% confidence in exceedance
Poor/Severe		

Table 2-3 Impaired waters on the 303(d) list in category 5 (Exceeding Criteria) for the Pasquotank River basin (2018).

AU Name	AU Number	Stream Class	Parameter of Interest	303d Year
Albemarle Sound	30c2a	SB	Copper (3 µg/l, AL, SW)	2008
Albemarle Sound	30c2a	SB	pH (8.5, AL, SW)	2018
Albemarle Sound	30c2b	SB	Copper (3 µg/l, AL, SW)	2008
Albemarle Sound	26	B;NSW	Dioxin Fish Tissue Advisory (Advisory, FC, NC)	2010
Albemarle Sound	30b	SB	Copper (3 µg/l, AL, SW)	2008
Albemarle Sound	30c1	SB	Copper (3 µg/l, AL, SW)	2008
Alligator River	30-16-(7)	SC;Sw,ORW	Copper (3 µg/l, AL, SW)	2008
Baum Creek	30-20-5	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Blackmar Gut	30-22-13	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2008
Broad Creek	30-21-7a	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2008
Callaghan Creek	30-20-4	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Colington Creek	30-19-1b	SC	Enterrococcus (GM 35, REC, SW)	2014
Croatan Sound	30-20-(2)b	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Croatan Sound	30-20-(2)c	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Croatan Sound	30-20-(2)d	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Croatan Sound	30-20-(2)e	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Croatan Sound	30-20-(2)f	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Currituck Sound	30-1c	SC	Enterrococcus (GM 35, REC, SW)	2014
Cut Through	30-20-8b	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Dowdys Bay (Poplar Branch Bay)	30-1-15b	SC	Enterrococcus (GM 35, REC, SW)	2014
Johns Creek	30-21-5	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Kendrick Creek (Mackeys Creek)	30-9-(2)	SC	Nickel (8.3 µg/l, AL, SW)	2008
Little River	30-5-(1)b	C;Sw	Chlorophyll a (40 µg/l, AL, NC)	2010
Main Canal	30-9-4	C;Sw	Benthos (Nar, AL, FW)	1998
Oyster Creek (Croatan Sound)	30-20-6	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Pasquotank River	30-3-(12)	SB	Copper (3 µg/l, AL, SW)	2008

AU Name	AU Number	Stream Class	Parameter of Interest	303d Year
Pasquotank River	30-3-(12)	SB	Dissolved Oxygen (5 mg/l, AL, SW)	2018
Pasquotank River	30-3-(12)	SB	pH (6.8 su, AL, SW)	2014
Pond Island	30-21-4a	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Pond Island	30-21-4b	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21b	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21c	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21d	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21e1a	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2010
Roanoke Sound	30-21f	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21g	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21h	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21i	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Roanoke Sound	30-21j	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Rockhall Creek	30-21-6	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Sand Beach Creek	30-21-5-1	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Spencer Creek	30-20-3	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Stumpy Point Bay	30-22-8b	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
Stumpy Point Bay	30-22-8c	SA;HQW	Shellfish Growing Area Status (Fecal, SH, SA)	2002
AL = Aquatic Life SW = Salt Water SH = Shellfish Harvesting GM = Geometric Mean				

2.3 Benthic Macroinvertebrate Monitoring Data

The Water Science Section (WSS) Biological Assessment Branch (BAB) of DWR monitors benthic macroinvertebrates using two biological indices. The Ephemeroptera, Plecoptera, Trichoptera (EPT) index is a measure of pollution-sensitive aquatic insects inhabiting a waterbody. A stream showing high EPT richness is less likely to be polluted than one with low richness in the same geographic region. In addition, they evaluate the streams biotic integrity (BI), which measures the presence of pollution-tolerant species. High BI values characterize streams that have poor water quality and are dominated by pollution-tolerant species. The Pasquotank River basin has three types of stream collection methods: Qual 4, Coastal B (boat), and Swamp (Figure 2-1 and).

Table 2-4). For specific methodology defining how these ratings are given, refer to the Benthic Standard Operating Procedures (SOP). The Qual 4 method applies to small streams, which are defined as those sites having a drainage area less than 3.0 square miles (NCDWQ, 2009). All representative specimens of the entire macroinvertebrate community (i.e., not just EPT taxa) are picked from the collections. Qual 4 stream bioclassification fall into five categories: Excellent, Good, Good-Fair, Fair, and Poor.

Coastal B rivers are defined as waters in the coastal plain that are deep (non-wadeable), freshwater systems with little or no visible current under normal or low flow conditions. Other characteristics may include an open canopy, low pH and low dissolved oxygen. There currently is not an approved biocriteria for these Coastal B streams, and therefore a bioclassification of Not Rated is assigned to these sites.

The BAB defines swamp streams as streams that are within the coastal plain ecoregion and have little to no visible flow during certain parts of the year. Little or no flow usually occurs during summer months, but flowing water should be present in swamp streams during winter months. Samples are collected during winter months (February to early March) because sampling during the high-flow months provides the best opportunity for detecting differences in naturally occurring communities. Swamp stream bioclassification fall into three categories: Natural, Moderate and Severe.

Several sites sampled during the basinwide cycle in 2005 were not sampled in 2010 due to staffing reductions including Newbegun Creek at SR 1132 (Camden County) Pasquotank River at SR 1361 (Pasquotank County), Newland Drainage Canal at SR 1363 (Pasquotank County), Perquimans River at NC 37 (Perquimans County) and UT Cowells Creek at NC 34 (Currituck County) (NCDENR, 2011). Between the 2010 and 2015-time frame, several sites including Burnt Mill Creek (Chowan County), Perquimans River (Perquimans County), and Main Canal (Washington County) were not sampled due to staffing reductions. Overall between the 2006 to 2015-time frame, the biological communities in the Pasquotank River basin were rated Moderate, Not Impaired, or Not Rated (Figure 2-1 and Table 2-4).

Table 2-4 Benthic macroinvertebrate monitoring data results (2006 – 2015).

Station ID	Waterbody Name	Assessment Unit Number	Drainage Area (mi^2)	Assessment Method	Sample Date	Bioclassification
MB3	Pasquotank River	30-3-(3)	393	Boat	8/24/2005	Fair
					7/23/2010	Not Impaired
					7/14/2015	Not Rated
MB6	Burnt Mill Creek	30-8-1	4.9	Swamp	2/21/2005	Moderate
					3/2/2010	Moderate
MB7	Little River	30-5-(1)	33.9	Swamp	2/23/2005	Moderate
					3/1/2010	Moderate
					2/3/2015	Moderate
MB14	Perquimans River	30-6-(1)	127	Boat	8/23/2005	Fair
					7/22/2010	Not Impaired
MB9	Main Canal	30-9-4	2.56	Swamp	2/21/2005	Severe
					3/2/2010	Moderate
MB10	Scuppernong River	30-14-4-(1)	129	Boat	8/25/2005	Poor
					7/20/2010	Not Rated
					7/15/2015	Not Rated
DB17*	FILBERT CR	-	1.53	Qual 4	4/18/2006	Not Rated
DB18*	FILBERT CR	-	1.56	Qual 4	4/18/2006	Not Rated
DB19*	FILBERT CR	-	1.62	Qual 4	4/18/2006	Not Rated
MB27*	Deep Creek	30-14-2	10.1	Swamp	3/11/2014	Moderate
*Special Study monitoring not part of 5-year Basin Cycle Monitoring						

Figure 2-1 Benthic macroinvertebrate sampling sites (2006 – 2015).

2.4 Fish Kill Assessment

DWR has systematically monitored and reported fish kill events across the state since 1996. Field reports since 2007 have generally shown elevated occurrences of reported fish kills; especially in 2017 and 2018 (Table 2-5). Hurricane Florence in 2018 and the resulting floods flushed swamps and backwaters as well as urban areas washing large quantities of oxygen consuming debris, and organic matter into streams. As the storm passed, dissolved oxygen (DO) levels in many systems were depleted to concentrations lethal to aquatic life (NCDENR, 2018). Elevated occurrence of fish kills could also be the result of the ease of reporting via the DWR mobile app. A link to the mobile app, information on how to report a fish kill, recent fish kill activity, and annual fish kill reports can be found on DWR's WSS website.

Table 2-5 Historical fish kill events reported by the public or investigated by DWR (2018).

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fish Kill Events	1	4	0	1	3	0	0	0	2	3	6	7

2.5 Fish Communities

Fish community monitoring uses the North Carolina Index of Biological Integrity (NCIBI) which incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of comprehensive influences upon aquatic faunal communities such as water quality, energy source, habitat quality, flow regime, and biotic interactions. The NCIBI has not been developed for the Coastal Plain (Chowan, Neuse, Pasquotank, Roanoke, Tar, and White Oak River basins) due to staffing and other limitations. Accordingly, the unratable fish community sites located in the Pasquotank River basin have not been sampled since 2000 or earlier. Additional information about wadeable streams fish community assessments can be found on DWR's WSS website

2.6 Fish Tissue Contaminants

As fish spend their entire lives in water, chemicals that occur within their aquatic environments can be incorporated into their tissues over time. Contamination of aquatic resources including freshwater, estuarine, and marine fish and shellfish species have been documented for heavy metals, pesticides, and other complex organic compounds such as PCBs. Fish tissue monitoring data is primarily used by the NC Division of Public Health for human risk assessments related to fish consumption, and when necessary for issuing fish consumption advisories in North Carolina.

A 2008, fish mercury study was conducted by the United States Fish and Wildlife Service, North Carolina Division of Water Quality, and North Carolina Wildlife Resources Commission in the Alligator River and Pocosin Lakes Nation Wildlife Refuges in the Pasquotank River Basin (US FWS et al., 2008). More information about this study and their results can be found in their report (link).

Dioxins have been identified as an impairment for the Albemarle Sound to the mouths of the Chowan and Roanoke rivers. Dioxins are the byproducts of industrial processes and are formed during the chlorine bleaching process at pulp and paper mills. The current dioxins advisory was issued by the Department of Health and Human Services (DHHS) in 2001. The advisory is for the consumption of catfish and carp in the Albemarle Sound from Bull Bay to Harvey Point; West to the mouth of the Roanoke River and to the mouth of the Chowan River to the U.S. Highway 17 Bridge (Perquimans, Chowan, Bertie, Washington, and Tyrrell counties). Women of childbearing age and children should not eat any catfish or carp from this area until further notice. All other persons should eat no more than one meal per month of catfish and carp from this area. For more information on this advisory please visit the DHHS website https://epi.dph.ncdhhs.gov/oee/fish/advisories.html .

2.7 Ambient Data

The Ambient Monitoring System (AMS) is a network of stream, lake and estuarine stations strategically located for the collection of physical and chemical water quality data. North Carolina has approximately 329 active AMS stations. Parameters collected at each site depend on the waterbody's classification but typically include specific conductance, dissolved oxygen, pH, temperature, turbidity, nutrients, and fecal coliform. The following subsections summarize the last thirteen years of data for several parameters collected in the Pasquotank River basin with discussions about specific water quality parameters of interest in Chapters 3, Chapter 4, and Chapter 5. A summary of the last twenty years of nutrient, chlorophyll *a*, and algal blooms is discussed in the context of the Albemarle Sound in Chapter 6.

Table 2-6 Ambient monitoring stations in the Pasquotank River basin.

Station ID	Station Location	Active Date	County	Stream AU#	Stream Classification
D999500C	ALBEMARLE SOUND NR EDENTON MID CHANNEL	1997-Present	Washington	26	B, NSW
D999500N	ALBEMARLE SOUND NR EDENTON N SHORE	1997-Present	Chowan	26-1	C, NSW
D999500S	ALBEMARLE SOUND NR EDENTON S SHORE	1997-Present	Chowan	30	SB
D9490000	CHOWAN RIVER AT US 17 AT EDENHOUSE	1969-Present	Bertie	25c	B, NSW
M2750000*	PASQUOTANK RIV AT ELIZABETH CITY	1968-2014	Camden	30-3-(12)	SB
M2490000	PASQUOTANK RIV AT MOUTH OF CHARLES CRK AT ELIZABETH CITY	2015-Present	Camden	3-3-(7)	SC
M3500000	LITTLE RIV AT SR 1367 AT WOODVILLE	1973-Present	Pasquotank	30-5-(1)	C, Sw
M390000C	ALBEMARLE SOUND NR FROG ISLAND MID CHANNEL	1997-Present	Tyrrell	30	SB
M390000N	ALBEMARLE SOUND NR FROG ISLAND N SHORE	1997-2014	Camden	30	SB
M390000S	ALBEMARLE SOUND NR FROG ISLAND S SHORE	1997-2014	Tyrrell	30	SB
M5000000	PERQUIMANS RIV AT SR 1336 AT HERTFORD	1968-Present	Perquimans	30-6-(3)	SC
M610000C	ALBEMARLE SOUND BETWEEN HARVEY PT AND MILL PT MID CHANNEL	1997-Present	Tyrrell	30	SB
M610000N	ALBEMARLE SOUND BETWEEN HARVEY PT AND MILL PT N SHORE	1997-2014	Perquimans	30	SB
M610000S	ALBEMARLE SOUND BETWEEN HARVEY PT AND MILL PT S SHORE	1997-2014	Tyrrell	30	SB
M6920000	KENDRICK CRK AT SR 1300 AT MACKEYS	1982-Present	Washington	30-9-(2)	SC
M6980000	SCUPPERNONG RIV AT SR 1105 NR COLUMBIA	1997-Present	Tyrrell	30-14-4-(1)	C, Sw
M7175000	ALLIGATOR RIV AT US 64 NR ALLIGATOR	1982-Present	Tyrrell	30-16-(7)	SC, Sw, ORW
N9700000	ALBEMARLE SOUND AT BATCHELOR BAY NR BLACK WALNUT	1974-Present	Washington	30	SB

Ambient Monitoring Stations with a letter as the eight digit indicates a spatial location in context of other stations (i.e. N = North, C = Center, and S = South)
*Station was relocated see Chapter 3 for details on the Pasquotank River station

Figure 2-2 Ambient monitoring stations in the Pasquotank River basin.

During the 2007 – 2019-time period, there were two additional short-term (2-year) Random Ambient Monitoring System (RAMS) stations (Table 2-7). The RAMS program does not routinely collect nutrients and chlorophyll *a* samples at stations, but a few nutrient samples were collected at station D9480000 before staff limitations restricted nutrient sampling (Appendix III). Both M6930000 and D9480000 were monitored for pesticides, semi-volatiles and volatile organic compounds, dissolved metals and low-level mercury as well as physical parameters. It is recommended that as funding, personnel, laboratory capacity resources become available the RAMS program incorporate collection of nutrients and where appropriate, chlorophyll a samples. Since most of the RAMS stations are located in smaller headwater streams, this would help the division understand "background" nutrient concentrations in smaller watersheds. This information could give some perspective to nutrient concentrations and chlorophyll *a* throughout the basin.

Table 2-7 Random ambient monitoring stations in the Pasquotank River basin.

Station ID	Station Location	County	RAMS Year	Stream AU#	Stream Classification
M6930000	DEEP CRK AT SR 1303 NR SCUPPERNONG	Washington	2013-2014	30-14-2	C, Sw
D9480000	UT Pollock Swamp nr SR 1316 Coffield Rd nr Valhalla	Chowan	2019-2020	-	-

2.7.1 Turbidity

Turbidity is a measure of cloudiness in water and is often accompanied with excessive sediment deposits in the streambed. Excessive sediment deposited on stream and lake bottoms can choke spawning beds (reducing fish survival and growth rates), harm fish food sources, fill in pools (reducing cover from prey and high temperature refuges), and reduce habitat complexity in stream channels. Excessive suspended sediments can also make it difficult for fish to find prey and at high levels can cause direct physical harm, such as clogged gills. Sediments can also cause taste and odor problems, block water supply intakes, foul treatment systems, and fill reservoirs. Soil erosion is the most common source of turbidity. Some erosion is a natural phenomenon, but human actions and land use practices can accelerate the process to unhealthy levels. Construction sites, mining operations, agricultural operations, logging operations, and excessive stormwater flow off of impervious surfaces are all potential sources of erosion and turbidity in a stream channel. Turbidity for freshwater streams shall not exceed 50 Nephelometric Turbidity Units (NTU) to avoid a violation of the state water quality standard. Tidal saltwater, lakes and reservoirs shall not exceed 25 NTU.

During the 2007 through 2019-time frame, annual mean turbidities of waters flowing from the Chowan (D9490000) and Roanoke (N9700000) river basins and across the Albemarle Sound (D999500[N,C,S], M610000[N,C,S], and M390000[N,C,S]) ranged from 3.5 to 15.6 NTU with few individual readings that exceeded water quality standards (Figure 2-3 and Figure 2-4). Similarly, the northern shore rivers which include the Perquimans (M5000000), Little (M3500000), and Pasquotank (M2750000) had annual mean turbidities ranging from 2.9 to 16.3 NTU with few individual readings that exceeded the water quality standards. Elevated turbidity readings were observed in the tidal saltwater Kendrick Creek (M6920000) and in the freshwater Scuppernong River (M6980000) with many events correlated with rainfall events indicating possible erosion and transport of sediments. These individual occurrences of elevated turbidity are reflected in the annual mean turbidity for these each of the two rivers (Figure 2-6).

Figure 2-3 Annual Mean Turbidity Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

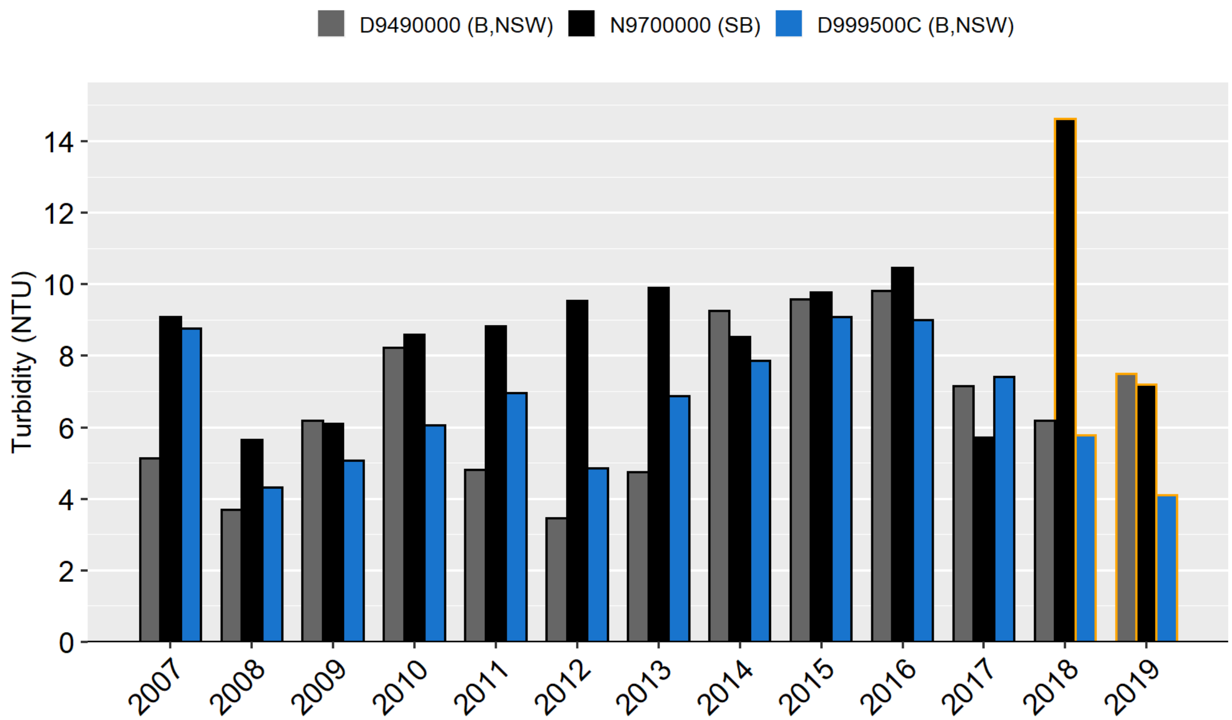


Figure 2-4 Annual Mean Turbidity Readings from the Albemarle Sound. Blue Color Bars Are Stations Located Near the Western Side of the Sound, Green Color Bars Are Stations Located Near the Center of the Sound, and Purple Are Stations Located Near the Eastern Side of the Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

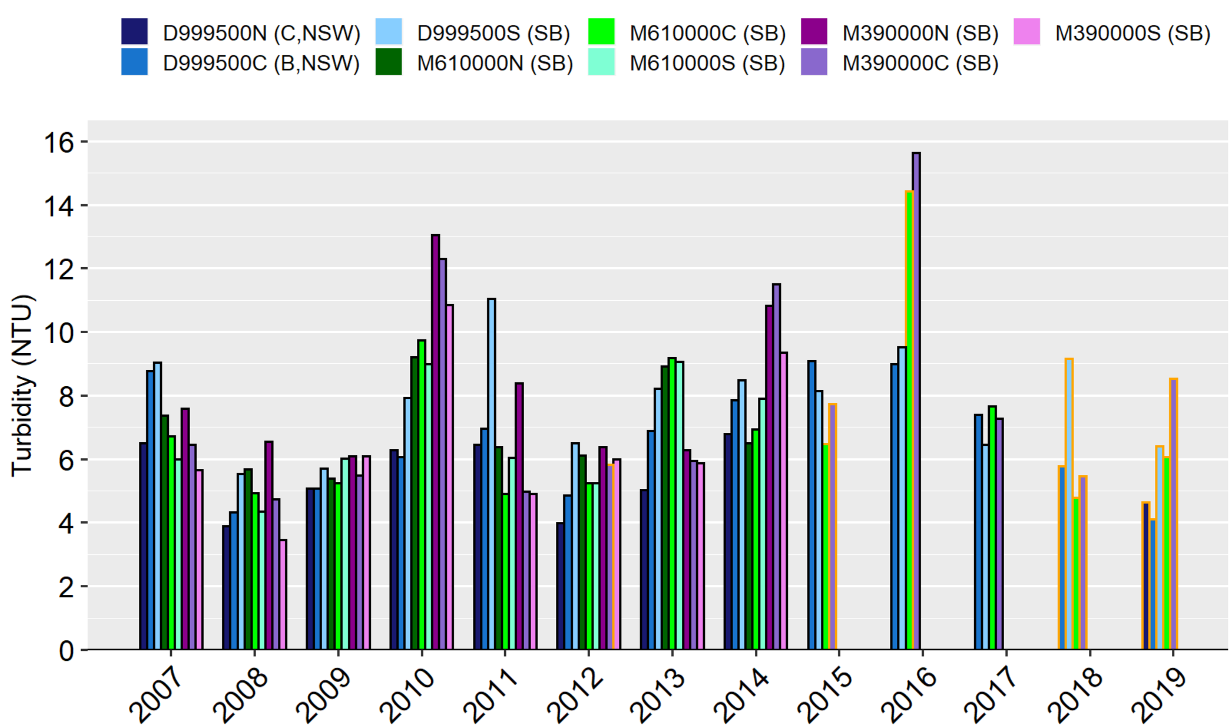


Figure 2-5 Annual Mean Turbidity Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

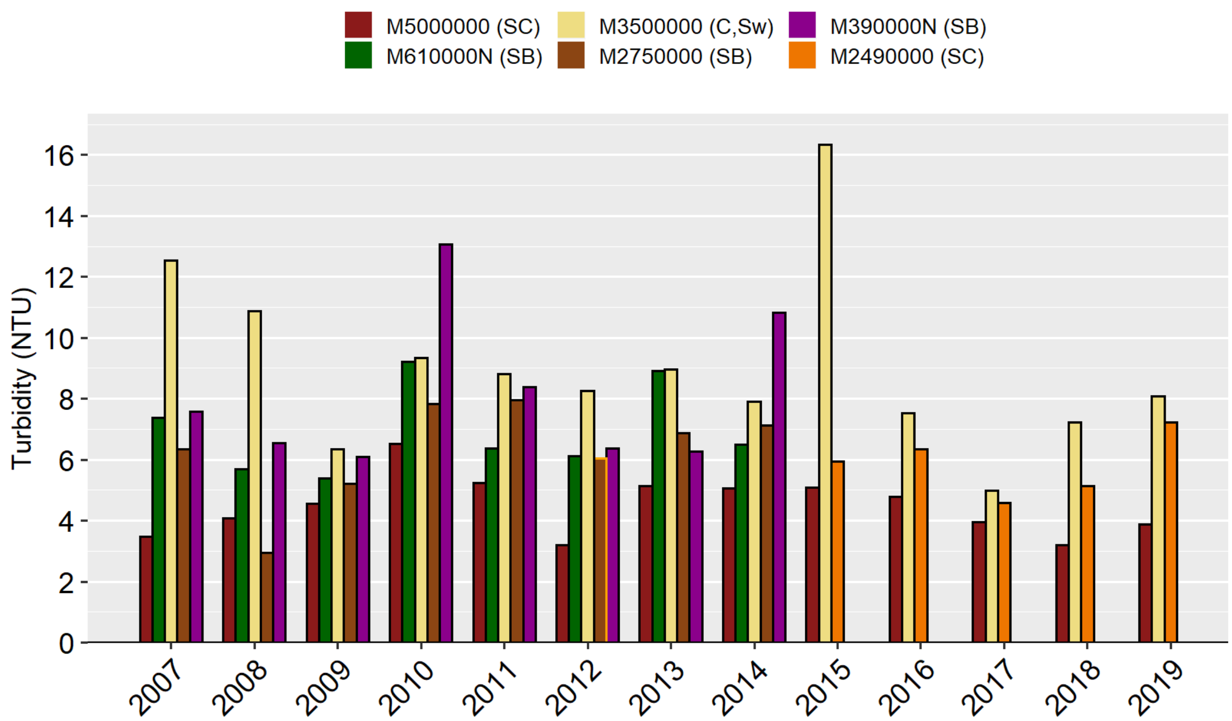
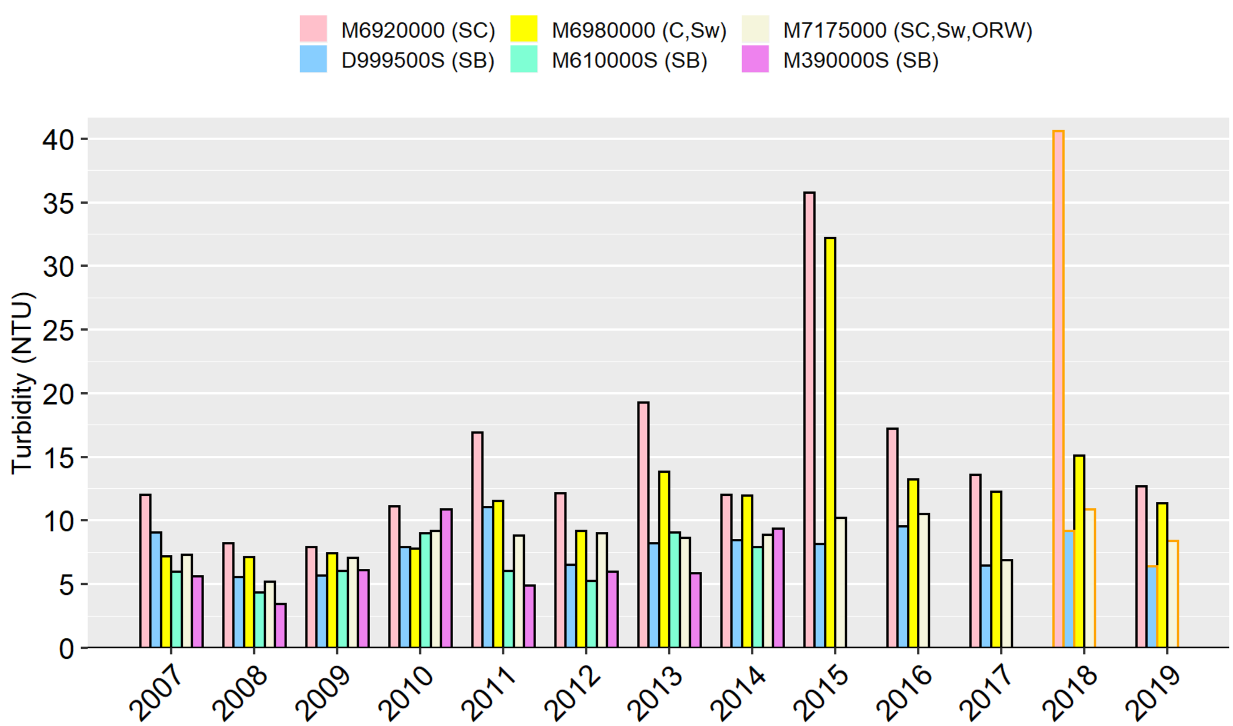


Figure 2-6 Annual Mean Turbidity Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.



2.7.2 pH

Potential of hydrogen (pH) is the measure of hydrogen ion concentration in water expressed on a scale from 0 to 14 to determine whether a solution is acidic, neutral or alkaline (basic) (Figure 2-7, Figure 2-8, Figure 2-12, and Figure 2-13). Low values (< 6.0) can be found in waters rich in dissolved organic matter, such as swamp waters. High values (> 9.0) may be found in sea water and in water experiencing an algal bloom. Lower values can have chronic effects on the community structure of macroinvertebrates, fish and phytoplankton. Changes in the pH of surface waters can occur during algal events, acidic rain and snow melt, changes in temperature, stormwater runoff, mining operations, point source discharges, geologic conditions, and accidental chemical spills. Class C freshwaters shall have a pH between 6.0 and 9.0 (15A NCAC 02B .0211). Class SC tidal salt waters, shall have a pH between 6.8 and 8.5 (15A NCAC 02B 0.220). Class C or Class SC waters with the supplemental classification of Sw (swamp) may have a pH as low as 4.3 if due to natural conditions.

During the 2007 to 2019-time frame, pH in water flowing from the Chowan (D9490000) and Roanoke (N9700000) river basins had few (less than 10) individual measurements which exceeded their respective water quality standards. This is also reflected in the annual median pH values which ranged from 6.9 to 7.6 for water from the Roanoke River basin and 7.0 to 7.8 for water from the Chowan River basin (Figure 2-7). Across the Albemarle Sound, pH progressively increases from west to east with the exception of 2019 (Figure 2-8, Figure 2-9, Figure 2-10, and Figure 2-11). After relocating the tidal saltwater Pasquotank River (M2750000) monitoring station upstream in 2015, all three monitored northern shore rivers displayed similar annual median pH values ranging from 6.2 to 6.8 (Figure 2-12). Similar to the northern shore rivers, the Scuppernong River (M6980000) and Kendrick Creek (M6920000) on the southern shore display a similar range of annual median pH values (Figure 2-13).

Figure 2-7 Annual Median pH Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

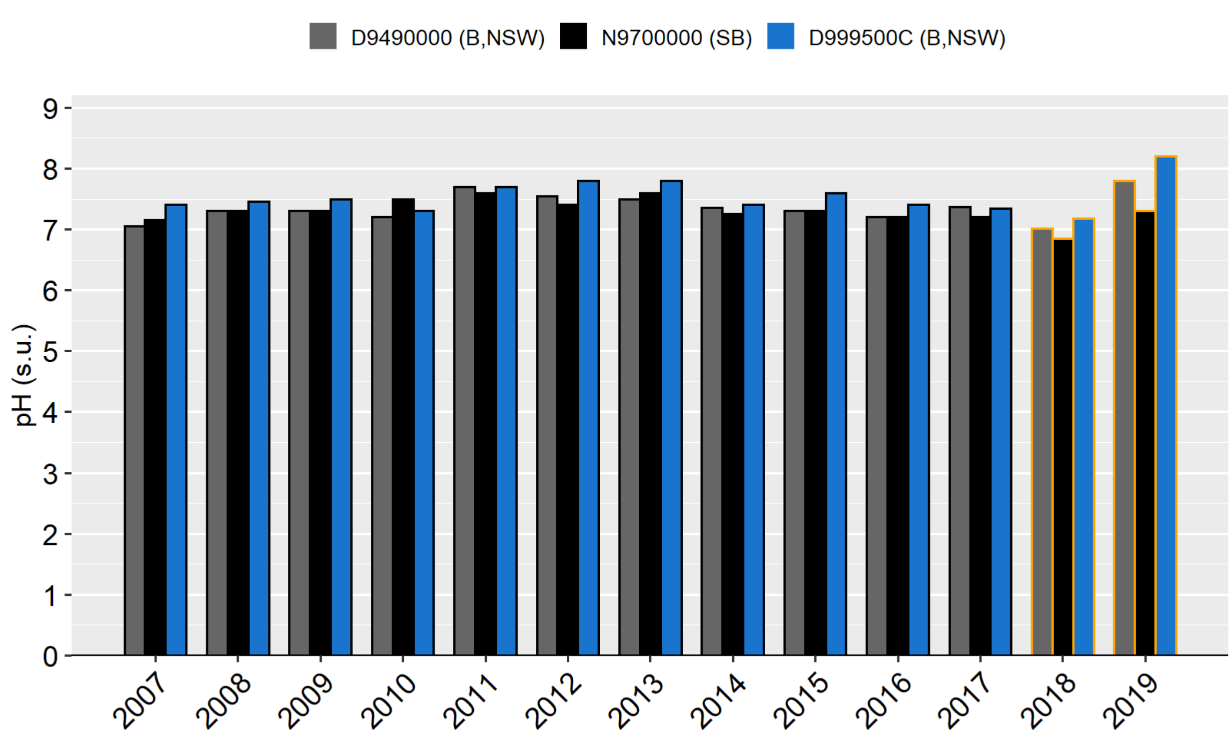


Figure 2-8 Annual Median pH Readings from the Albemarle Sound. Blue Color Bars Are Stations Located Near the Western Side of the Sound, Green Color Bars Are Stations Located Near the Center of the Sound, and Purple Are Stations Located Near the Eastern Side of the Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

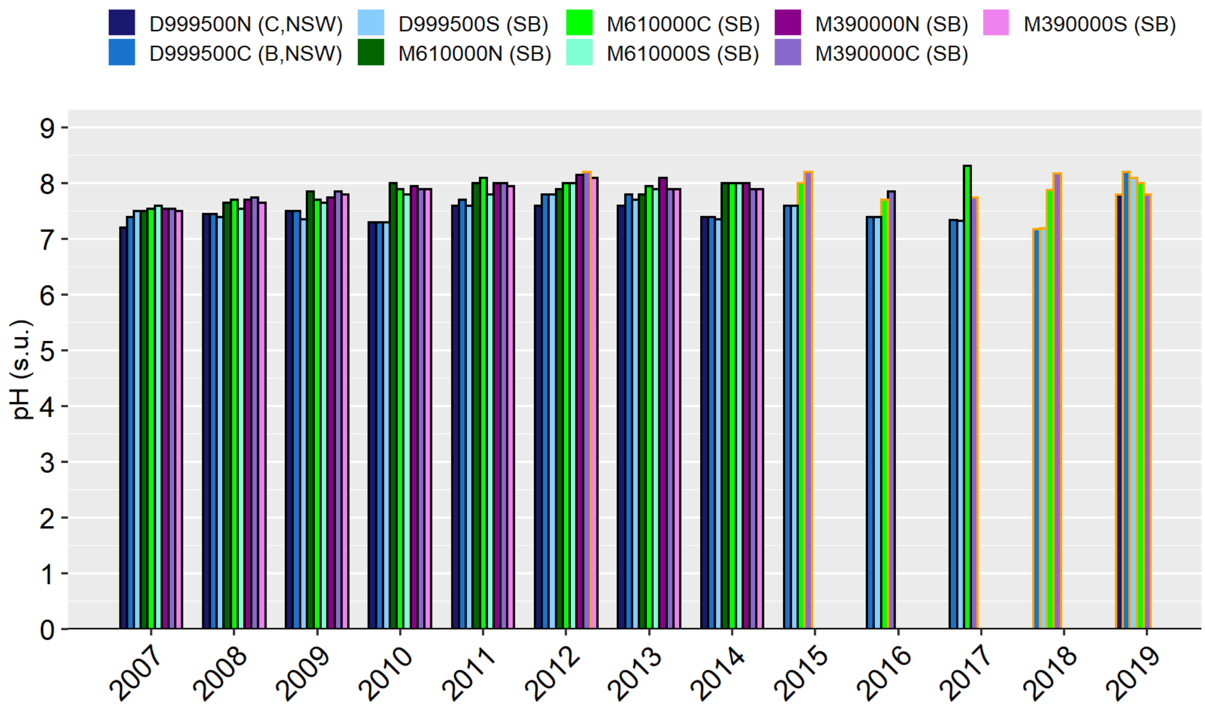


Figure 2-9 Individual pH readings with respect to depth near the western side of the Albemarle Sound (D999500C).

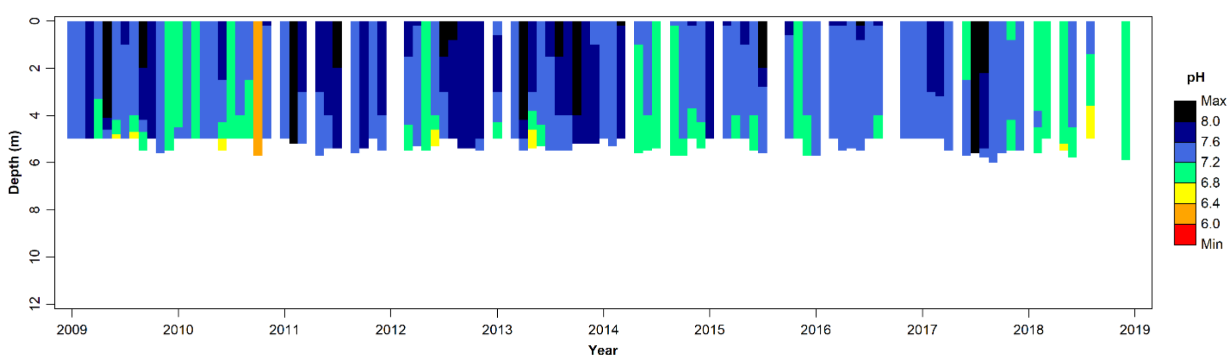


Figure 2-10 Individual pH readings with respect to depth near the center of the Albemarle Sound (M610000C).

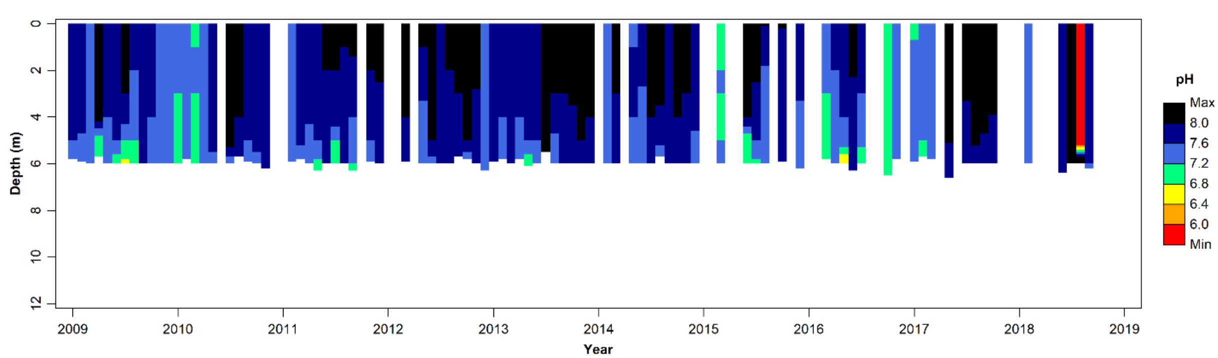


Figure 2-11 Individual pH readings with respect to depth near the eastern side of the Albemarle Sound (M390000C).

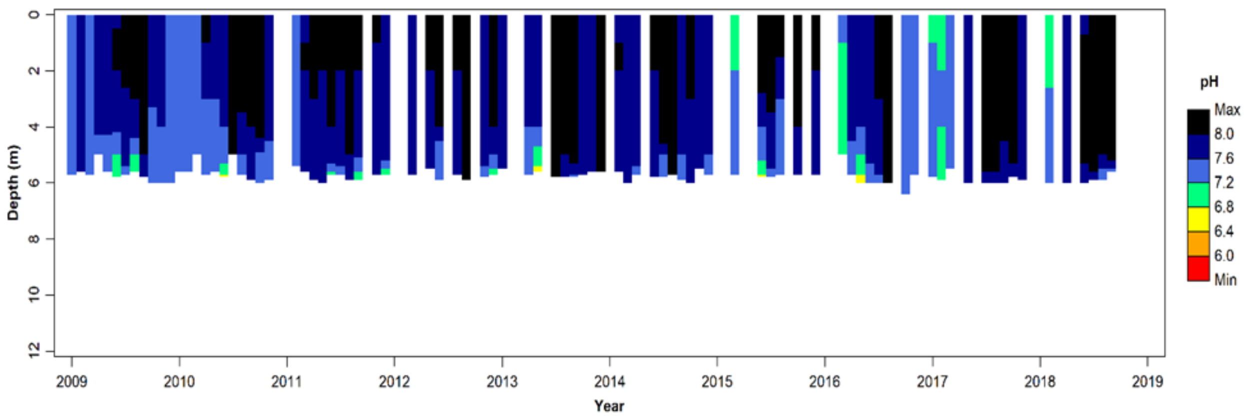


Figure 2-12 Annual Median pH Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

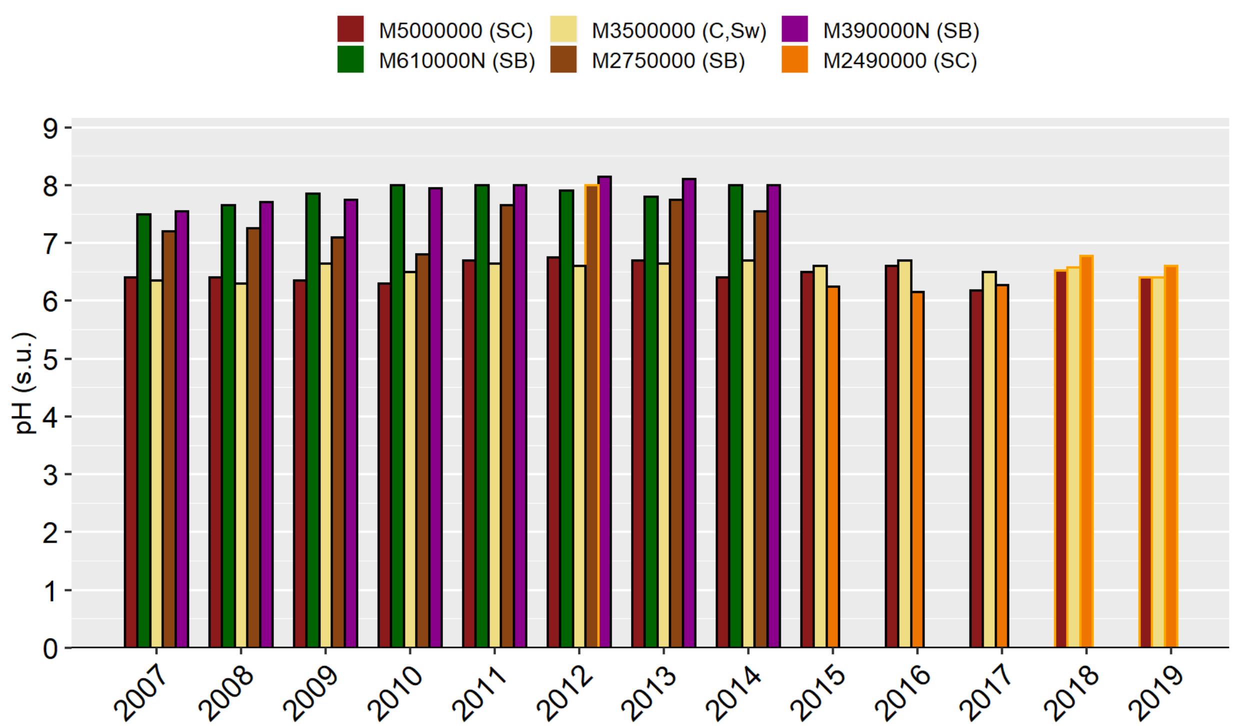
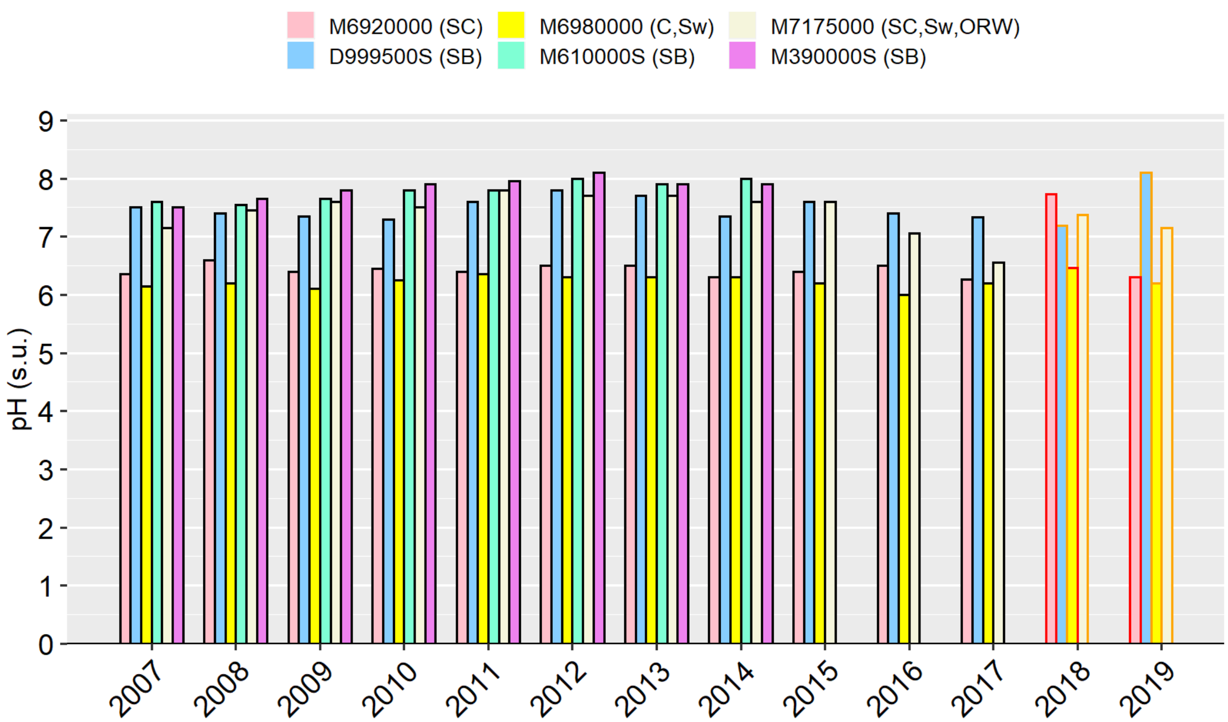


Figure 2-13 Annual Median pH Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements. Red Outlines Around the Bars Indicate Annual Means Based on Less than Three Measurements.



2.7.3 Dissolved Oxygen

Dissolved oxygen (DO) levels are often the product of wind or wave action mixing air into the water. It is also produced through aquatic plant photosynthesis. During the day, DO levels are higher when photosynthesis occurs and drop at night when respiration occurs by aquatic organisms. High DO levels are found mostly in cool, swift moving waters, and low levels are found in warm, slow moving waters. In slow moving waters, such as lakes and reservoirs, depth is also a factor. Wind action and plants can cause these waters to have a higher DO concentration near the surface, while biochemical reactions lower in the water column may result in concentrations as low as zero at the bottom. The DO in Class C freshwaters shall not be less than a daily average of 5 mg/L or a minimum instantaneous value of not less than 4 mg/L. Swamp waters, backwaters, and lake bottoms may have lower DO if caused by natural conditions (15A NCAC 02B .0211). DO levels in saltwater should not be less than 5.0 mg/L. Swamp waters, poorly flushed tidally influenced streams or embayments, or estuarine bottom waters may have lower values if caused by natural conditions (15A NCAC 02B .0220).

During the 2007 to 2019-time frame, the water flowing from the Chowan (D9490000) river basin was on average higher in dissolved oxygen than water flowing from the Roanoke (N9700000) river basin and closely resembles the annual mean dissolved oxygen for water on the western side of the Albemarle Sound (Figure 2-14). As the Albemarle Sound is observed west to east, the water generally increases in dissolved oxygen concentrations based on annual mean dissolved oxygen (Figure 2-15) and individual dissolved oxygen readings with respect to depth (Figure 2-16, Figure 2-17, and Figure 2-18). On average, the northern and southern shore rivers have annual mean dissolved oxygen which remains relatively low compared to the Albemarle Sound. The swamp waters of the Little River (M3500000) consistently has the lowest annual mean dissolved oxygen of the northern shore rivers (Figure 2-19). The swamp waters of the

Scuppernong River (M6980000) on the southern shore rivers also have relatively low dissolved oxygen compared to the Albemarle Sound (Figure 2-20).

Figure 2-14 Annual Mean Dissolved Oxygen (DO) Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

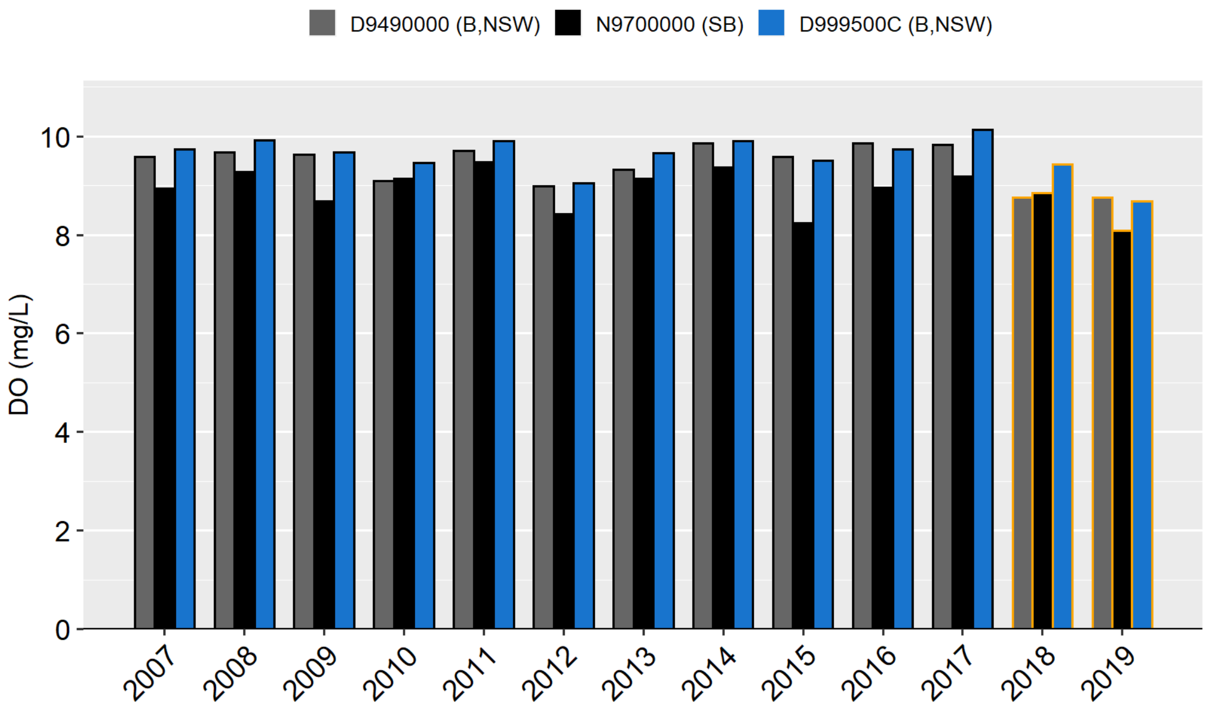


Figure 2-15 Annual Mean Dissolved Oxygen (DO) Readings from the Albemarle Sound. Blue Color Bars Are Stations Located Near the Western Side of the Sound, Green Color Bars Are Stations Located Near the Center of the Sound, and Purple Are Stations Located Near the Eastern Side of the Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

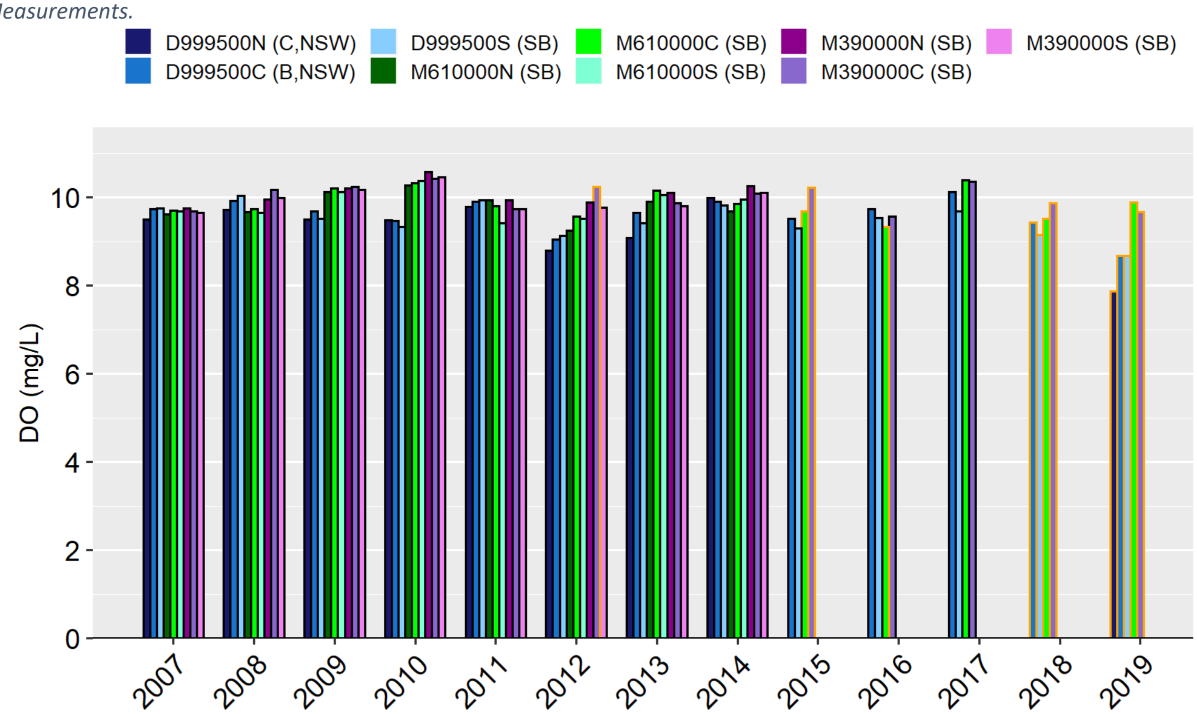


Figure 2-16 Individual DO readings with respect to depth near the western side of the Albemarle Sound (D999500C).

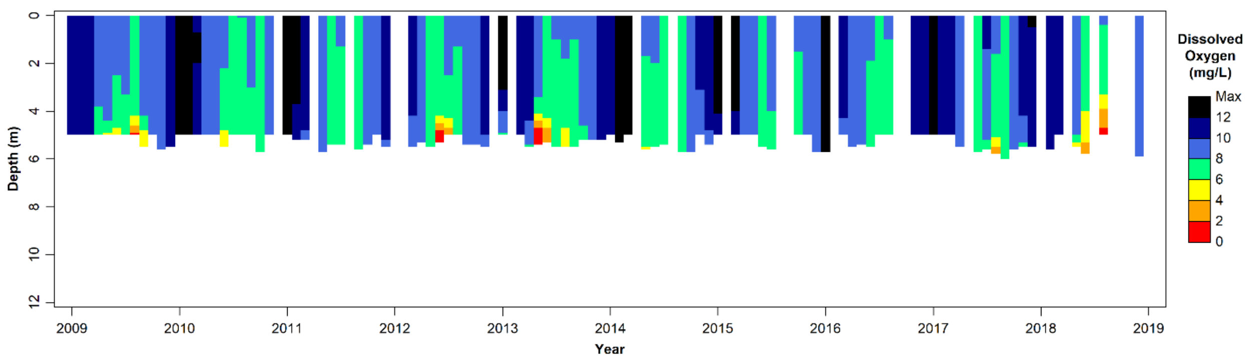


Figure 2-17 Individual DO readings with respect to depth near the center of the Albemarle Sound (M610000C).

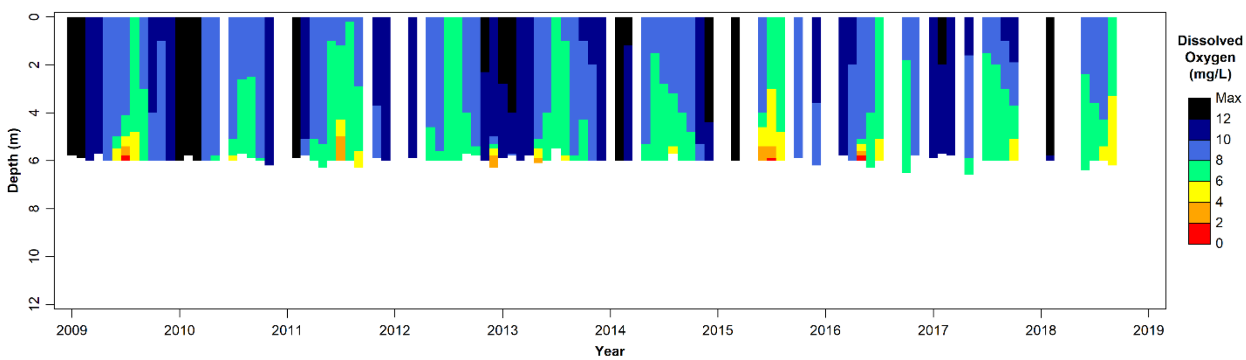


Figure 2-18 Individual DO readings with respect to depth near the eastern side of the Albemarle Sound (M390000C).

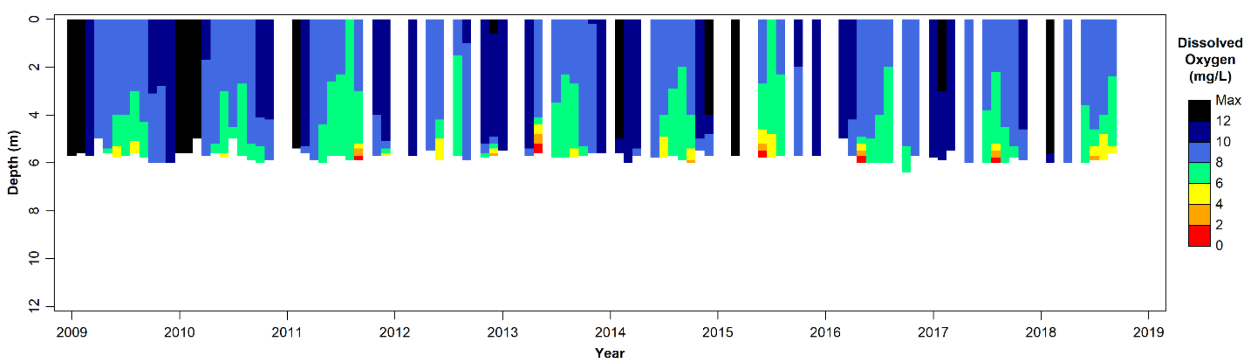


Figure 2-19 Annual Mean Dissolved Oxygen (DO) Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

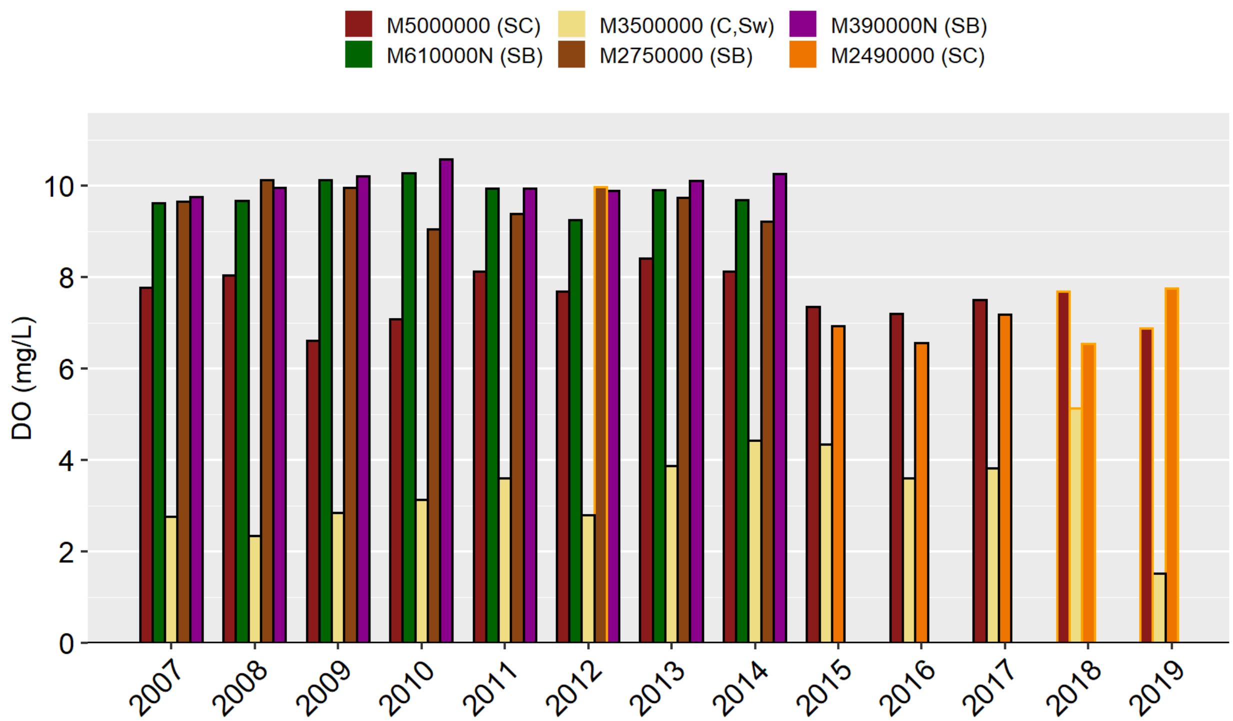
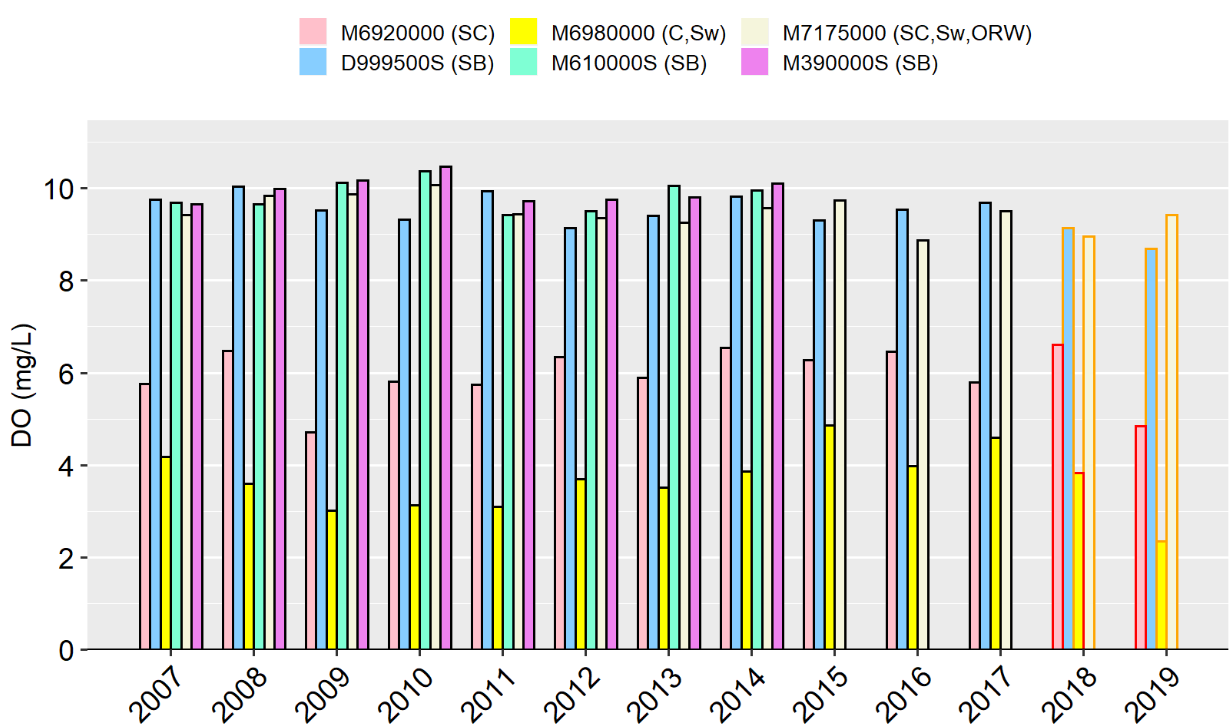


Figure 2-20 Annual Mean Dissolved Oxygen (DO) Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements. Red Outlines Around the Bars Indicate Annual Means Based on Less than Three Measurements.



2.7.4 Fecal Coliform Bacteria and Enterococci

Fecal coliform bacteria (FCB) and enterococci bacteria in aquatic environments indicates that the water has been exposed to fecal material from humans or other warm-blooded animals (Figure 2-21, Figure 2-22, Figure 2-23, and Figure 2-24). At the time of occurrence, the source water might have been contaminated by pathogens or disease-producing bacteria or viruses that can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to the water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or runoff from nonpoint sources of human and animal waste. Class C and Class B freshwaters shall not exceed a fecal coliform geometric mean of 200 colonies/100 mL or 400 colonies/100 mL in 20% of the samples where five samples have been taken in a 30- day period (5-in-30). Class SC tidal waters shall not exceed a geometric mean of 35 enterococci/100 mL (5-in-30). Only results from a 5-in-30 study are used to determine if the stream is impaired (exceeding criteria) or supporting (meeting criteria). Class B or SB (primary recreation) waters will receive priority for 5-in-30 studies. Other waterbodies will be studied as resources permit. Note the fecal coliform results are qualified due to the time required to transport the samples for analysis which is greater than the hold time, so the following results should be viewed as screening values.

During the 2007 through 2019-time frame, the annual geometric mean for fecal coliform in water flowing from the Chowan (D9490000) and Roanoke (N9700000) river basins remained relatively low (Figure 2-21). Similarly, the Albemarle Sound has low fecal coliform across the estuary (Figure 2-22). Notably, the Pasquotank River (M2750000) annual geometric means displayed a sharp increase in fecal coliform following the relocation upstream (Figure 2-23). Additionally, the Perquimans River (M5000000) and Little River (M3500000) have experience increasing annual geometric mean fecal coliform readings since 2007 (Figure 2-23). Similarly, the Scuppernong (M6980000) and Kendrick Creek (M6920000), have increasing annual geometric mean fecal coliform readings since 2007 (Figure 2-24).

Figure 2-21 Annual Geometric Mean for Fecal Coliform Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

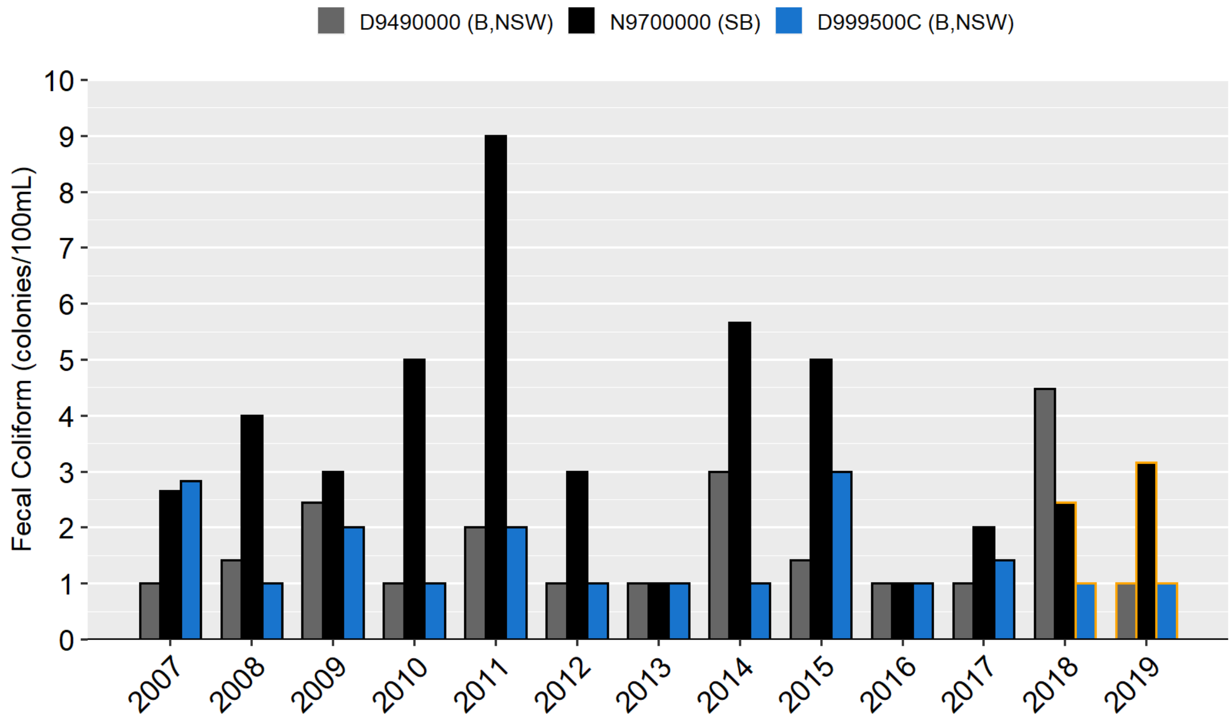


Figure 2-22 Annual Geometric Mean for Fecal Coliform Readings from the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

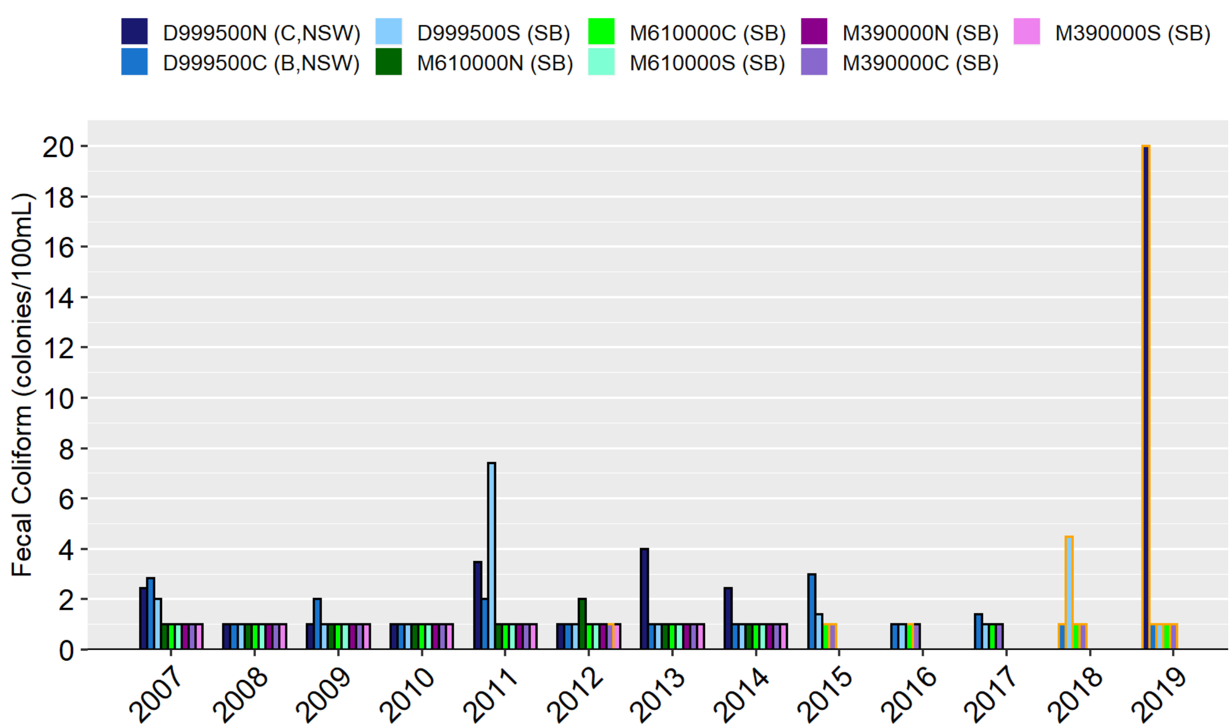


Figure 2-23 Annual Geometric Mean for Fecal Coliform Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

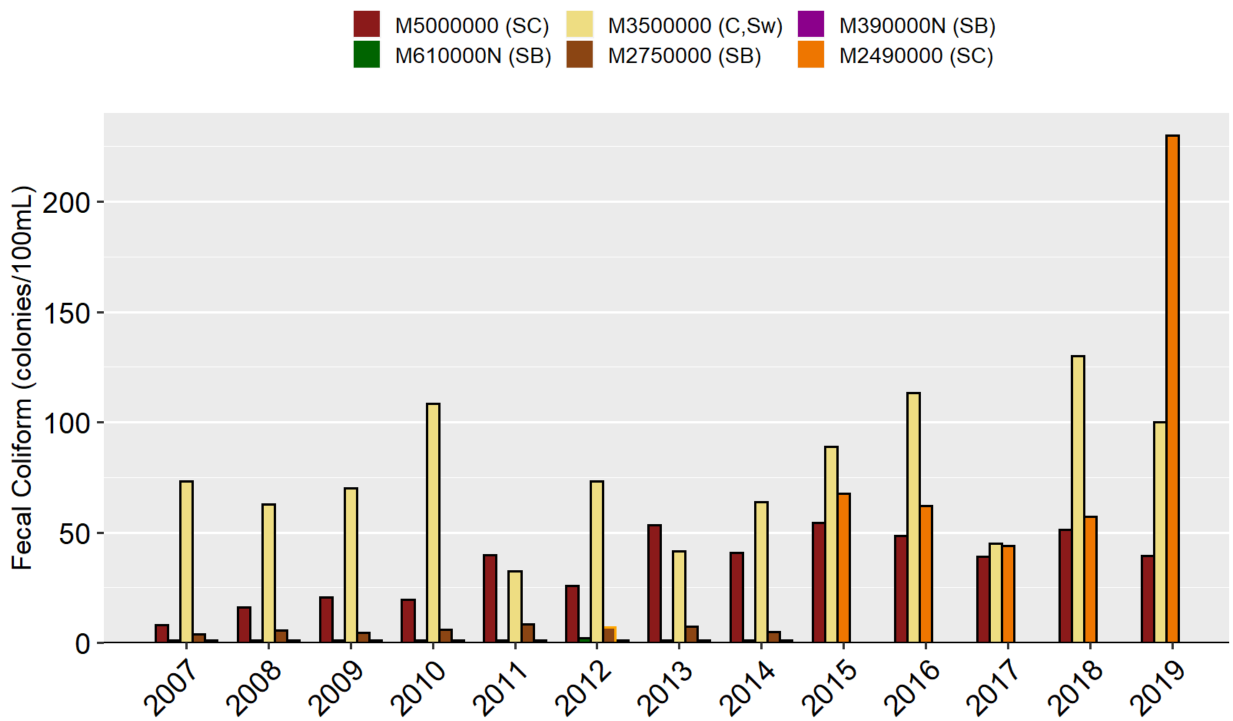
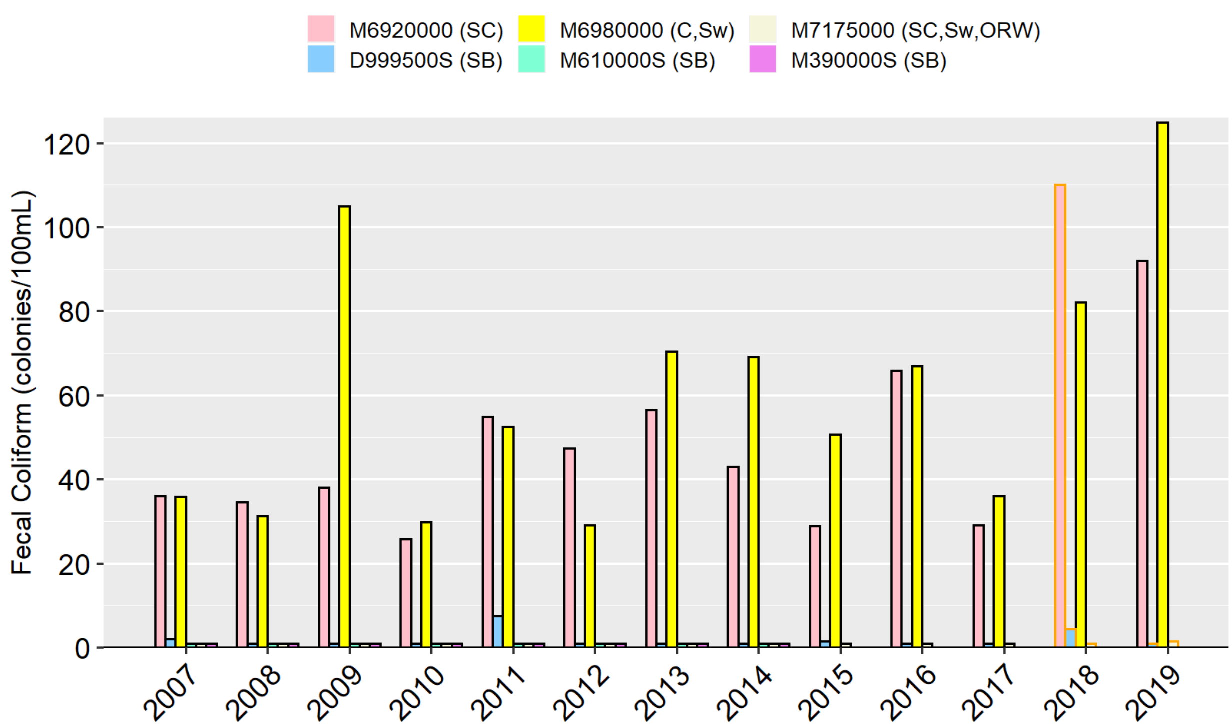


Figure 2-24 Annual Geometric Mean for Fecal Coliform Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.



2.7.5 Specific Conductance/Salinity

Specific conductance, also referred to as specific conductivity or conductivity, is a measure of the ability of water to pass an electrical current. Specific conductance is similar to salinity. Salinity is a measure of the amount of dissolved salts in a waterbody (Figure 2-25, Figure 2-26, Figure 2-30, and Figure 2-31). Relatively low conductivity can be found in mountainous streams with little to no impact from point and nonpoint sources of pollution. Higher conductivity values are often found in estuaries where water is influenced by dissolved solids from the mixing of sea water with freshwater from coastal freshwater streams. Outside the coastal plain, higher conductivity can be an indicator of pollutants associated with the application of road salts during winter months and the discharge or runoff of chlorides, phosphates, nitrates, and other inorganic dissolved solids. North Carolina does not have a water quality standard for specific conductivity. Instead, specific conductivity is often used to identify changes in water quality over time. Changes in conductivity can impact aquatic communities and potentially impact their overall productivity.

During the 2007 through 2019-time frame, annual mean salinity in water flowing from the Chowan (D9490000) and Roanoke (N9700000) river basins is consistently lower than the western side of the Albemarle Sound (D999500C) (Figure 2-25). As the Albemarle Sound is observed from western stations ($D999500^{N,C,S}$) to the central stations ($M610000^{N,C,S}$) and ultimately the eastern stations ($M390000^{N,C,S}$) salinity progressively increases as the estuary flow towards the Croatan and Roanoke sounds (Figure 2-26, Figure 2-27, Figure 2-28, Figure 2-29). Similarly, the northern shore rivers and southern shore rivers have relatively low salinities compared to their nearest monitoring station in the Albemarle Sound (Figure 2-30 and Figure 2-31). Overall, salinity readings in the Pasquotank River Basin appear to have declined in surface waters possibly as a result of the recovery from Severe Drought conditions in September 2007 through August 2008. Refer to Chapter 9 for more information about drought condition monitoring.

Figure 2-25 Annual Mean Salinity Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

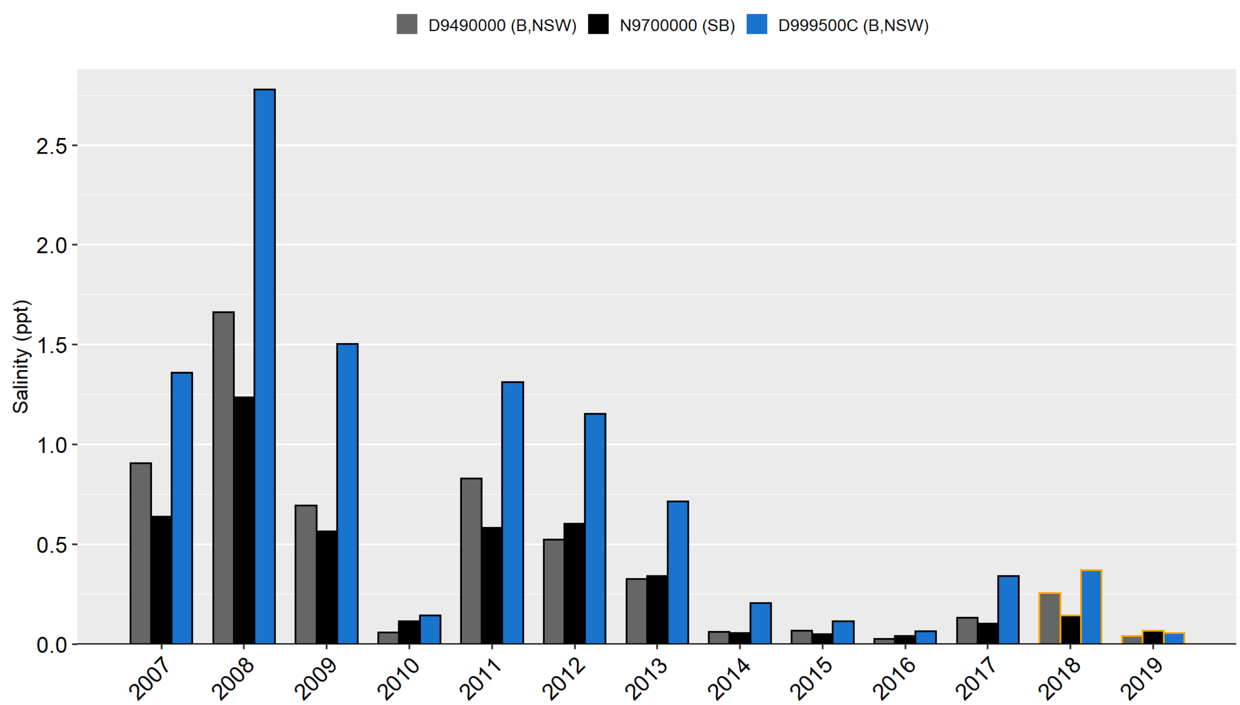


Figure 2-26 Annual Mean Salinity Readings from the Albemarle Sound. Blue Color Bars Are Stations Located Near the Western Side of the Sound, Green Color Bars Are Stations Located Near the Center of the Sound, and Purple Are Stations Located Near the Eastern Side of the Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

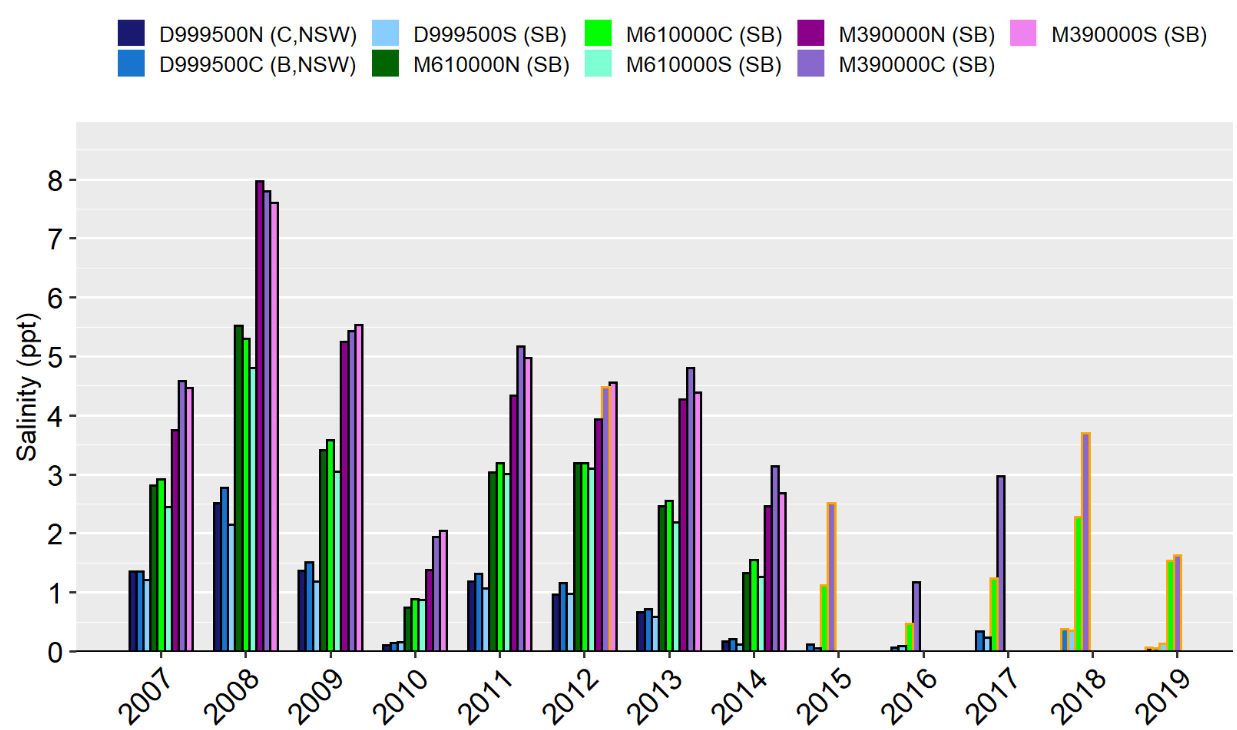


Figure 2-27 Individual salinity readings with respect to depth near the western side of the Albemarle Sound (D999500C).

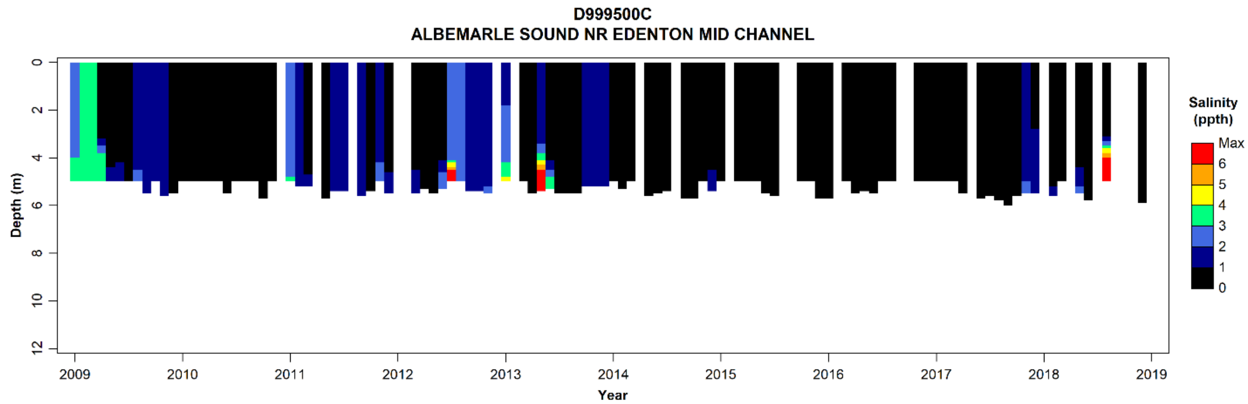


Figure 2-28 Individual salinity readings with respect to depth near the center of the Albemarle Sound (M610000C).

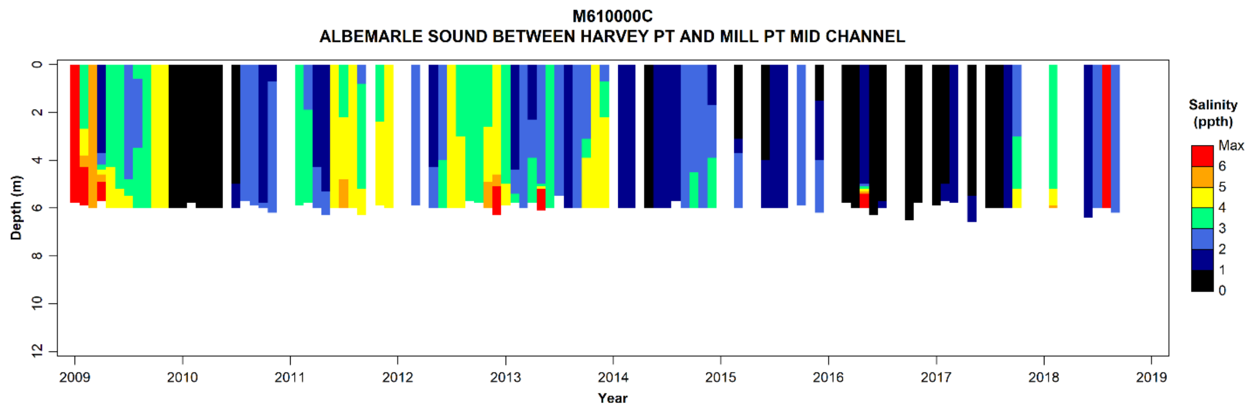


Figure 2-29 Individual salinity readings with respect to depth near the eastern side of the Albemarle Sound (M390000C).

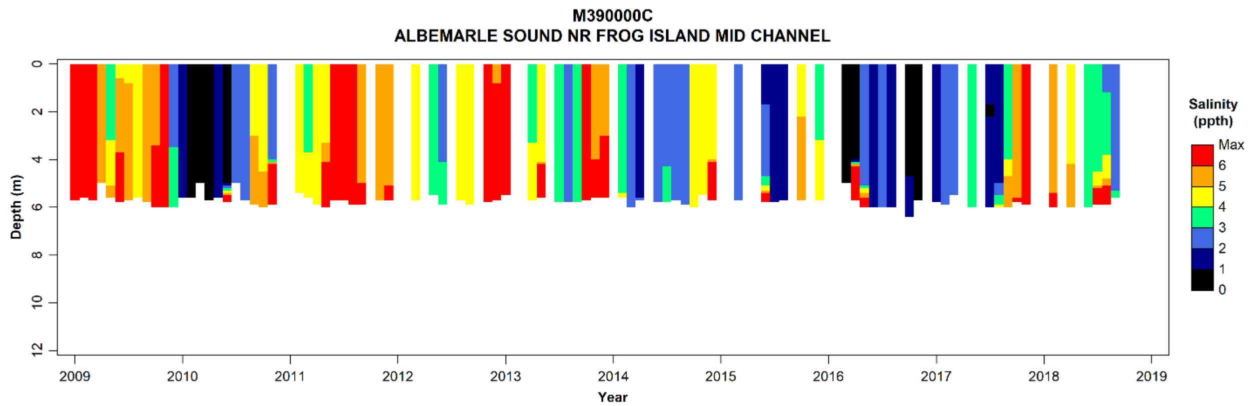


Figure 2-30 Annual Mean Salinity Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

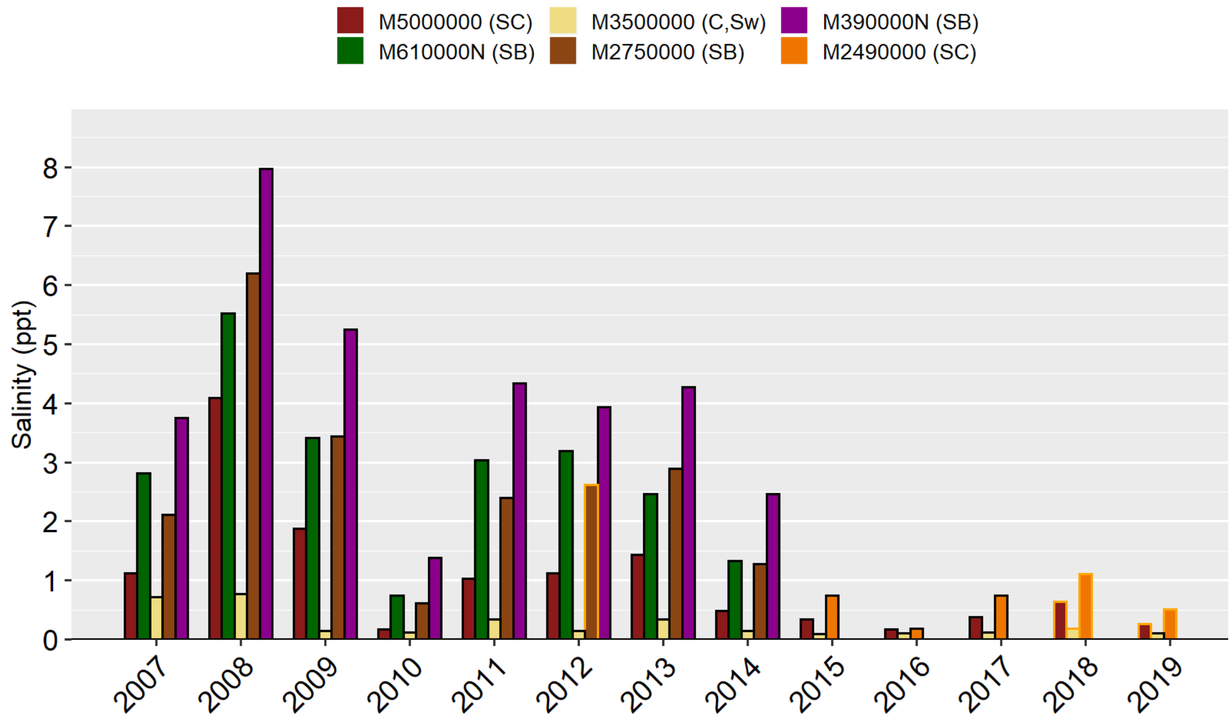
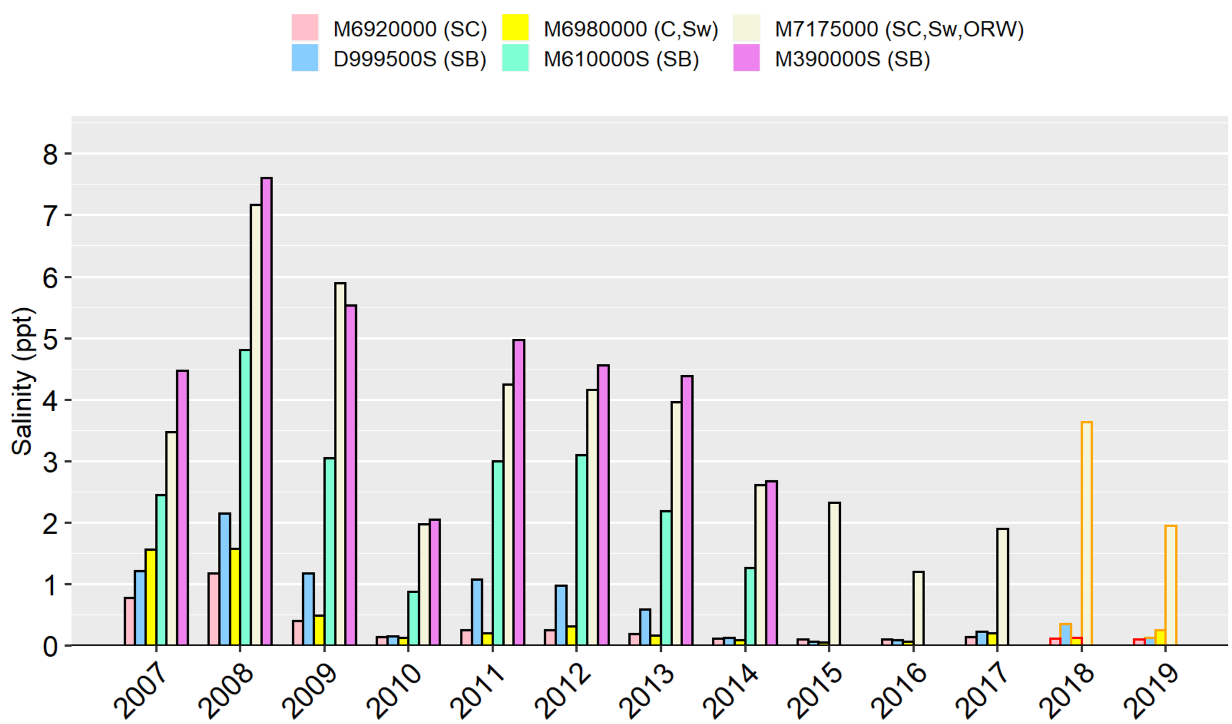


Figure 2-31 Annual Mean Salinity Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements. Red Outlines Around the Bars Indicate Annual Means Based on Less than Three Measurements.



2.7.6 Temperature

All aquatic species require specific temperature ranges in order to be healthy and reproduce. An aquatic species becomes stressed when water temperatures exceed their preferred temperature range, often making them more susceptible to injury and disease. Trout, for example, prefer temperatures below 20°C (68°F) and cannot survive in the water reservoirs of the piedmont and coastal plain where temperatures can exceed 30°C (86°F). Changes to natural conditions or weather patterns can often change the ambient water temperature (Figure 2-32, Figure 2-33, Figure 2-34, and Figure 2-35). For example, higher ambient water temperatures are expected during years with severe drought in areas where there is little shade. Higher ambient water temperatures can also be expected when air temperatures are high during summer months.

North Carolina water quality standards state that discharge from permitted facilities should not exceed the natural temperature of the receiving waterbody by more than 2.8°C (5.04°F) and that waters should never exceed 29°C (84.2°F) for the mountain or upper piedmont regions and 32°C (89.6°F) for lower piedmont and coastal plain. In salt water, the temperature (1) shall not be increased above the natural water temperature by more than 0.8°C (1.44°F) during the months of June, July and August; (2) shall not be increased by more than 2.2°C (3.96° F) during other months of the year; and (3) shall in no case exceed 32°C (89.6°F) due to the discharge of heated liquids (15ANCAC 02B.0220). When assessing temperature, climatic conditions are also taken into account. When climatic conditions result in the temperature standard being exceeded, the stream is identified as Data Inconclusive or Not Rated in the IR.

Figure 2-32 Annual Mean Water Temperature Readings from the Roanoke River Basin (N9700000), Chowan River Basin (D9490000), and West-Central Albemarle Sound (D999500C). Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

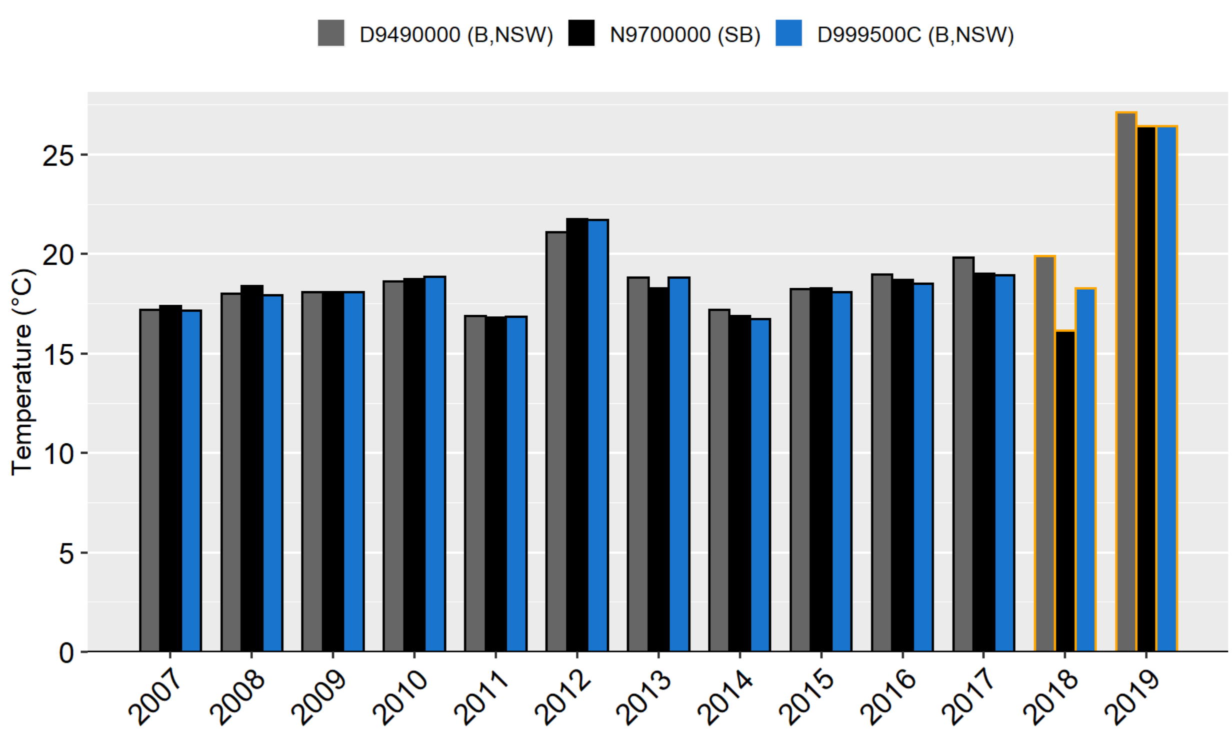


Figure 2-33 Annual Mean Water Temperature Readings from the Albemarle Sound. Blue Color Bars Are Stations Located Near the Western Side of the Sound, Green Color Bars Are Stations Located Near the Center of the Sound, and Purple Are Stations Located Near the Eastern Side of the Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

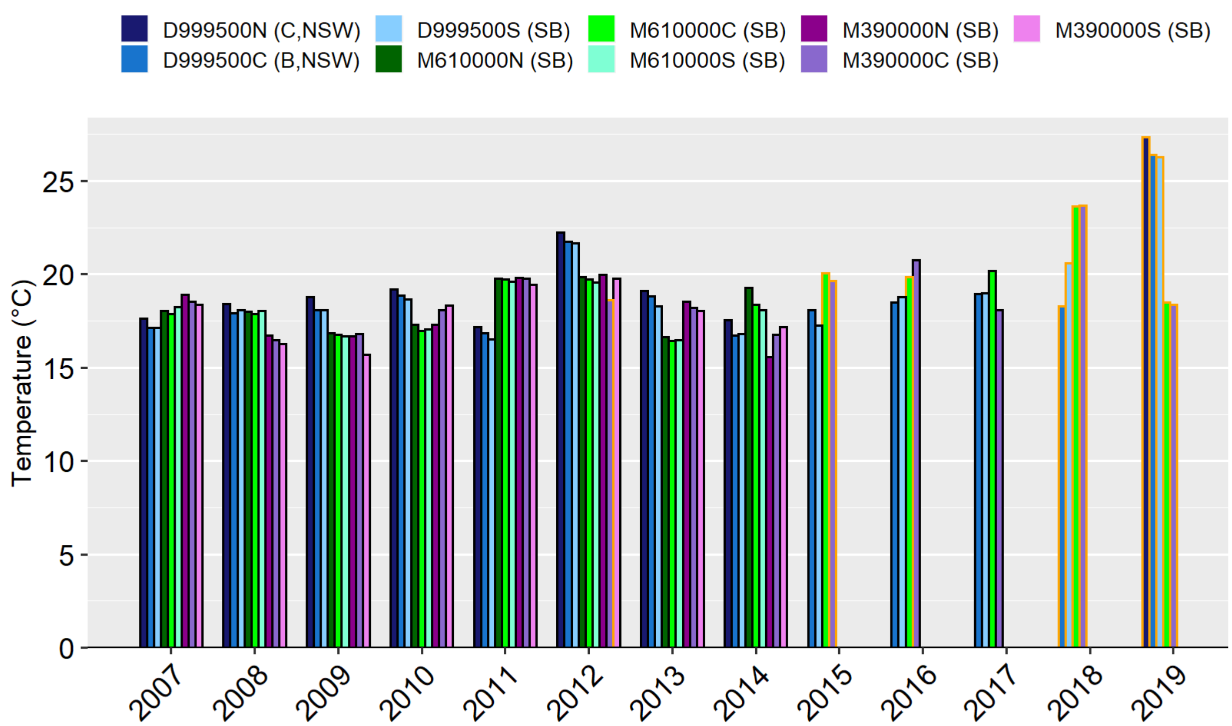


Figure 2-34 Annual Mean Water Temperature Readings from the Northern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements.

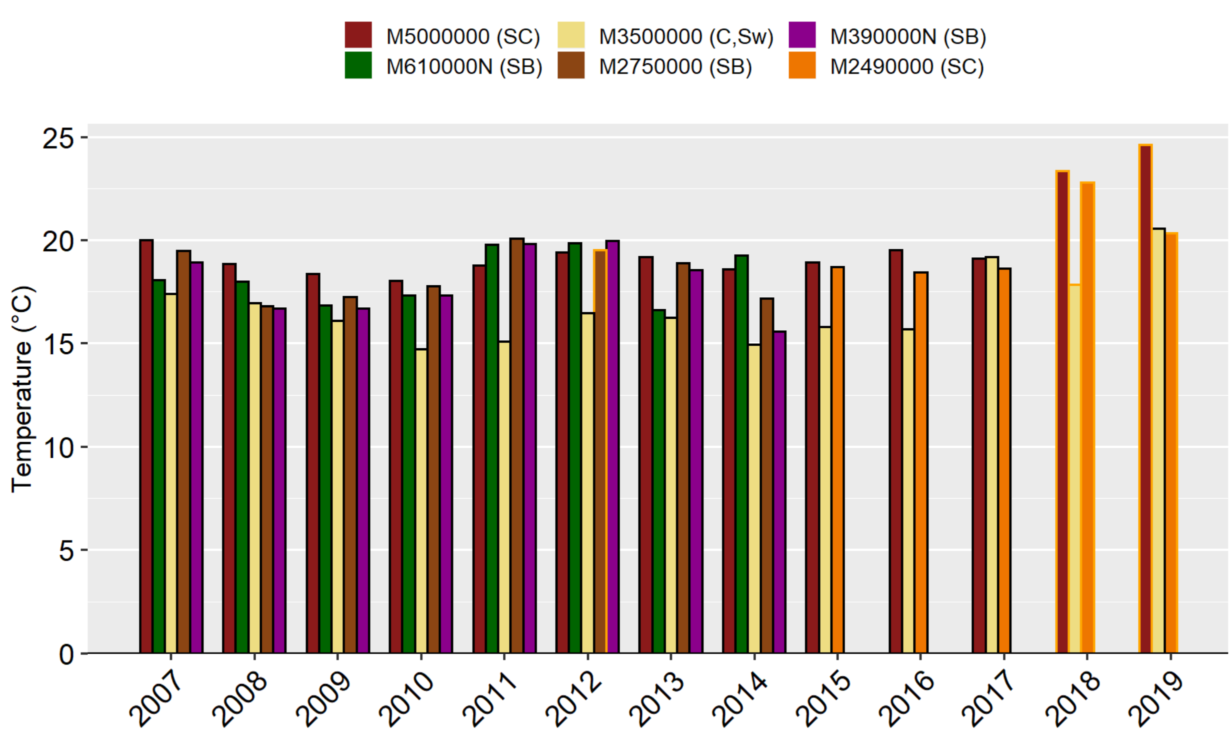
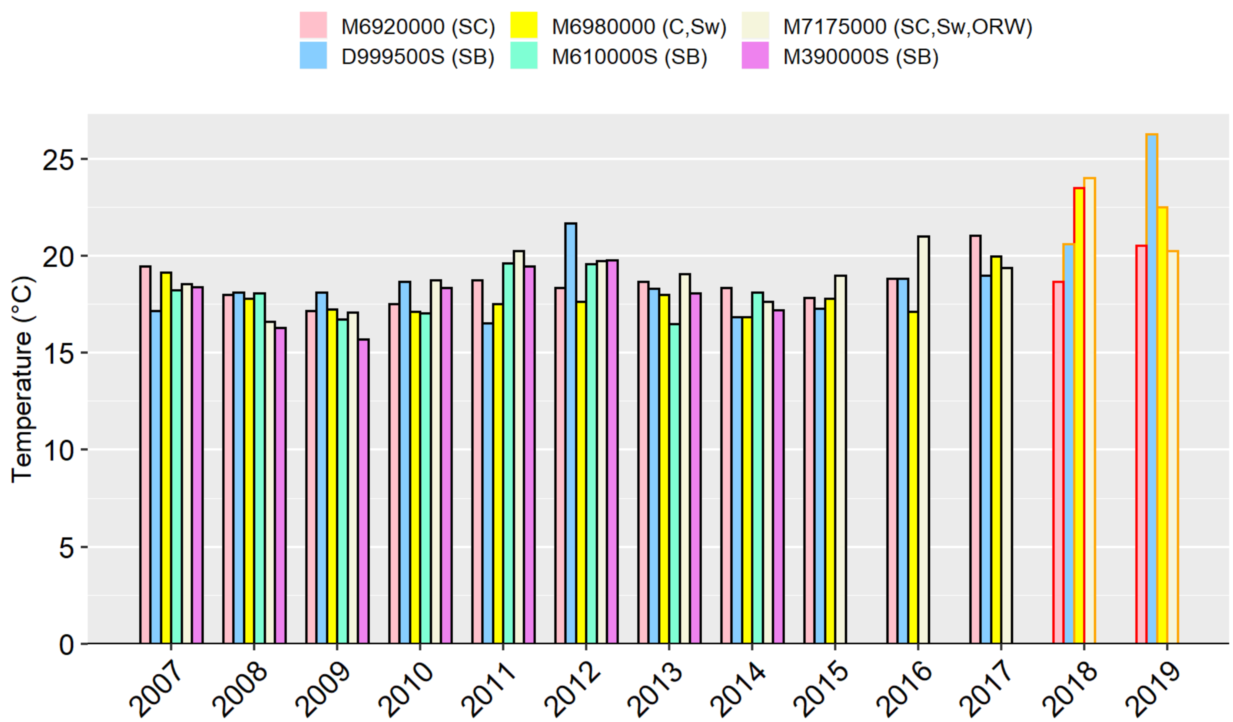


Figure 2-35 Annual Mean Water Temperature Readings from the Southern Shoreline of the Albemarle Sound. Orange Outlines Around the Bars Indicate Annual Means Based on Less Than Eight Measurements. Red Outlines Around the Bars Indicate Annual Means Based on Less than Three Measurements.



2.8 Lakes and Reservoirs

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. The WSS Intensive Survey Branch (ISB) collects and interprets biological, chemical, and physical data from North Carolina's lakes for their Ambient Lakes Monitoring Program (ALMP), Lake TMDL studies, and other special studies or intensive surveys. The program monitors lakes that are greater than 10 acres, are accessible to the public, and are used for water supply and/or significant recreation, as well as, other lakes that may have been requested due to certain characteristics or water quality issues. The ALMP originated under the EPA's Clean Lakes Program and was designed to identify long-term water quality trends in North Carolina's lakes (and reservoirs).

The ambient monitoring data collected from lakes and reservoirs are used to calculate the state of nutrient enrichment (trophic state) and determine if the lake is meeting its designated use. The trophic state is a relative description of the biological productivity of a lake based on the calculated North Carolina Trophic State Index (NCTSI) value. The NCTSI was specifically developed for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (1982). The index accounts for nutrients along with chlorophyll *a* concentrations and Secchi depth to calculate the lake's biological productivity. Trophic states can range from extremely productive (hypereutrophic) to very low productivity (oligotrophic). Generally, lakes are monitored monthly from May through September on the same 5-year monitoring cycle as the biological sampling. The number of stations in each lake varies based on the size and characteristics of the lake and purpose of the study.

2.9 Algae Assessment Program

The WSS Algae Assessment Program provides two types of evaluations: episodic and routine. Samples for episodic evaluations are collected in response to specific events such as fish kills, algal blooms, and nuisance aquatic plant and algal growth. Routine evaluations are targeted studies of specific waterbodies of interest and are generally performed in cooperation with other DWR programs. Routine evaluations are conducted to assess changes in algal assemblages over time and are often focused on estuarine systems where there are known issues of nutrient enrichment and have had frequent algal blooms or fish kills. This program also maintains the NC DWR Algal Bloom Dashboard which displays locations analyzed by DWR for algal bloom activity. To report an algal bloom on your phone, tablet, or PC please complete this DWR Citizen Report (Algal Bloom and Fish Kill Survey).

2.10 Groundwater Quality

The NC DWR's Groundwater Resources Section, Groundwater Management Branch (GWMB) has maintained and operated a statewide monitoring well network (MWN) for groundwater quantity since the 1960s and recently expanded its scope in 2015 to include groundwater quality monitoring. Together the MWN and groundwater quality programs provide comprehensive coverage, both geographically and geologically, for a statewide characterization of ambient groundwater quantity and quality. Chloride sampling allows the GWMB to monitor salinity levels and trends at the fresh water-salt water interface within each of the major coastal plain aquifers (Laughinghouse, 2020). Salinity levels and the location of the interface can change as a result of sea level rise, storm surges during hurricanes, groundwater pumping, and mine dewatering. Chloride levels are used to determine if groundwater is fresh (< 250 ppm chloride) or salty (>=250 ppm chloride). Chloride sampling is also used to identify the transition zone between the fresh and salty zones. This transition zone is characterized by a vertical salinity gradient within the aquifer in which salinity increases with depth, from fresh to salty (Laughinghouse, 2020). A brief description of each aquifer and maps of chloride monitoring and sampling locations is provided in Chapter 9. More information about North Carolina's aquifers can also be found on the GWMB's website.

Groundwater quality information in the Pasquotank River basin also comes from the routine sampling of newly-constructed private drinking water wells. Under the statewide private well testing program administered by Department of Health and Human Services (DHHS) and local health departments, all new private drinking water wells are sampled by local health departments and analyzed for a standardized list of chemical constituents by the State Laboratory of Public Health in DHHS. In addition to their value to individual well users, these samples are the most abundant source of data on the status of ground water quality across the state. When a constituent within an individual well exceeds drinking water health standards or groundwater standards established by the Department of Environmental Quality (DEQ) for one or more constituents, the local health department, along with DHHS, provides the well owner with information about the constituents identified in the ground water sample and what steps may be necessary to protect the well users' health. More information can be found on DHHS's website or by contacting your local health department.

2.11 Atmospheric Deposition

The National Atmospheric Deposition Program (NADP) is a collaboration between federal, state, and local agencies. The NADP precipitation chemistry network started in 1978 providing water quality information (H^+ as pH, conductance, calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, ammonium, and mercury) by collecting weekly samples. Currently, there are no monitoring locations in the

Pasquotank River basin. Historically, there were locations sampling for nutrients including dissolved inorganic nitrogen (NH_4^+ and NO_x (NO_2^- + NO_3^-)) and dissolved phosphate (PO_4^{3-}) between 2005 - 2008 near Phelps Lake and Alligator River (Rossignol et al., 2011). A mercury sampling station located in Pettigrew State Park was also in operation between 1996 and 2013. Site information for the mercury atmospheric deposition site (NC 42), associated data, and an interactive map with all the NADP sites can be found on their website (http://nadp.slh.wisc.edu/).

References

Laughinghouse S. 2020. North Carolina Division of Water Resources Ground Water Management Branch 2020 Annual Report. Accessed: https://www.ncwater.org/Publications/gwms/annual/fy2019-20_network_ann_report.pdf

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2005), Benthos Site MB1 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB001

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2005), Benthos Site MB2 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB002

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2015), Benthos Site MB3 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB003

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2005), Benthos Site MB4 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB004

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2002), Benthos Site MB5 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB005

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2010), Benthos Site MB6 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB006

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2015), Benthos Site MB7 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB007

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2005), Benthos Site MB8 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB008

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2010), Benthos Site MB9 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB009

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2015), Benthos Site MB10 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB010

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2005), Benthos Site MB11 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB011

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2010), Benthos Site MB14 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB014

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2000), Benthos Site MB15 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB015

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2000), Benthos Site MB16 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB016

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2000), Benthos Site MB18 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB018

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2000), Benthos Site MB20 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB020

North Carolina Department of Environmental Quality Biological Assessment Branch (NCDEQ BAB), (2014), Benthos Site MB27 Details. Accessed: https://www.ncwater.org/?page=672&SiteID=MB027

North Carolina Department of Environmental Quality, Division of Water Resources. 2018. North Carolina Division of Water Resources Annual Report of Fish Kill Events 2018. Accessed: https://files.nc.gov/ncdeq/Water%20Quality/Environmental%20Sciences/FishKill/Kill%20Reports/Annual%20Kill%20Reports/2018KillreportFinalAll.pdf

North Carolina Department of Environmental Quality, Division of Water Resources. 2018. North Carolina Division of Water Resources Annual Report of Fish Kill Events 2016. Accessed: https://files.nc.gov/ncdeq/Water%20Quality/Environmental%20Sciences/FishKill/Kill%20Reports/Annual%20Kill%20Reports/2016_Killreport_Word.pdf

Rossignol K. L., Paerl H. W., Fear J. M., Braddy J. S., 2011. Nutrients in Precipitation and the Phytoplankton Responses to Enrichment in Surface Waters of the Albemarle Peninsula, NC, USA after the Establishment of a Large-scale Chicken Egg Farm.

United States Fish and Wildlife Service (US FWS), North Carolina Division of Water Quality (NC DEQ), North Carolina Wildlife Resources Commission (NC WRC), 2008. Site-Specific Fish Tissue Mercury at Four Eastern North Carolina National Wildlife Refuges. Accessed: https://www.fws.gov/Raleigh/pdfs/FishHgReport_0108Final.pdf