

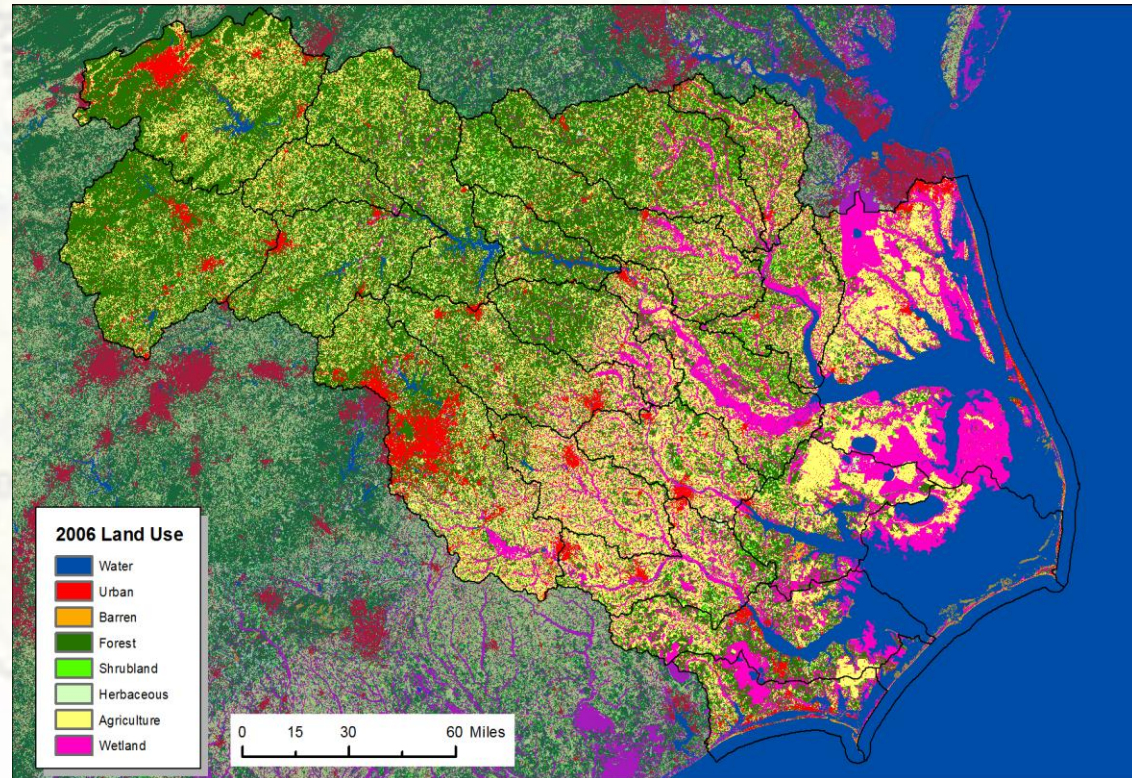
An Overview of the 2012 Ecosystem Assessment of the Albemarle-Pamlico Estuarine System

Dean Carpenter, APNEP Program Scientist
Albemarle-Pamlico National Estuary Partnership (APNEP)

EBM Track
Craven Boardroom
11:00am – 12:00pm

Presentation

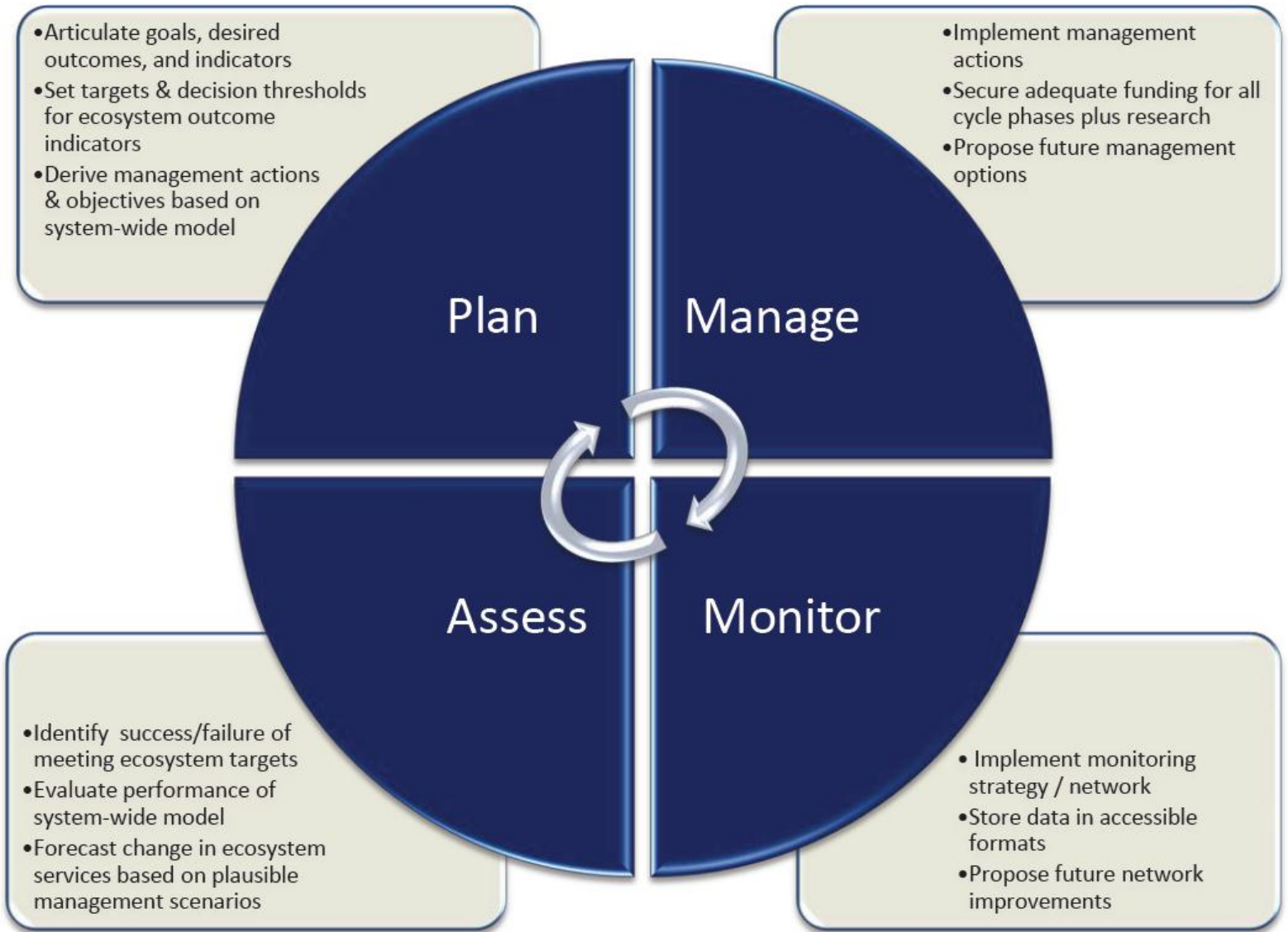
- ❖ Assessment in Ecosystem-based Management
- ❖ History of Assessment in Albemarle-Pamlico Region
- ❖ 2012 Protocol and Format
- ❖ Selection of Featured Indicators
- ❖ Indicator Assessment Examples
- ❖ Planned 2014+ Upgrades
- ❖ Role of Monitoring



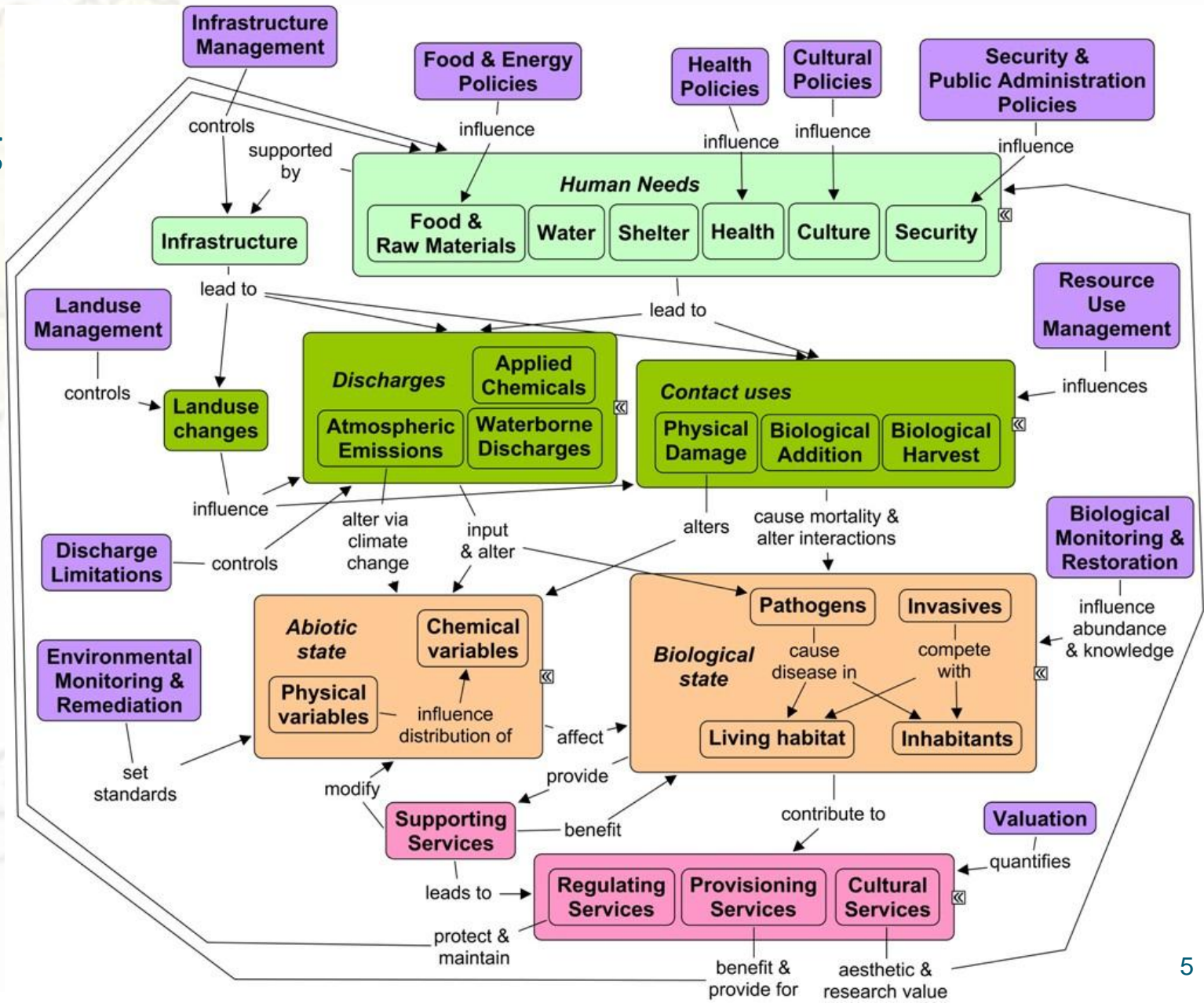
Seven Steps of APNEP's Ecosystem-Based Management

1. Articulate **program goals**
2. Develop **system level model** for goal attainment
3. Assess current management efforts –identify **gaps**
4. Develop **management strategy (CCMP)**
5. Develop **monitoring program**
6. **Assess** performance
7. **Manage adaptively**

Figure 2: APNEP's adaptive management cycle.



DPSER Modeling



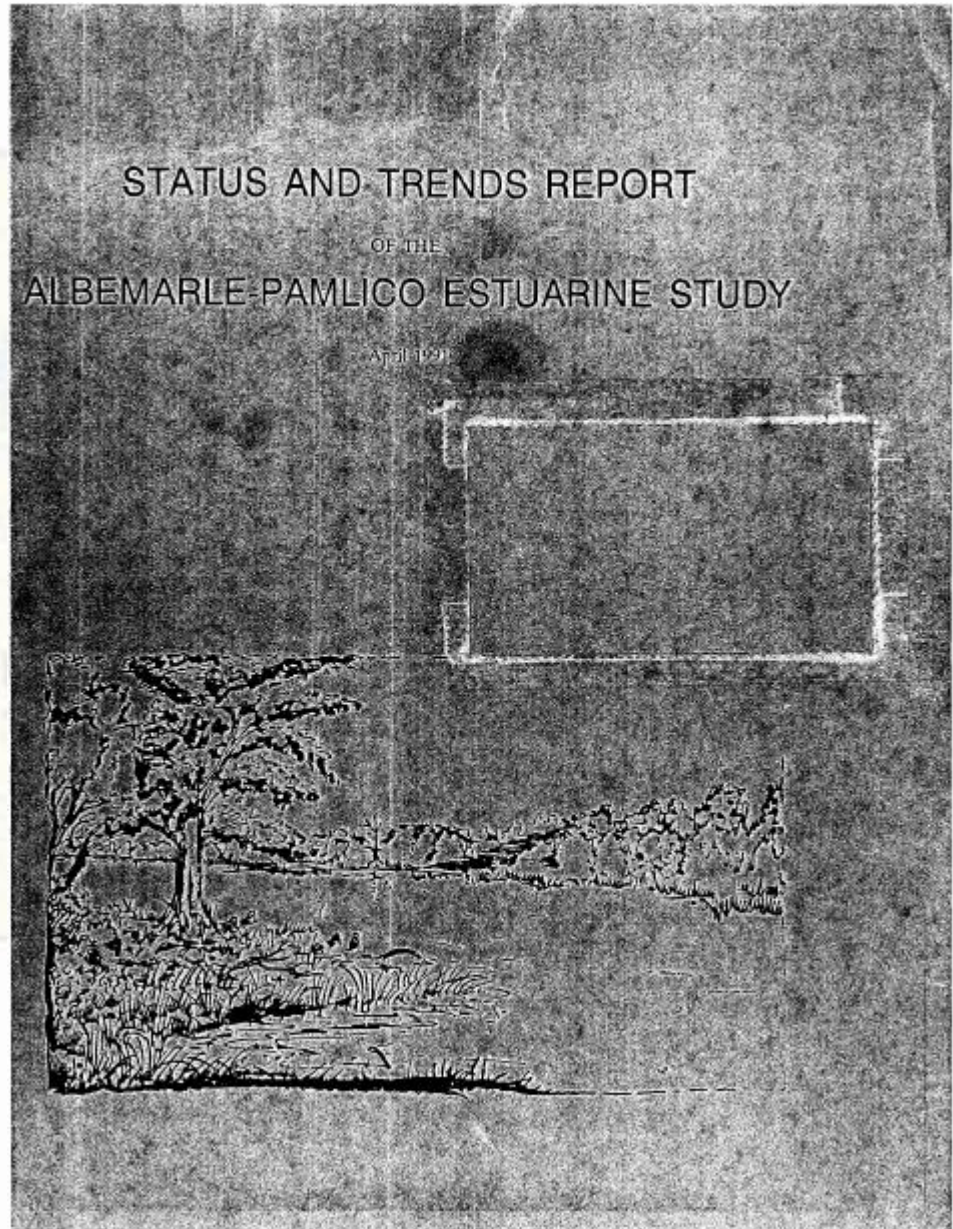
Lt. green = Drivers
 Dk. Green = Pressure
 Orange = State
 Red = Ecosystem Services
 Purple = Response

EPA-ORD-ESRP 2010



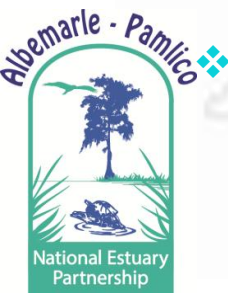
APES's Status & Trends Assessment (1991)

- ❖ Chapters: Critical Areas, Water Quality, Fisheries, Human Environment
- ❖ Themes: 4-5 per chapter
- ❖ Indicators: explicit or implied



USGS's A-P Drainage Unit of NAWQA

- ❖ Extent = 1991-Present
- ❖ First Cycle (1991-2001), compilation & synthesis, synoptic monitoring
- ❖ Second Cycle (2002-2010), process modeling NRB, urban development impacts, SPARROW, aquifer water quality
- ❖ Third Cycle (2011-2020), in planning status as of 2012



Water Quality in the Albemarle-Pamlico Drainage Basin

North Carolina and Virginia, 1992-95

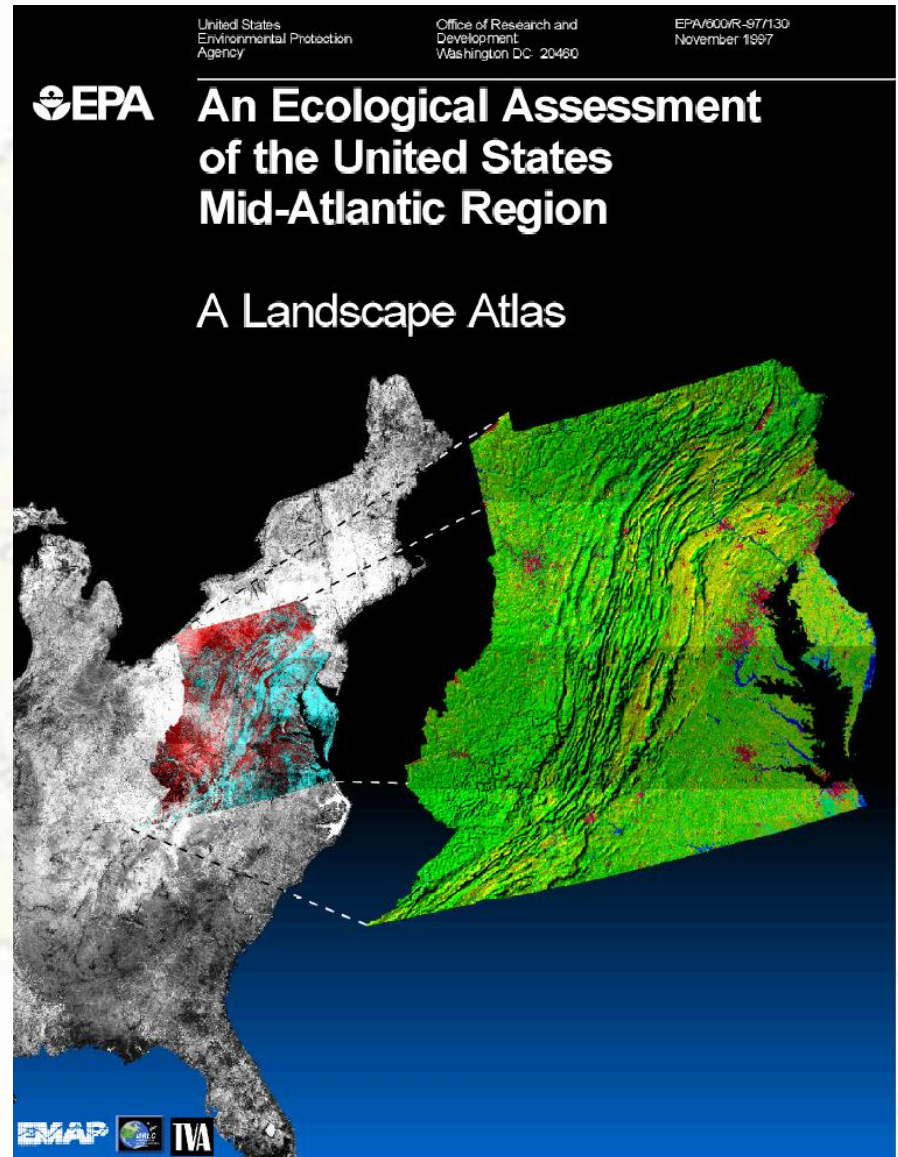


U.S. Department of the Interior
U.S. Geological Survey

Circular 1157

USEPA's Ecological Assessment of the Mid-Atlantic Region (1997)

- ❖ Period = Various
- ❖ Frequency = Various
- ❖ Extent = region
- ❖ Grain = 8-Digital HUCs including Virginia
- ❖ Indicators = land-based, quintile classes



NC-DWQ/DWR's Basin Assessments

- ❖ Extent = 2000-Present
- ❖ Frequency = 5 years
- ❖ Categories = biological, physiochemical
- ❖ Indicators = water quality

BASINWIDE ASSESSMENT REPORT: CHOWAN RIVER BASIN



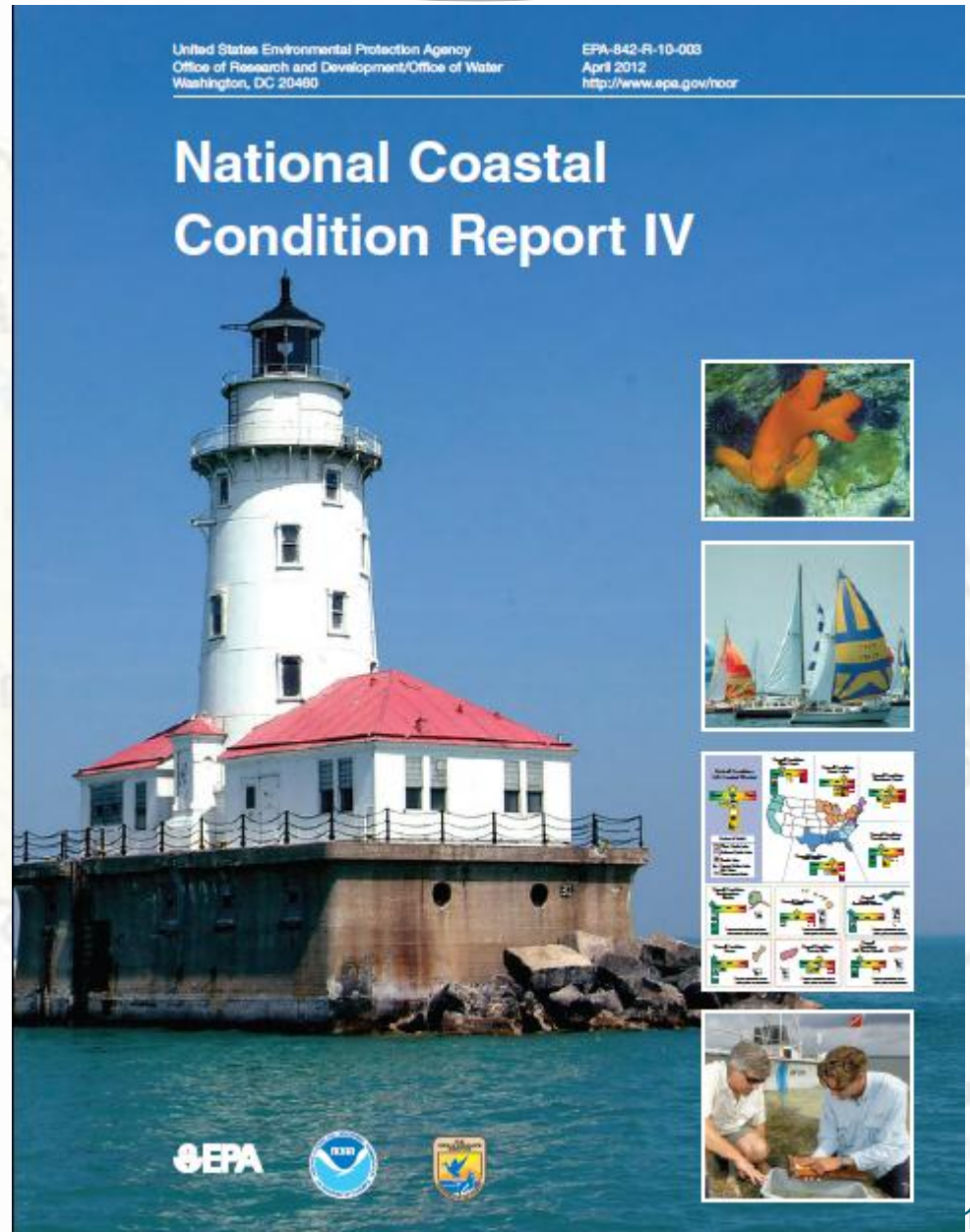
NORTH CAROLINA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES
Division of Water Quality
Environmental Sciences Section

December 2011



USEPA's Coastal Condition Report Series

- ❖ Period = 2001 - Present
- ❖ Frequency = 2001, 2004, 2008, 2012 (3-4 years)
- ❖ Extent = national
- ❖ Grain = region, NEP unit
- ❖ Categories (Indices) = water quality, sediment quality, benthic, coastal habitat, fish tissue contaminants



North Carolina's Forest Resources Assessment

- ❖ Period = 2010 - Present
- ❖ Frequency = 2010
- ❖ Extent = state
- ❖ Grain = various
- ❖ Categories = forest; declining forest types; family and minority forest ownership; population growth and land-use change impacts; emerging markets in ecosystem services; insects, diseases, and non-native invasive plants; fire and fire exclusion; climate, atmosphere, and natural disasters; water quality/quantity; forest wildlife habitat; urban forests

North Carolina's Forest Resources Assessment

A statewide analysis of the past, current and projected future conditions of North Carolina's forest resources

2010



Virginia's Forest Resources Assessment

- ❖ Period = 2010 - present
- ❖ Frequency = 2010
- ❖ Extent = state
- ❖ Grain = various
- ❖ Categories = forest land, forest management, landscapes, landscape management



Virginia Statewide Assessment of Forest Resources

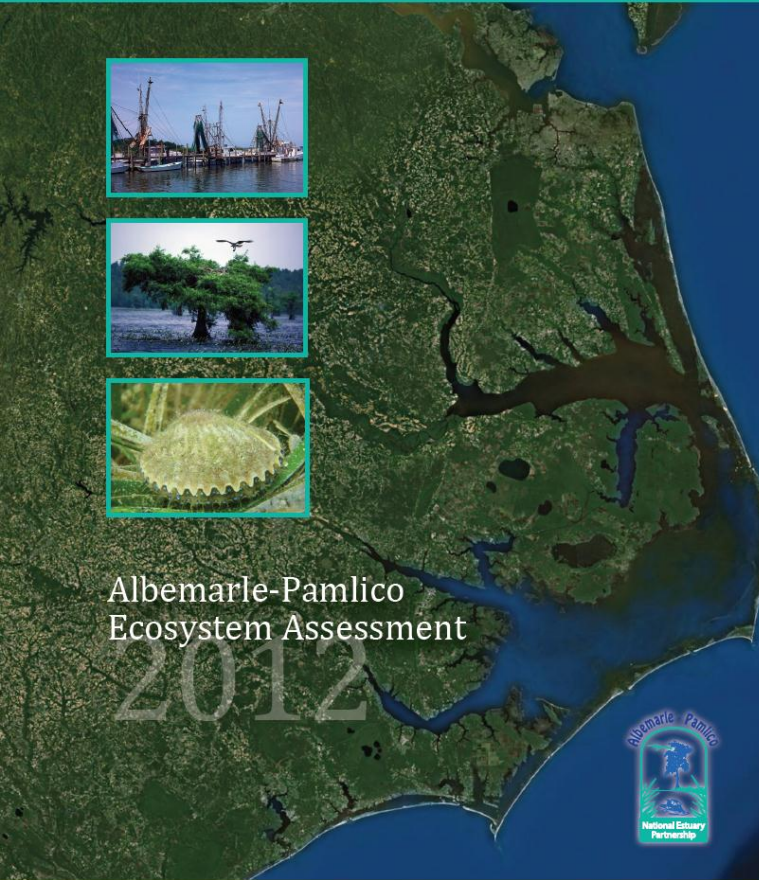
*A Comprehensive Analysis of
Forest Conditions, Trends,
Threats and Priorities*

June 2010




APNEP Progress 2012


Albemarle-Pamlico National Estuary Partnership



Albemarle-Pamlico
Ecosystem Assessment
2012



Collaborative Actions for Protecting and Restoring the Albemarle-Pamlico Ecosystem



IDENTIFY
PROTECT
RESTORE
ENGAGE
MONITOR

Comprehensive Conservation
and Management Plan
2012 - 2022

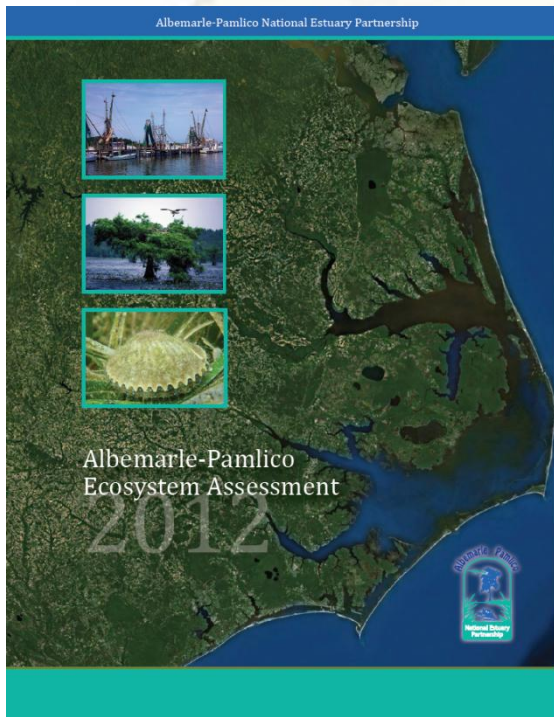


Collaborative Actions for Protecting and Restoring the Albemarle-Pamlico Ecosystem



2012 Albemarle-Pamlico Ecosystem Assessment

- A top priority in the STAC's 2010-2012 Action Plan
- Makes the most of resources and knowledge at hand to share the status and trends on a limited suite of indicators for three ecosystem types:
 - System-Wide
 - Coasts, Sounds, and Near Marine
 - Fresh Waters



Chapter 1: Introduction

Chapter 2: The Region's Ecosystems

Chapter 3: System-Wide

Chapter 4: Coasts, Sounds, and Near-Marine

Chapter 5: Fresh Waters

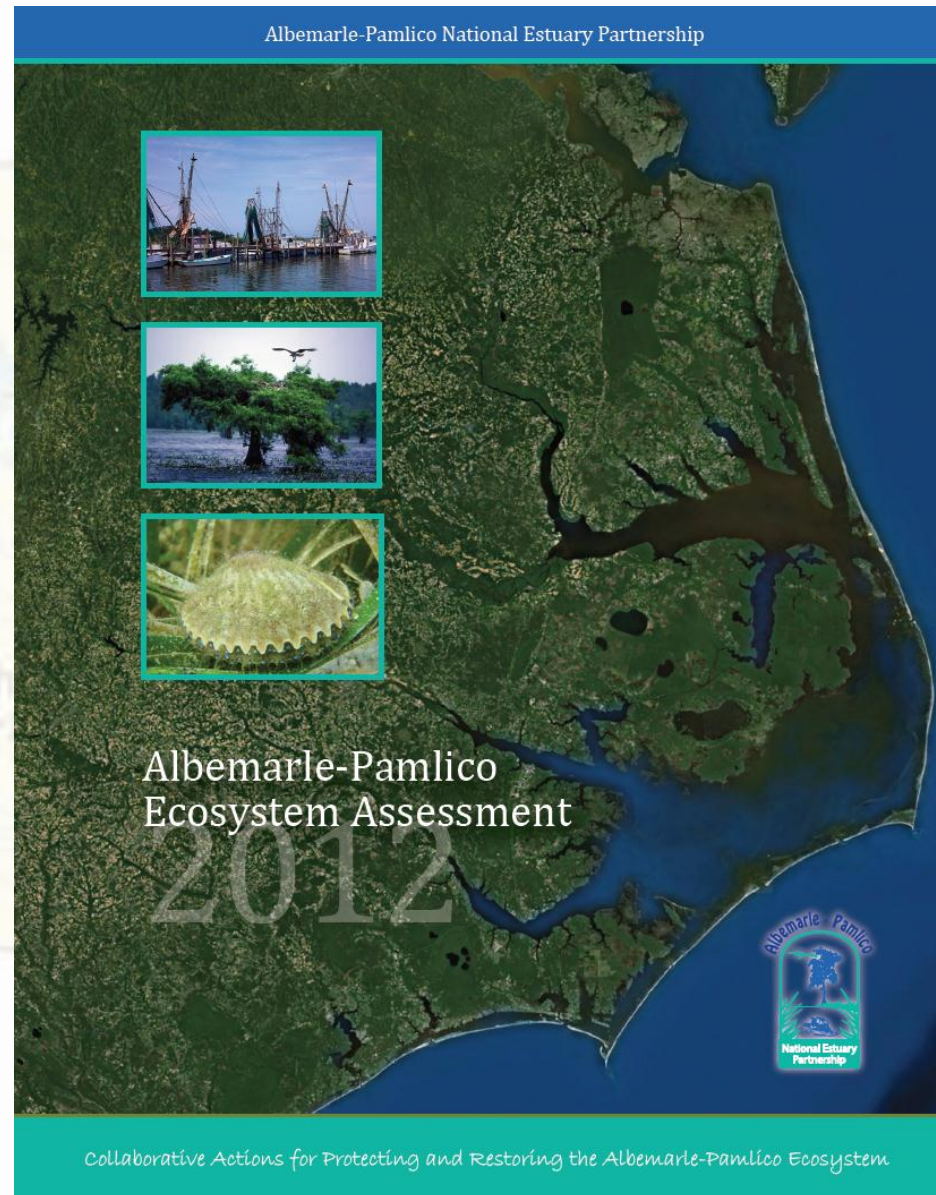
Chapter 6: Next Steps

Appendix: Technical Methodologies of
Indicator Assessments



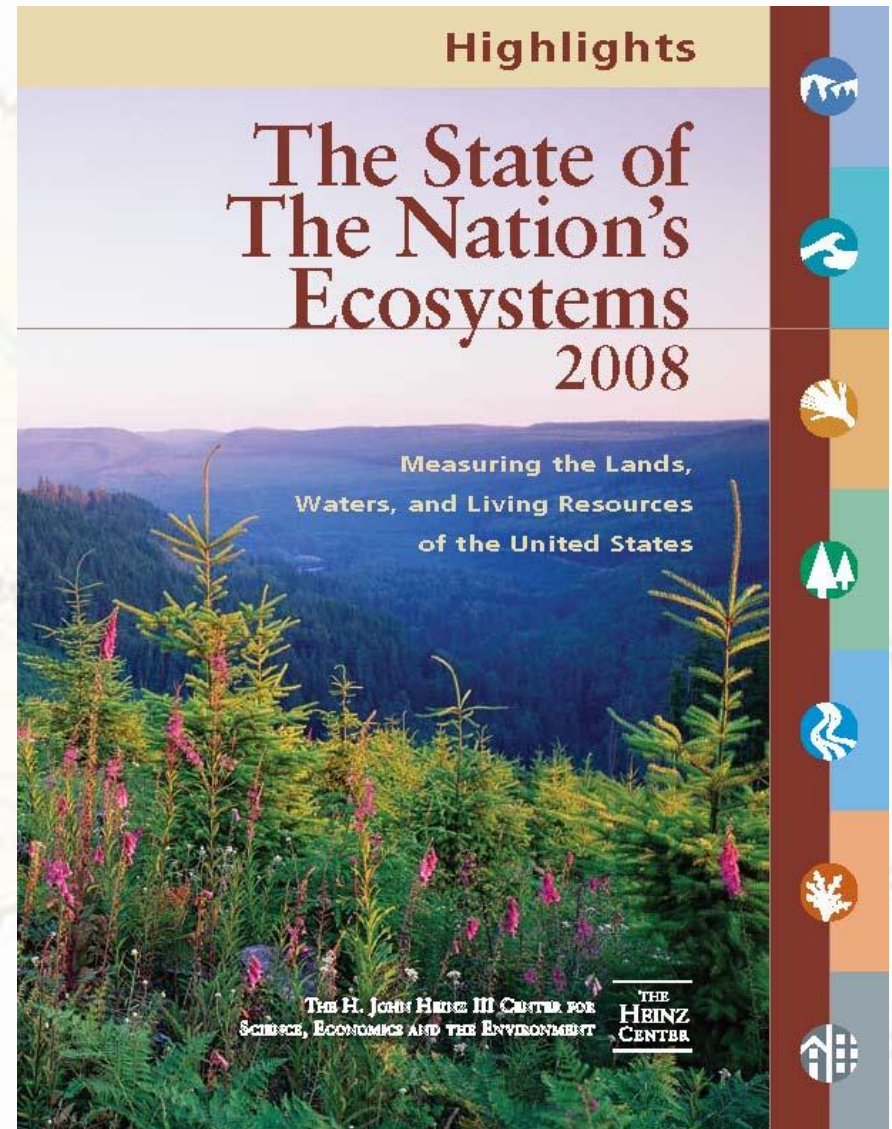
Ecosystem Assessment Protocol & Format

- ❖ Beginning snapshot, not comprehensive nor evaluation of sustainability
- ❖ Project began mid-2010 in accordance with STAC Action Plan
- ❖ Project coordinators (and authors): Drs. Dubbs and Carpenter
- ❖ 12 STAC and 6 non-STAC contributors
- ❖ Modeled after Heinz Center “State of Nation’s Ecosystems” format

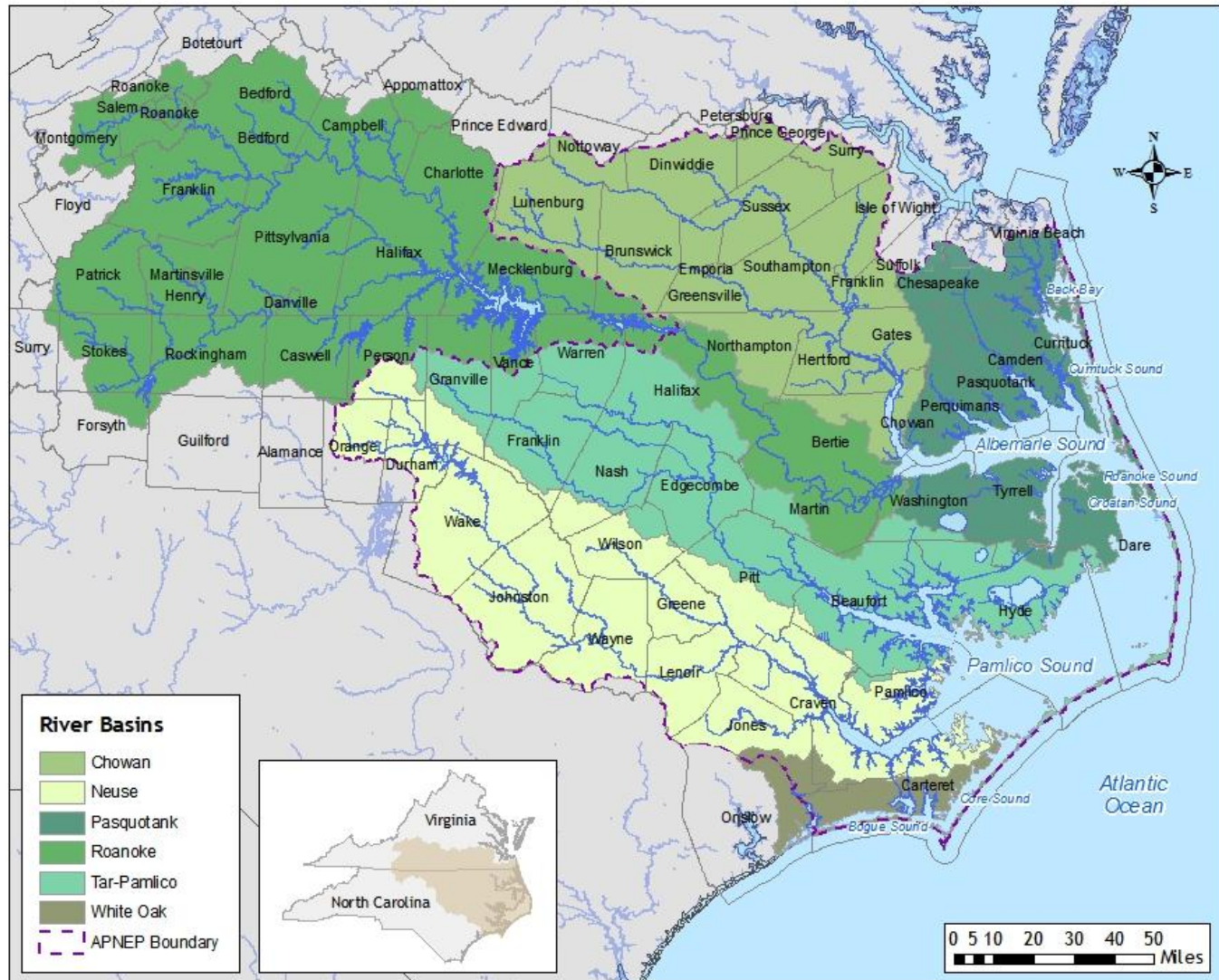


Commonalities

- Current, high-quality, scientifically credible information
- “Big picture” insights into regional ecosystem health
- Indicator selection based on gauging ecosystem health and not limited to those that are currently monitored
- Broad array of partners during indicator selection, data compilation, and assessment
- Data origin not a limiting factor
- Four levels of conceptual organization (top two levels applied in interim)
- Initial technical assessment only status & trends



APNEP Implementation Area and Management Institutions



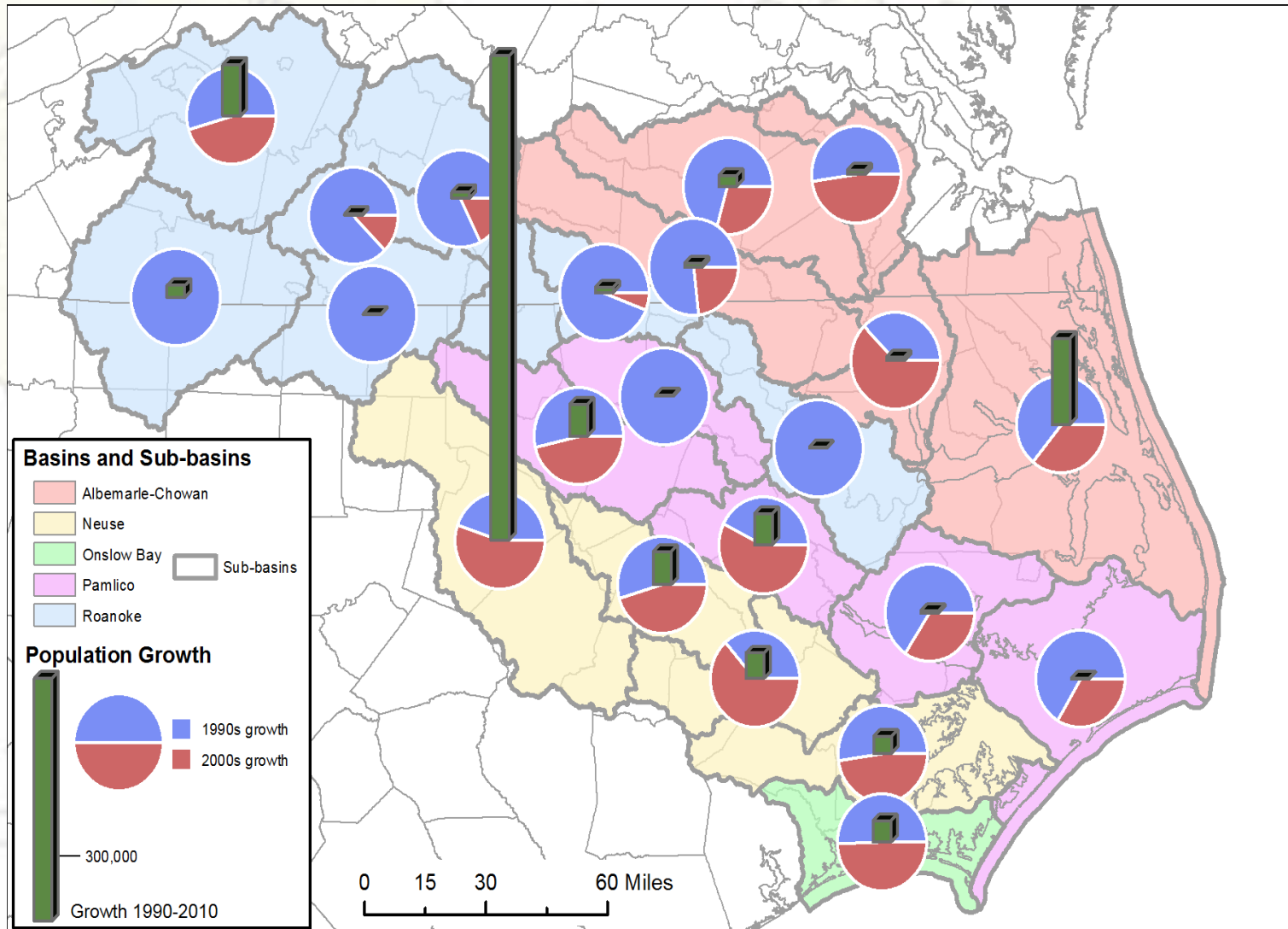
					Reporting Scales			
Type	Category	Indicator	Origin	Units	Space		Time	
					Extent	Resolution	Extent	Frequency
System-Wide	Extent & Pattern	Human Population	O	persons	region	basin & sub	1990-2010	10 years
		Land Cover Extent	S&T	acres	region	basin & sub	1992-2006	5-9 years
	Chemical & Physical	Ambient Air Temperature	O	degrees count, F	4 stations	station	1895-2009	annual
		Storm Frequency & Intensity	O	scale W126	region	storm track	1950-2010	60 years
		Ground-Level Ozone Concentration	O	Index	11 stations	station	1993-2010	annual
		Total Inorganic Nitrogen Deposition	O	kg-N/ha	5 stations	station	1980-2009	3-yr moving average
		Dissolved Metal Concentrations	S&T	ug/L	state (VA)	basin	1998-2011	1-48 months
		Dissolved Oxygen Concentration	S&T	mg/L	region	basin	1980-2010	monthly
	Biological	Chlorophyll-a Concentration Violations	S&T	ug/L	region	basin	1980-2010	1-96 months
		River Herring Abundance	O	count, biomass	2 basins	basin	1972-2010	annual
American Shad Abundance		O	CPUE, relative F	region	basin	2000-2010	annual	
Coasts, Sounds, and Near-Marine	Extent & Pattern	Sturgeon Abundance	O	CPUE	region	basin	1990-2011	annual
		Submerged Aquatic Vegetation Extent	S&T	acres	region	census	2006-2008	2-yr average
	Chemical & Physical	Phragmites australis Extent	N	acres	13 stations	station	Various within 2009-2010	annual
		Relative Sea Level	O	mm	4 stations	station	Various within 1953-2010	annual
		Ocean Shoreline Migration	O	m/yr, m	region	station	Various within 1933-2009, 1996-2009	57-76 years, 13 years
		Estuarine Shoreline Migration	O	feet/yr	region & sub & 5 stations	sub & km	? & 1958-1998 & months	? & 40 years & months?
		Estuarine Salinity Concentration	S&T	ppt	region	sub	1980-2009	10 years
	Biological	Shellfish Closures	S&T	% closed	region	region	1980-2010	annual
Unusual Fish Mortalities		S&T	count	?	?	?	?	
Fresh Waters	Chemical & Physical	Streamflow	S&T	cfs	basin	station	Various within 1930-2008, 1996-2010	annual, 14-yr average
		Point Source Discharges	S&T	discharger number, tons	station	station	1960-2008	2-10 years
		Riverine Transport of Nitrogen & Phosphorus	S&T	tons, tons/mi ² , cfs	basin	station	1997-2008	annual
		Suspended Sediment	S&T	tons, tons/mi ² , NTU	region	basin	1980-1992, 1980-1989	9-12 years

APNEP Ecosystem Assessment

Coasts, Sounds, Near Marine: Extent & Pattern

- *Phragmites australis*
 - Why Is the Extent of the Wetland Plant Species *Phragmites australis* Important?
 - What Will This Indicator Report?
 - What Do the Data Show?
 - Why Can't This Entire Indicator Be Reported at This Time?
 - Discussion
 - Technical Notes

Human Population: Growth, 1990-2010

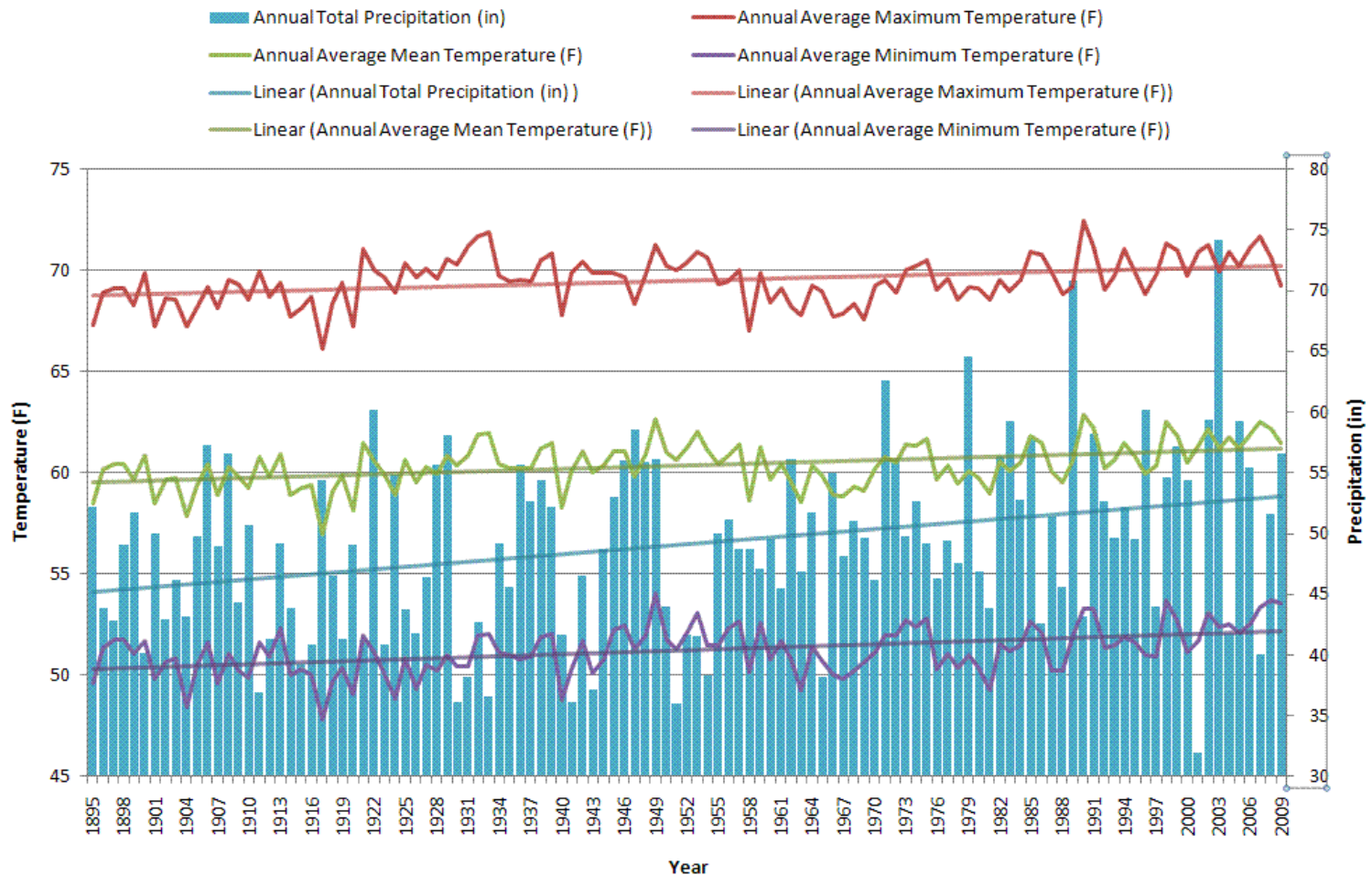


Land Cover: Change, 2001-2006

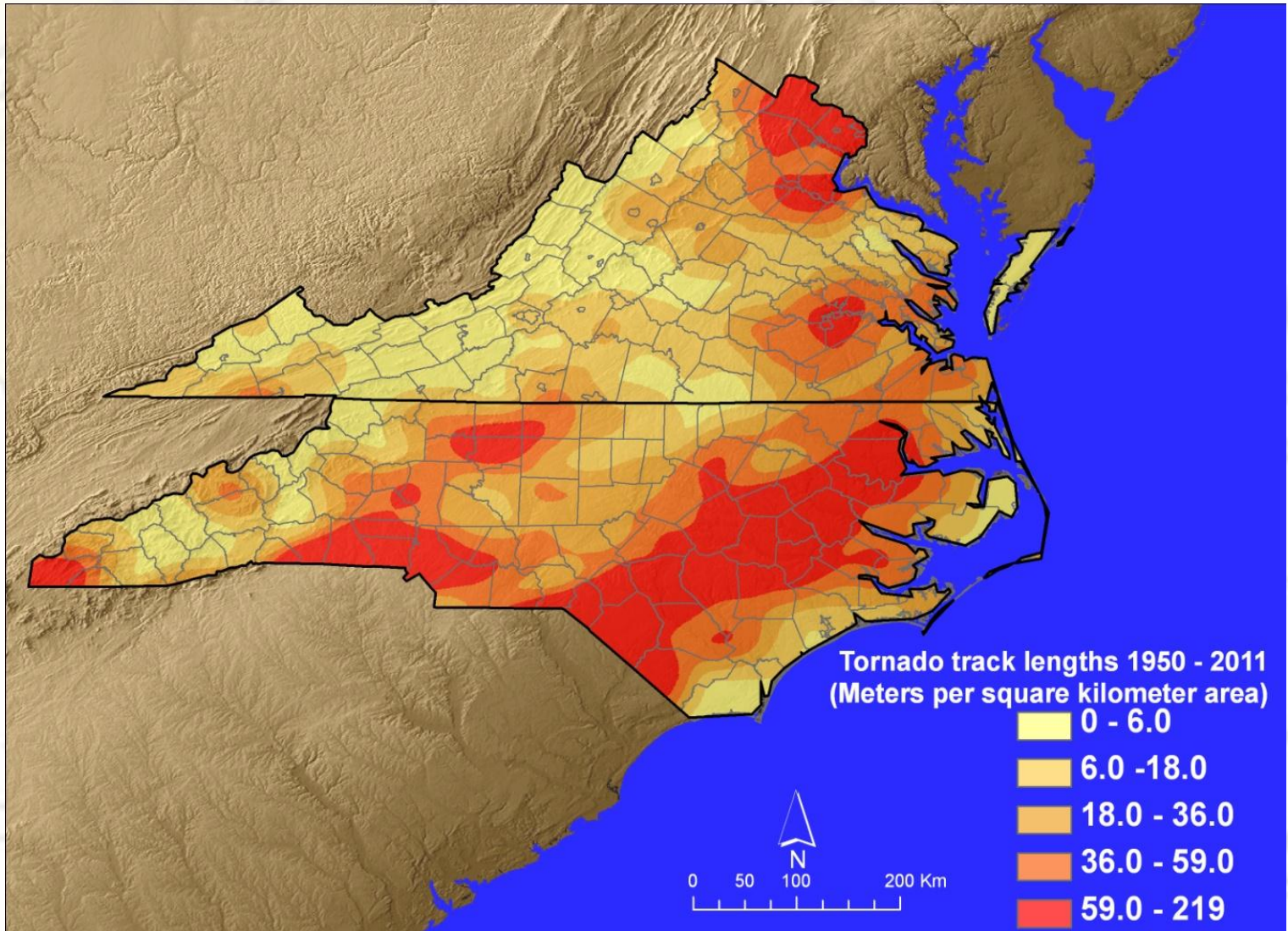
Basins/Sub-basins	Total Acres	Urban		Croplands		Forest		Wetlands	
		acres	% of total	acres	% of total	Acres	% of total	Acres	% of total
Albemarle-Chowan	4,856,193	3,976	0.08	23,708	0.49	-80,323	1.65	-19,861	0.41
Albemarle	1,701,240	3,164	0.19	19,269	1.13	-27,667	1.63	-2,036	0.12
Blackwater	473,596	587	0.12	3,675	0.78	-3,800	0.80	-5,154	1.09
Chowan	547,537	11	0.00	-8,748	1.60	-13,790	2.52	-2,697	0.49
Meherrin	1,031,410	71	0.01	6,595	0.64	-25,667	2.49	-5,402	0.52
Nottoway	1,102,410	143	0.01	2,916	0.26	-9,399	0.85	-4,572	0.41
Roanoke	6,245,323	3,414	0.05	6,276	0.10	-36,867	0.59	-4,767	0.08
Lower Roanoke	834,815	448	0.05	9,872	1.18	-11,211	1.34	-4,479	0.54
Roanoke Rapids	378,615	36	0.01	2,295	0.61	-7,391	1.95	-124	0.03
Middle Roanoke	1,112,130	50	0.00	-6,506	0.58	-2,995	0.27	-314	0.03
Upper Roanoke	1,401,630	1,968	0.14	-3,738	0.27	-3,370	0.24	-9	0.00
Banister	381,774	50	0.01	-1,636	0.43	-257	0.07	-6	0.00
Lower Dan	821,399	232	0.03	-59	0.01	-8,448	1.03	-101	0.01
Upper Dan	1,314,960	630	0.05	-6,504	0.49	-3,195	0.24	266	0.02
Pamlico	3,040,826	3,819	0.13	421	0.01	-23,577	0.77	-5,908	0.19
Pamlico Sound	280,227	0	0.00	-1,255	0.45	72	0.03	1,077	0.38
Pamlico	739,623	119	0.02	5,788	0.78	-10,300	1.39	-174	0.02
Lower Tar	614,297	1,807	0.29	-1,041	0.17	-3,297	0.54	-4,082	0.66
Upper Tar	834,737	1,841	0.22	-3,255	0.39	-5,995	0.72	-866	0.10
Fishing	571,942	52	0.01	184	0.03	-4,057	0.71	-1,863	0.33
Neuse	3,618,088	27,193	0.75	3,519	0.10	-49,791	1.38	-10,257	0.28
Lower Neuse	752,149	975	0.13	9,323	1.24	-16,476	2.19	-68	0.01
Middle Neuse	681,419	2,276	0.33	-183	0.03	-12,233	1.79	-5,158	0.76
Upper Neuse	1,539,320	22,133	1.44	-4,450	0.29	-18,632	1.21	-2,158	0.14
Contentnea	645,200	1,809	0.28	-1,171	0.18	-2,460	0.38	-2,873	0.44
Onslow Bay	385,256	752	0.19	4,689	1.22	-7,478	1.94	-441	0.11
White Oak River	385,256	752	0.19	4,689	1.22	-7,478	1.94	-441	0.11

Ambient Air Temperature: Trend, 1895-2009

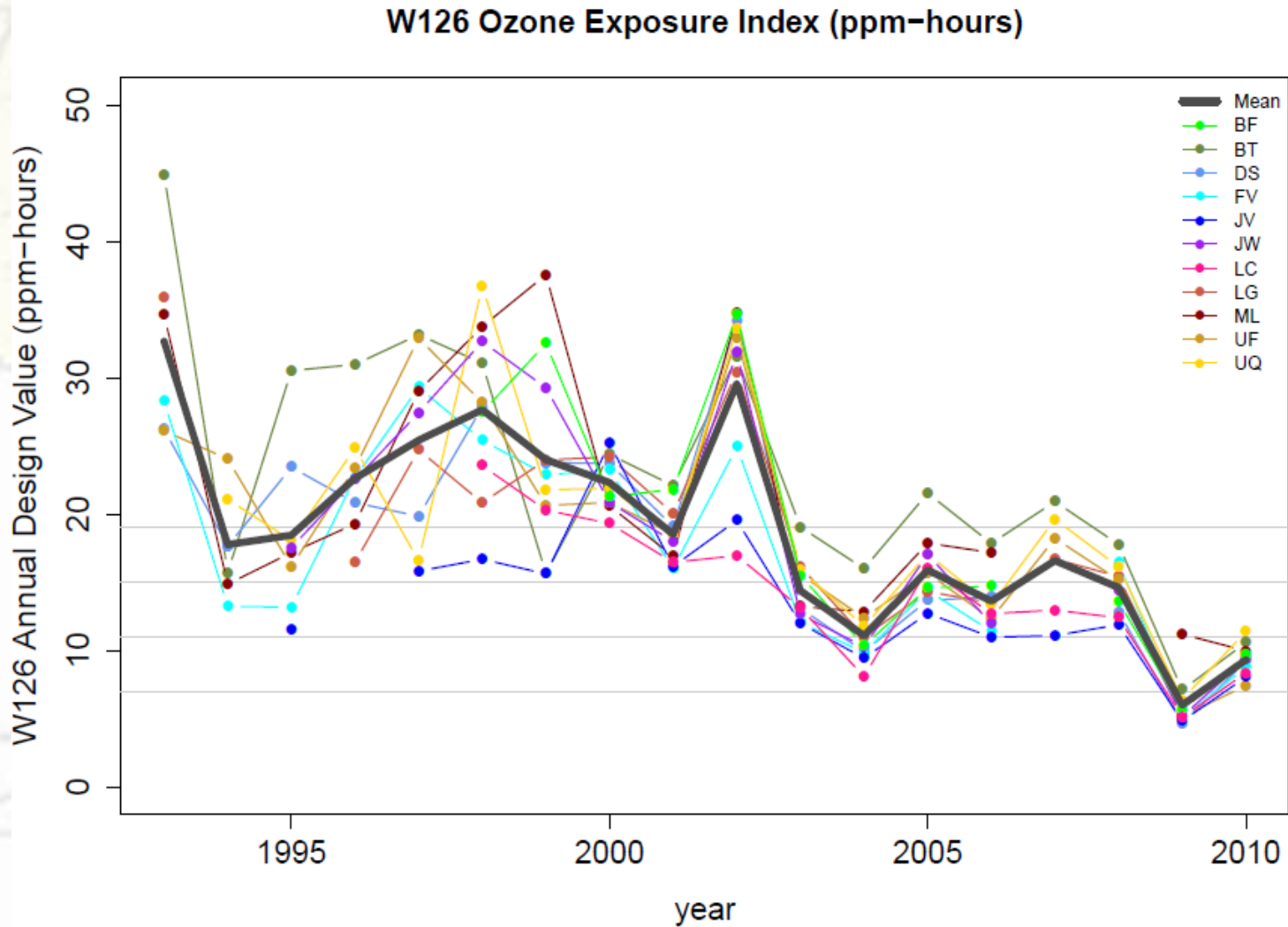
Spatial Average for Morehead City, Cape Hatteras, Edenton, Elizabeth City using US Historical Climatology Network Data



Storm Frequency & Intensity: Tornado Touchdown Density, 1950-2011

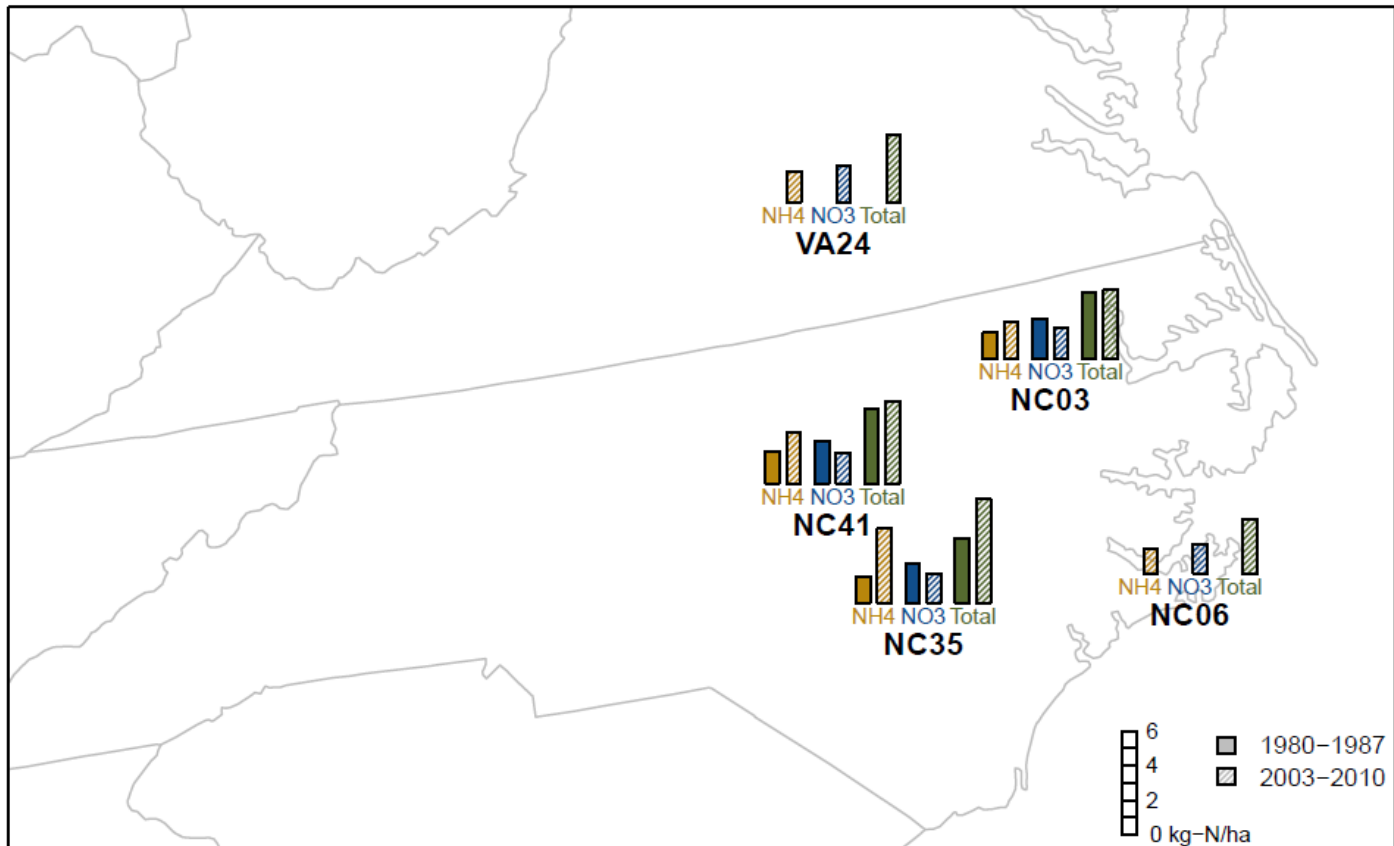


Ground Level Ozone: W126 Ozone Exposure Index, 1993-2010

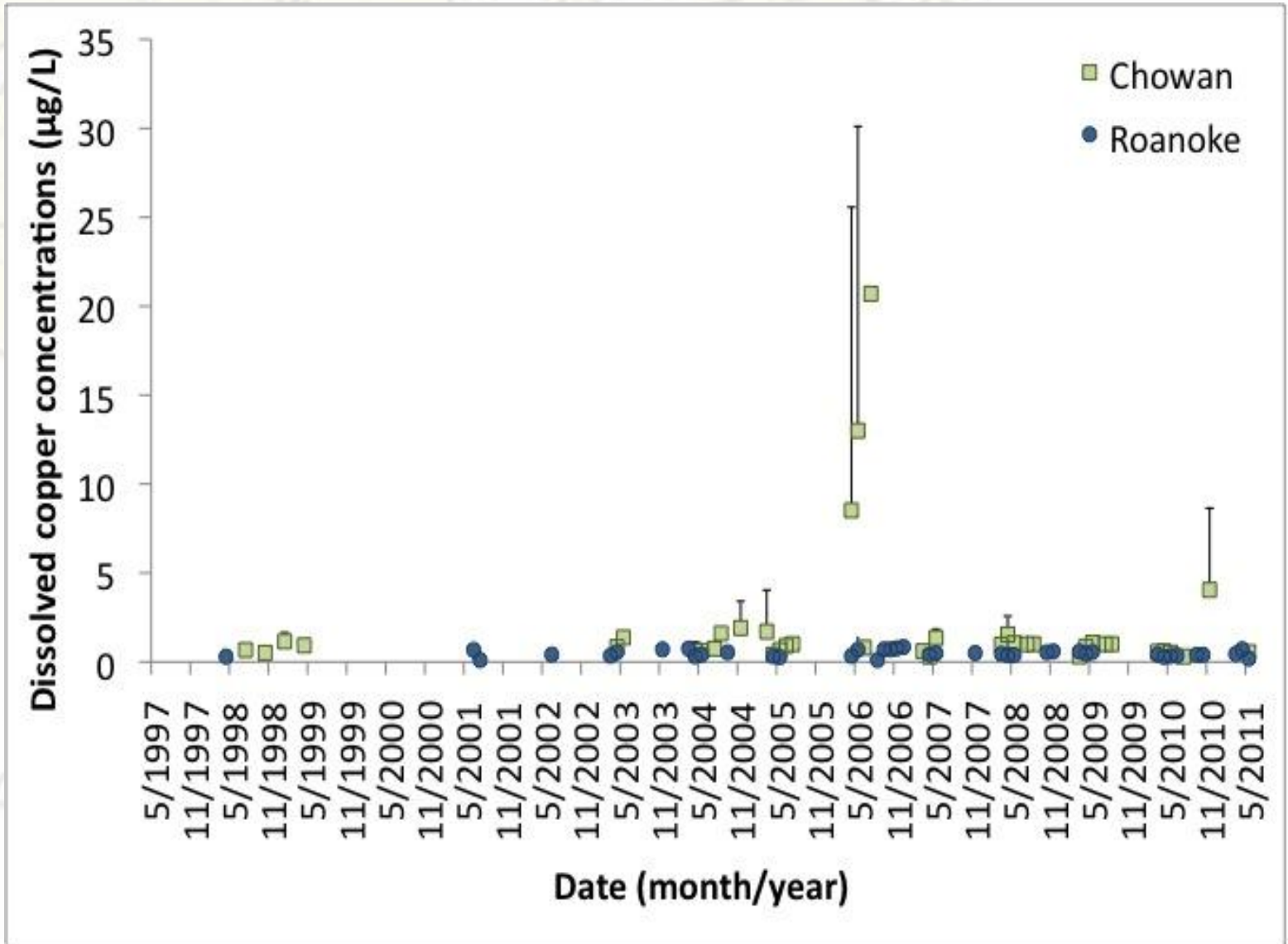


Total Inorganic Nitrogen Deposition: Wet Deposition, 1980-2010

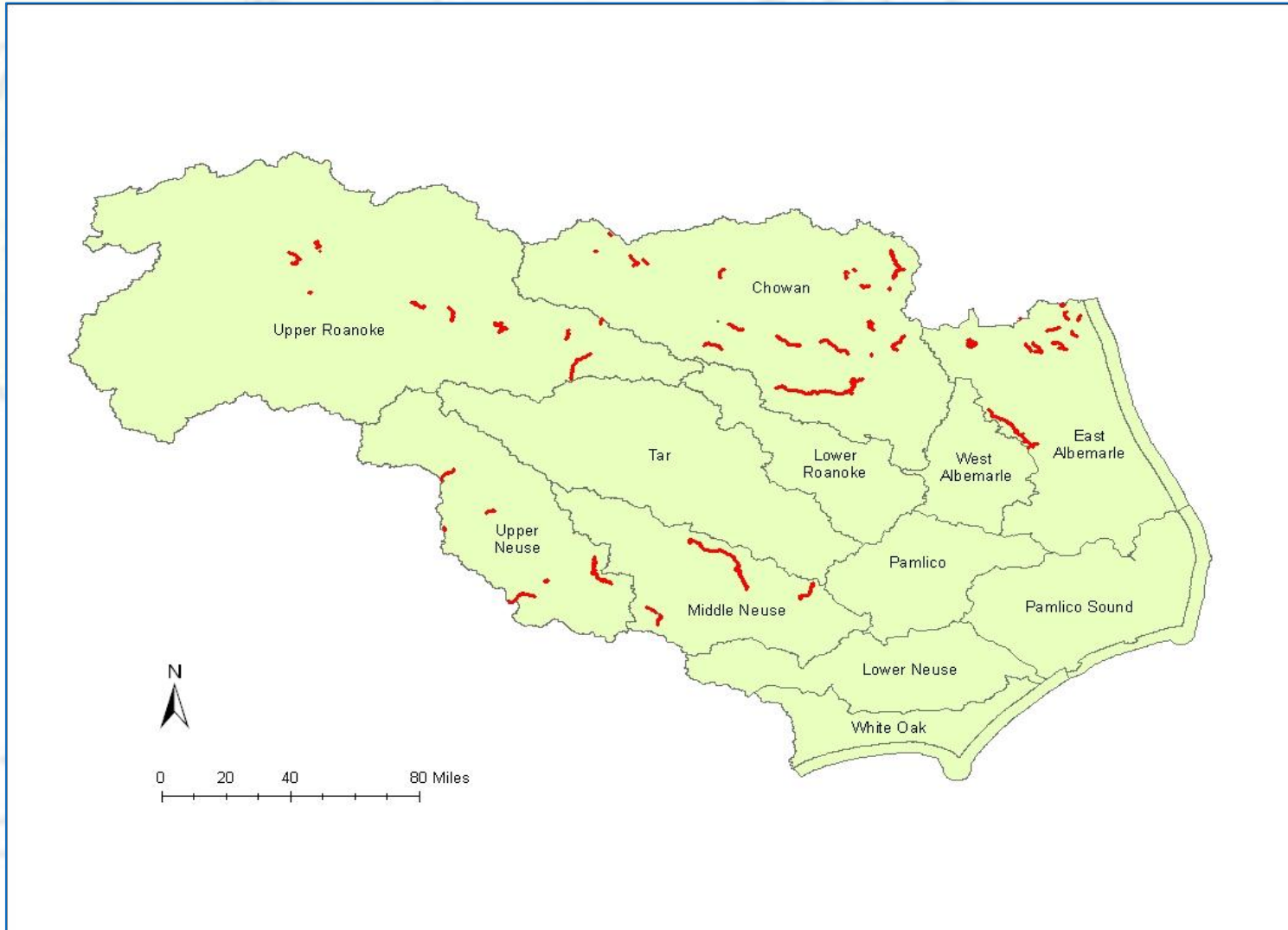
Average Wet Deposition Inorganic N ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) for 1980–1987 and 2003–2010



Dissolved Metal Concentrations: Copper in Virginia Waters, 1998-2011



Dissolved Oxygen Concentration Violations: DO Violations, 2010

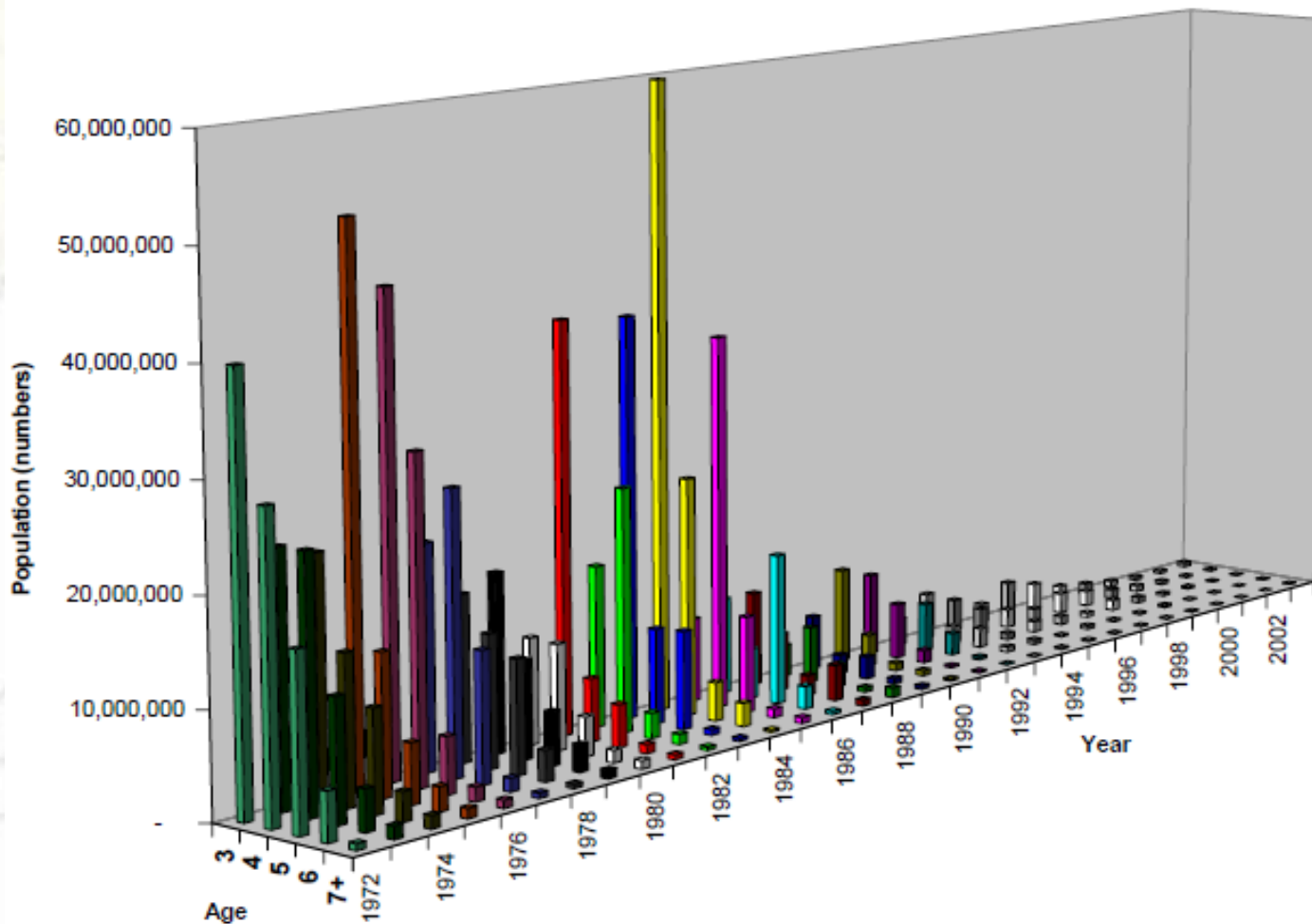


Chlorophyll-a Concentration Violations: Chl-a Violations, 2010

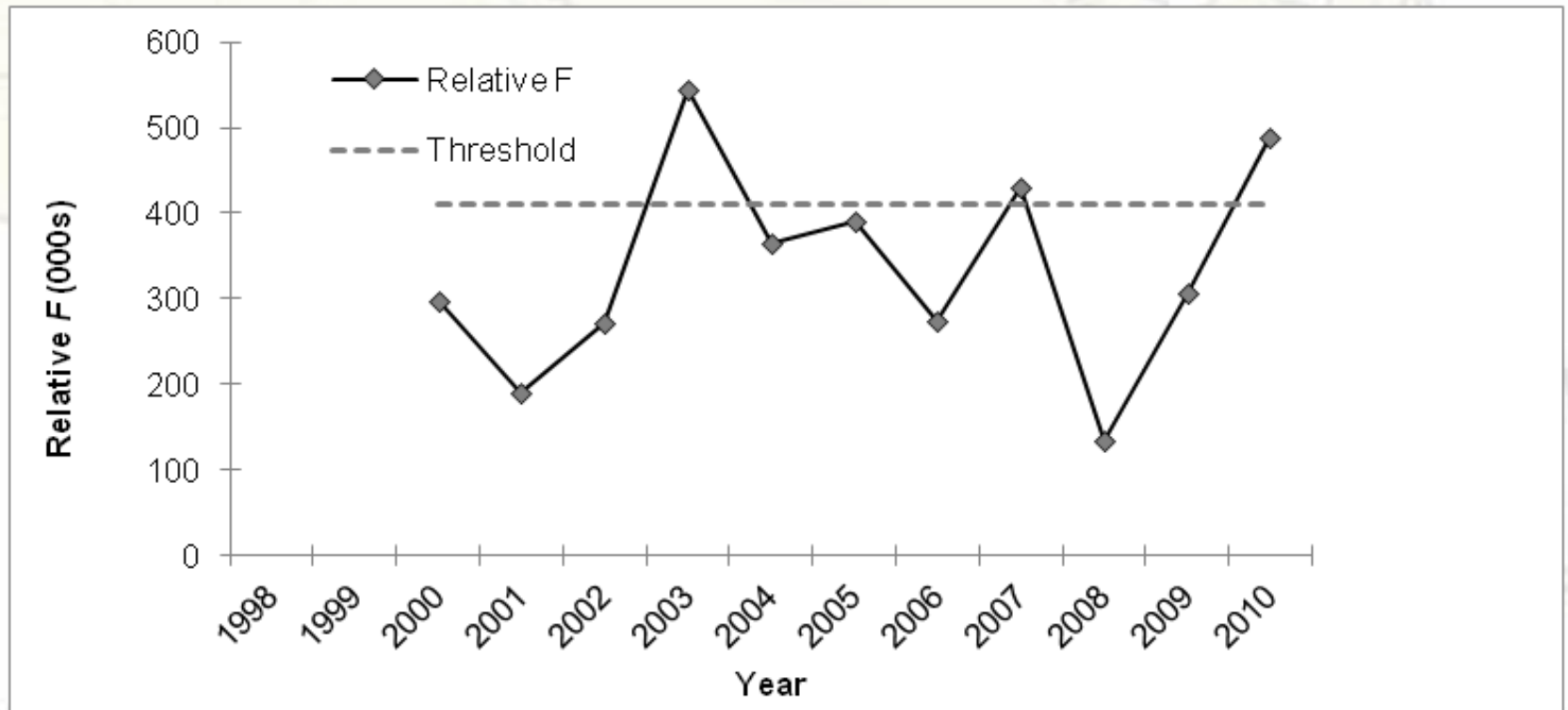


River Herring Abundance: Blueback Herring Population Age Structure, 1972-2003

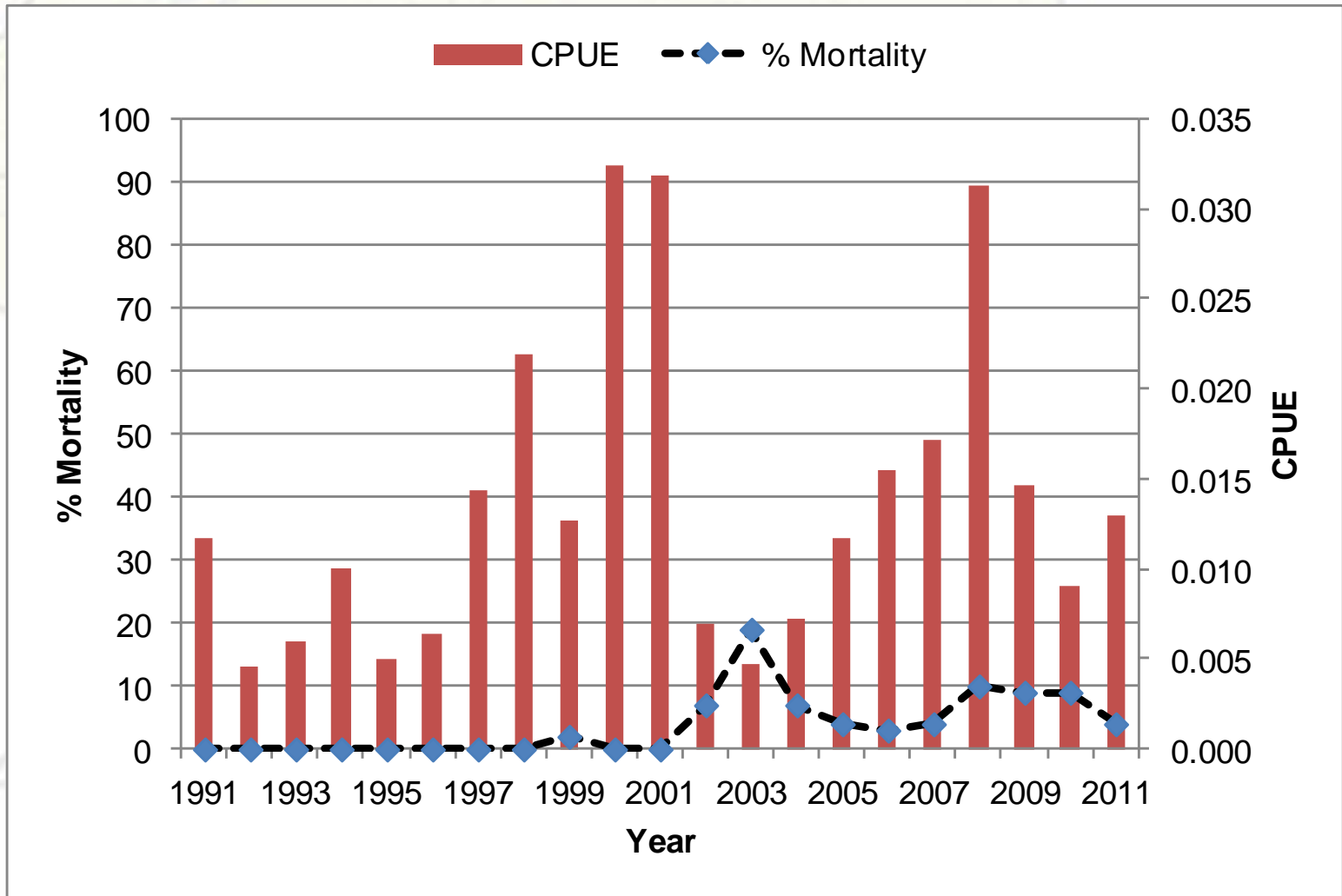
Population Age Structure: Blueback Herring



American Shad Abundance: Female Relative F Index for Albemarle Sound, 2000-2010



Sturgeon Abundance: Atlantic Sturgeon Mortality and Catch Per Unit Effort, 1991-2011



Extent of “Visible” Submerged Aquatic Vegetation, 2006-2008

APES	Chowan	Lower Neuse	Pamlico	White Oak	East Albermarle, Croatan Sound	Lower Roanoke	Pamlico Sound	South Coastal	West Albermarle	TOTAL
Dense	82	1,046	165	8,786	14,701	4	44,695	7	1,075	70,561
Patchy	598	1,909	52	10,572	9,789	92	42,511	53	1,814	67,390
TOTAL	680	2,955	217	19,358	24,490	97	87,206	60	2,890	137,951



Phragmites australis Extent: Back Bay, Virginia, 2009-2010

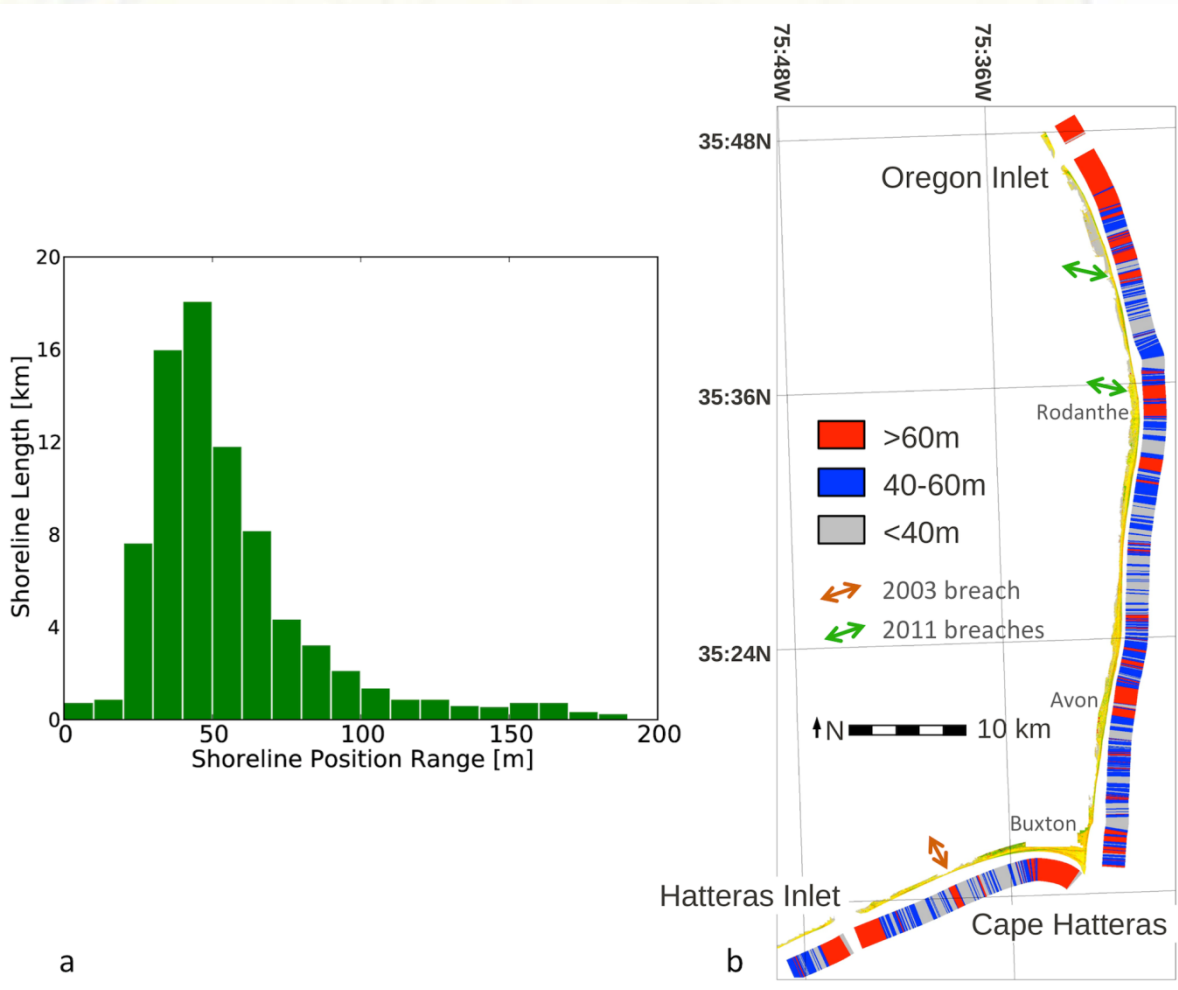
Location	# Patches	Acreage	Mean (acres)	Largest Patch
Back Bay (2009-2010)	2411	7567	3.1	734

Year	Author	Acreage	% Cover
1964	Sincock et al.	0	0
1977	Silberhorn	85	0.9%
1990	Priest and Dewing	1000	10%
2010	Heffernan	5885	59%

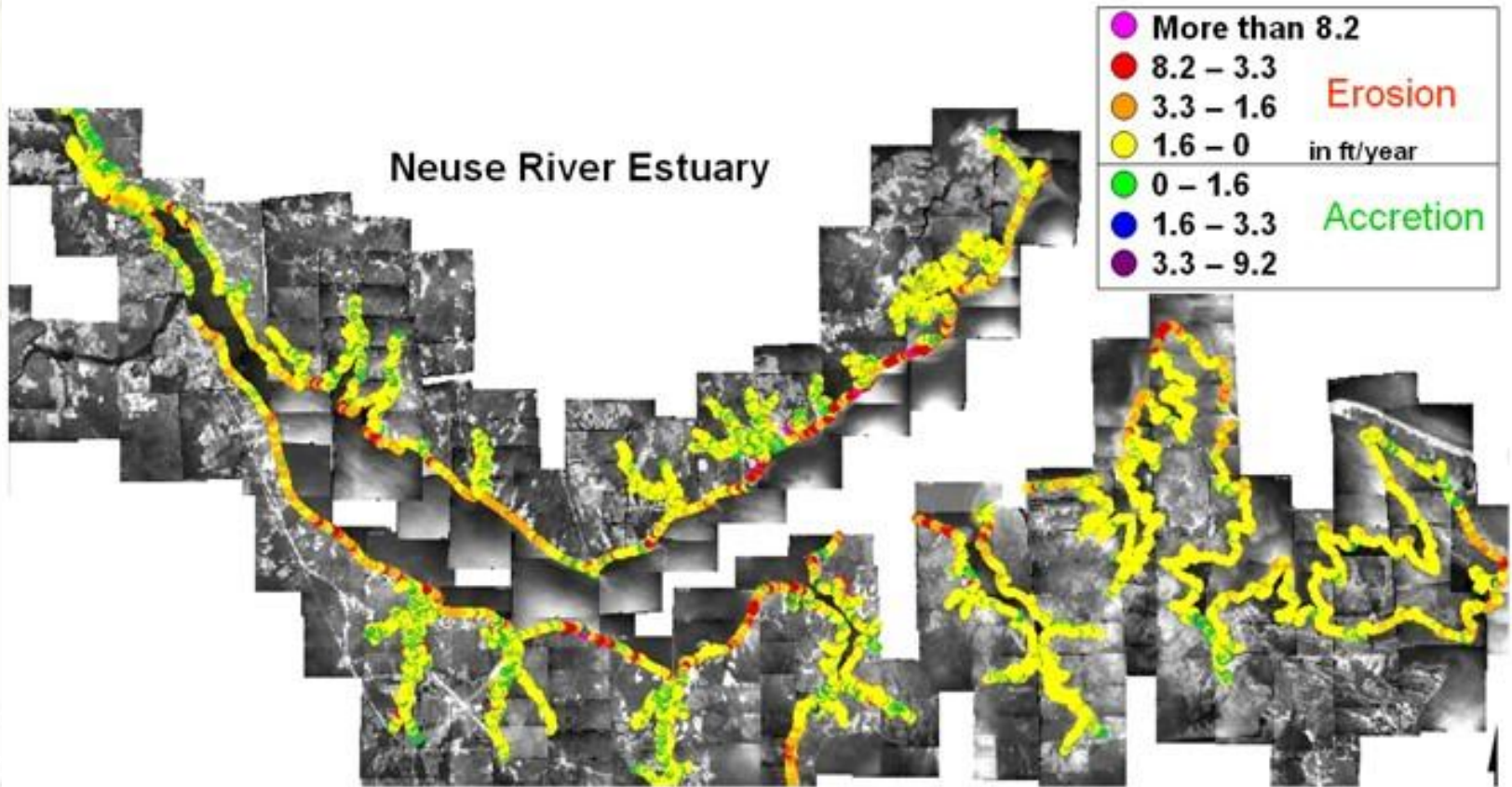
Relative Sea Level, 1953-2010

Station Number	Station Name	Mean RSL Trend (mm/yr)	Mean RSL Trend (inches/century)	Period of Data	Source
8651370	Duck	4.64 ± 1	18.3 ± 4	1978-2010	Zervas, unpublished
8652587	Oregon Inlet Marina	3.31 ± 1.65	13 ± 6.5	1977-1980, 1994-2010	Zervas, unpublished
8656483	Beaufort	2.61 ± 0.41	10.3 ± 1.6	1953-2010	Zervas, unpublished
8652587	Oregon Inlet Marina	2.82 ± 1.76	11.1 ± 6.9	1977-1980, 1994-2006	Zervas, 2009
8656483	Beaufort	2.57 ± 0.44	10.1 ± 1.7	1953-2006	Zervas, 2009
8651370	Duck	4.27 ± 1.45	16.8 ± 5.7	1978-2002	Zervas, 2004
8652587	Oregon Inlet Marina	2.55 ± 2.37	10.0 ± 9.3	1977-1980, 1994-2002	Zervas, 2004
8654400	Cape Hatteras	3.46 ± 1.47	13.6 ± 5.8	1978-2002	Zervas, 2004
8656483	Beaufort	3.20 ± 1.06	12.6 ± 4.2	1973-2002	Zervas, 2004

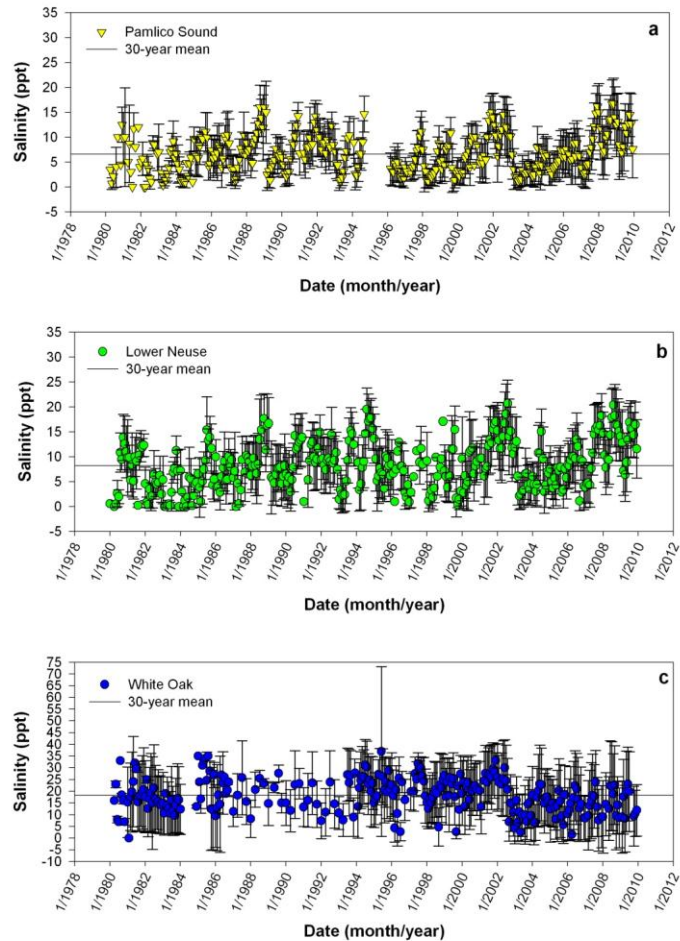
Ocean Shoreline Migration, 1996-2009



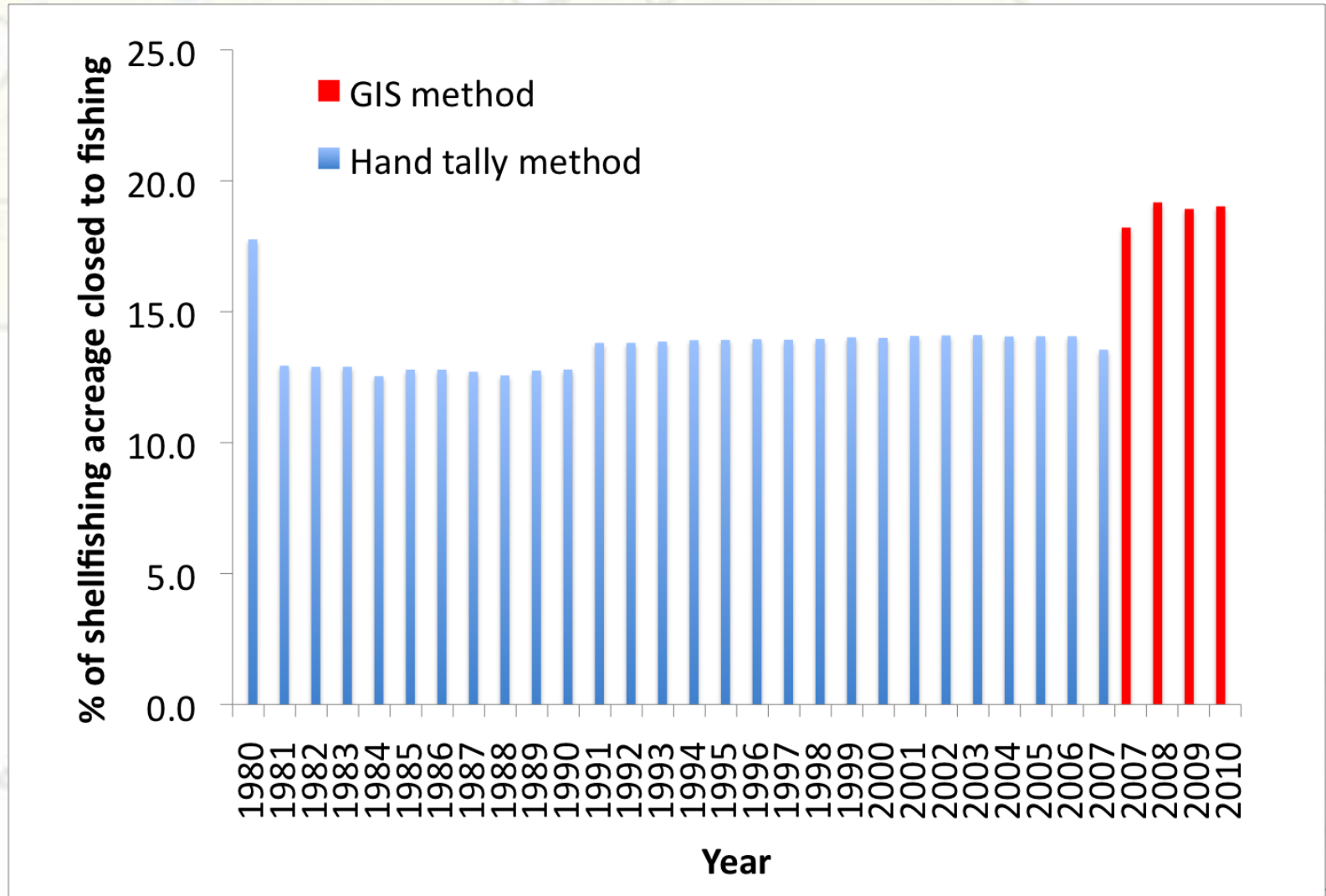
Estuarine Shoreline Migration: Neuse River Estuary, 1958-1998



Estuarine Salinity Concentration: West Pamlico Sound, Middle Neuse River, Water Oak River, 1980 - 2010



Shellfish Closures: % Area Closed, 1980 - 2010



Unusual Fish Mortalities and Disease Events: Fish Kills, 1996 - 2010

Year	Cape Fear				French Broad							White Oak		Annual Totals
	Broad	Fear	Catawba	Chowan	Broad	None	Lumber	Pasquotank	Roanoke	Tar/Pamlico	New/Watauga	Oak	Yadkin	
1996	None	21	None	2	None	14	4	10	2	3	None	3	1	60
1997	None	16	3	2	2	12	3	2	None	6	None	3	10	59
1998	None	23	1	1	3	8	5	8	1	5	None	1	2	58
1999	1	14	3	1	1	16	None	2	None	11	1	3	1	54
2000	None	12	2	None	None	23	2	None	None	14	None	3	2	58
2001	None	5	4	1	None	37	None	1	None	23	None	3	3	77
2002	None	8	1	2	1	9	None	6	None	8	None	3	8	46
2003	None	3	None	2	1	21	2	2	2	6	2	None	2	43
2004	None	1	None	1	None	8	1	None	1	2	None	None	3	17
2005	None	2	None	1	None	9	1	2	1	1	None	1	1	19
2006	1	5	2	None	None	10	2	None	2	2	None	None	1	25
2007	1	1	2	1	3	10	None	1	1	5	None	None	2	27
2008	None	10	2	2	2	21	None	4	None	16	None	None	4	61
2009	None	3	None	2	None	15	None	None	None	11	None	None	2	33
2010	None	7	5	1	1	2	None	1	None	1	2	1	1	22
Total	3	131	25	19	14	215	20	39	10	114	5	21	43	659

Steamflow: Neuse Basin, 1997 - 2008

Table 1. Mean annual flow and 95 percent confidence interval (in parentheses) for annual flow at 6 selected stations in the Albemarle-Pamlico Basin, 1997-2008
Spearman Rho Trend tested on 12 years of annual flow data. D=decreasing(alpha=0.05)

Station	Watershed	Flowtrend?	Flow(cfs)
Eno River Hillsborough	Neuse	D	31(35-75)
Little River Orange Fctory	Neuse	D	67.4(44.5-90.3)
Contentnea Cr Hookerton	Neuse	No	798 (537-1059)
Neuse River at Ft. Barnwell	Neuse	No	3879 (2845-4912)
Bear Creek Mays Store	Neuse	No	79.9 (50.7-109)
Trent River near Trenton	Neuse	No	191 (121-261)

Point Source Discharges, 1960 - 2008

Individual Permits	Major >= 1 MGD	Minor < 1 MGD	Method	Year	Literature Source for	Point Total N tons	Total nitrogen at New Bern in tons	Point Sources- Percent of Total N at New Bern
			PopTfactor	1960	Stanley92	1254	nd	nd
			PopTfactor	1970	Stanley92	1452	9594	15
			PopTfactor	1980	Stanley92	1617	4552	36
			PopTfactor	1986	Stanley92	1925	2656	72
169	30	139	ConXFlow	1990	DoddMcM1	1351	4931	27
	30		ConXFlow	1993	DWQ1993	1455	5817	25
168			ConXFlow	1995	DWQ2009	1199	7462	16
157	27	130	ConXFlow	2001	DWQ2002	683	2839	24
157	34		ConXFlow	2003	DWQ2009	649	6886	9
162	30	132	ConXFlow	2006	DWQ2009	425	4704	9
136	25	111	ConXFlow	2008	DWQ2009	297	3296	9

Riverine Transport of Nitrogen & Phosphorus: Neuse River Basin, 1997 - 2008

Total Nitrogen, phosphorus, and flow trends in AP area, 1997-2008											
Table 1. Total Nitrogen, phosphorus, and flow trends in AP area, 1997-2008											
Numbers in columns are as follows first number is the mean (12 years)											
and numbers in parentheses show the 95% confidence interval											
Trends tested with Spearman rho N=no trend; I=increasing; D=decreasing; alpha=0.05											
		Total Nitrogen			Total Phosphorus			Flow		Concentration	
Station	Basin	TNTrend?	TNLoad (tons)	TNYield (tpsm)	TPTrend?	TPLoad (tons)	TPYield (tpsm)	Flowtrend?	Flow(cfs)	TNTrend?	TPTrend
Eno River Hillsborough	Neuse	D	50 (28-72)	.77 (.43-1.1)	N	6.4(2.5-10.3)	0.10(0.04-0.19)	D	31(35-75)	N	N
Little River Orange Fctory	Neuse	D	69 (38-100)	0.86 (0.48-1.26)	N	8.18(4.34-12.02)	0.10(0.05-0.15)	D	67.4(44.5-90.3)	N	N
Contentnea Cr Hookerton	Neuse	N	894 (669-1118)	1.22 (0.91-1.52)	D	110(66.7-154.36)	0.15(0.09-0.21)	No	798 (537-1059)	N	D
Neuse River at Ft. Barnwell	Neuse	N	3942 (3063-4820)	1.01 (0.78-1.23)	N	430 (323-537)	0.11(0.08-0.14)	No	3879 (2845-4912)	N	N
Bear Creek Mays Store	Neuse	N	232 (147-317)	3.94 (2.50-5.38)	N	24.21(1.11-47.33)	0.41(0.02-0.80)	No	79.9 (50.7-109)	N	N
Trent River near Trenton	Neuse	N	208 (130-286)	1.25 (0.78-1.72)	N	21.9 (12.0-31.8)	0.13 (0.07-0.19)	No	191 (121-261)	I	D
		Significant at 5%									
		Significant at less than 1%									

Suspended Sediment: 48 Streams, 1980 - 1989

Table 2. Trend evaluation using Seasonal Kendall Tau on Suspended Solids data in 48 streams in Major Watersheds of the Albemarle-Pamlico Basin, 1980-89) from Harned et. al. (1995).

Watershed	Increasing	Decreasing	No trend	No data			
Roanoke	0	3	8	1			
Dan River	0	1	5	1			
Chowan	0	0	3	3			
Tar-Pamlico	0	1	6	1			
Neuse	1	3	7	4			
Total	1	8	29	10			



2013-2014 Albemarle-Pamlico Ecosystem Assessment Activities

- Publication of 2012 edition
- Management feedback on 2012 format
- Expand Phase 1 assessment content
 - Chapter: Forests, Farmlands, and Grasslands
 - Chapter: Urban and Suburban Landscapes
 - Additional indicator assessments
 - Refinement of 2012 assessments
- State of ecosystem report card
- Seek additional capacity



Longer-Term Albemarle-Pamlico Ecosystem Assessment Activities

- APNEP-oriented monitoring data
- “Beyond Condition”: Outcomes Phases 2 and 3
- “Beyond Outcomes”: Management actions and stakeholder understanding.
- Decision Support System
 - Citizens
 - Policy Makers
 - Environmental Managers
 - Environmental Scientists

Implementation Workgroups

- Freshwater Habitats & Fish Passage
- Policy & Economics
- Decision Support Tools
- Education & Engagement
- Water Quality Improvements
- Shorelines
- Contaminant Management
- Invasives
- Restoration Strategies
- Monitoring Networks
- Oysters
- Submerged Aquatic Vegetation
- Hydrologic Regimes
- Public Access

Seven Steps of APNEP's Ecosystem-Based Management

1. Articulate **program goals**
2. Develop **system level model** for goal attainment
3. Assess current management efforts –identify **gaps**
4. Develop **management strategy (CCMP)**
5. Develop **monitoring program**
6. **Assess** performance
7. **Manage adaptively**