South Carolina Department of Health and Environmental Control
Promoting and Protecting the Health of the Public and the Environment

Numeric Nutrient Criteria Development in SC Tidal Creeks and Estuaries

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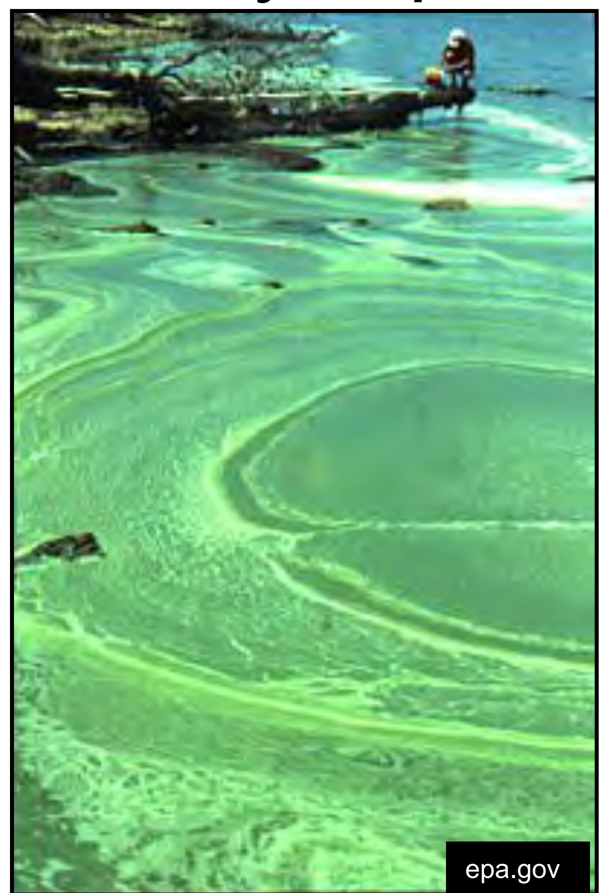
- Nutrients: TN & TP, considered by EPA as a leading cause of water body impairment



- EPA has requested that States develop NNC for all waterbodies
  - TN (causal)
  - TP (causal)
  - Chlorophyll a (response)
  - Turbidity (response)

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SC already has some numeric limits in place

- 45. Piedmont
- 63. Middle Atlantic Coastal Plain
- 65. Southeastern Plains
- 66. Blue Ridge
- 75. Southern Coastal Plain

Lakes over 40 acres

Shall not exceed

Ecoregion	Blue Ridge	Piedmont & SE Plains	Mid. Atlantic Coastal Plains
Chlorophyll a	10 µg/L	40 µg/L	40 µg/L
TP	0.02 mg/L	0.06 mg/L	0.09 mg/L
TN	0.35 mg/L	1.5 mg/L	1.5 mg/L

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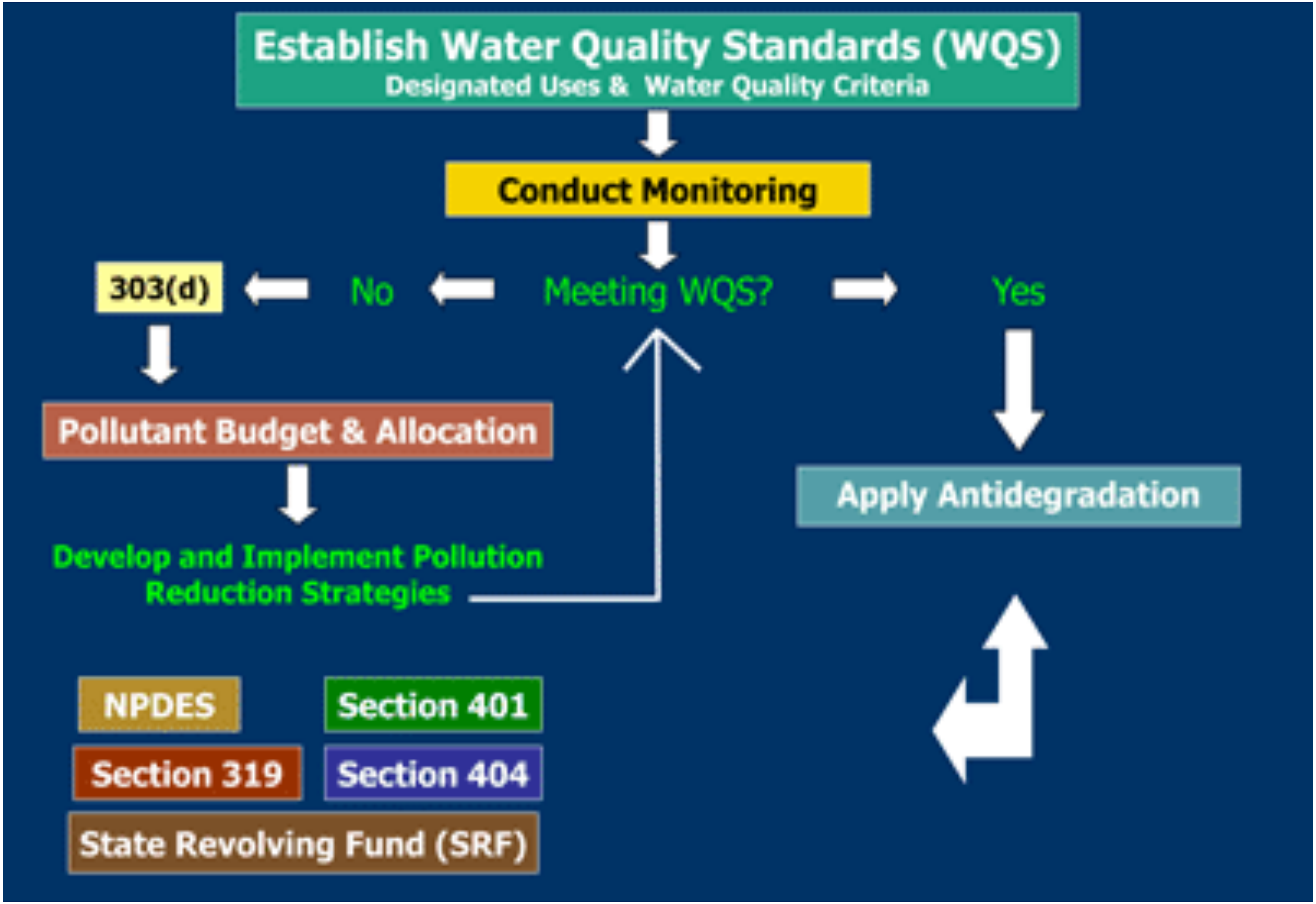
- South Carolina Turbidity criteria: 10-50 NTU

- South Carolina DO criteria: 4.0-6.0 mg/L


Establish Water Quality Standards (WQS)
Designated Uses & Water Quality Criteria
Conduct Monitoring
303(d)
No
Meeting WQS?
Yes
Pollutant Budget & Allocation
Apply Antidegradation
Develop and Implement Pollution Reduction Strategies
NPDES
Section 401
Section 319
Section 404
State Revolving Fund (SRF)

epa.gov

- Objectives of NNC Development in S.C.
  - Protect the physical, chemical and biological integrity of our waters
  - Identify waters not meeting their designated uses
  - Inform decision makers
  - Realistically attainable

- Database development:
  - Since May 2013, SCDHEC has complied a Coastal Nutrient Database
    - contains ~182,000 water nutrient records
    - 19,000,000 additional water quality parameters
    - 799 Sampling stations

- Database development: Data sources include:
  - DHEC's Ambient Water Quality Monitoring Program
  - NERRS Central Data Management Office
  - United States Geological Survey
  - Generous contributions by local scientists

- Estuary classification schemes:
  - S.C. coast has been subdivided using GIS software
    1. By estuary (15 total)
    2. Tidal creeks vs. open waters (>100m)
    3. Riverine vs. tidally dominated estuaries

- EPA Recommended approaches to Nutrient Criteria Development:
  - Reference condition approach
  - Data distribution approach
  - Predictive modeling approach

The reference condition approach

- North Inlet Estuary
  - Data rich
  - Yields highest correlation coefficients between causal and response variables
  - Chlorophyll *a*~TN=0.55
  - Chlorophyll *a*~TP=0.58
  - Low average chlorophyll a concentration across the growing season

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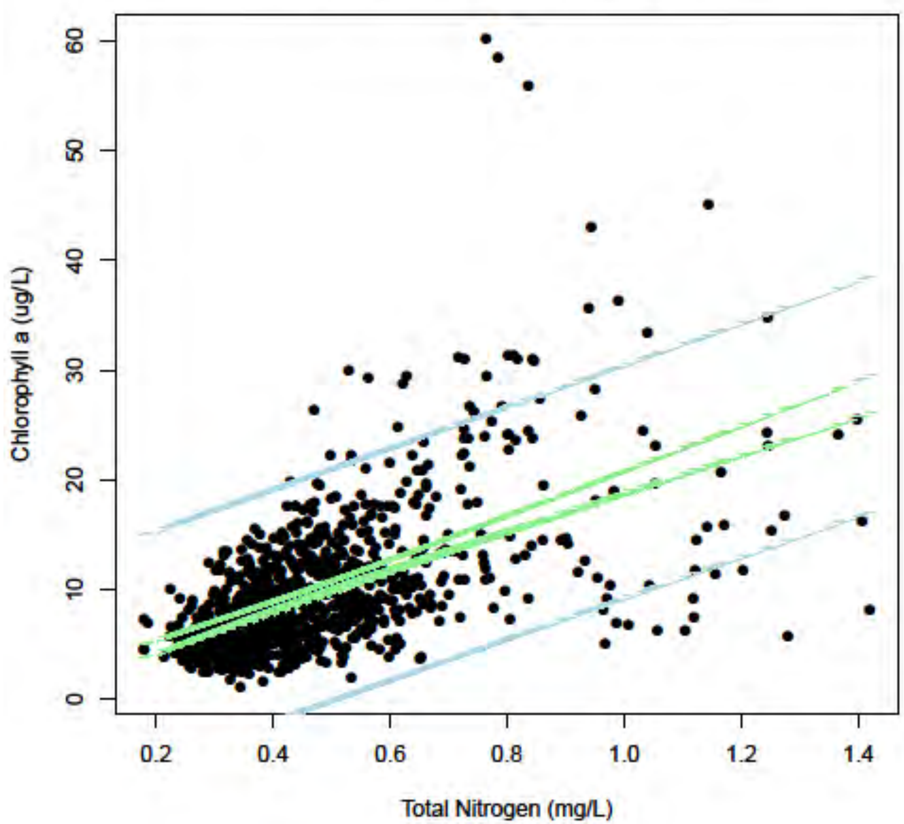
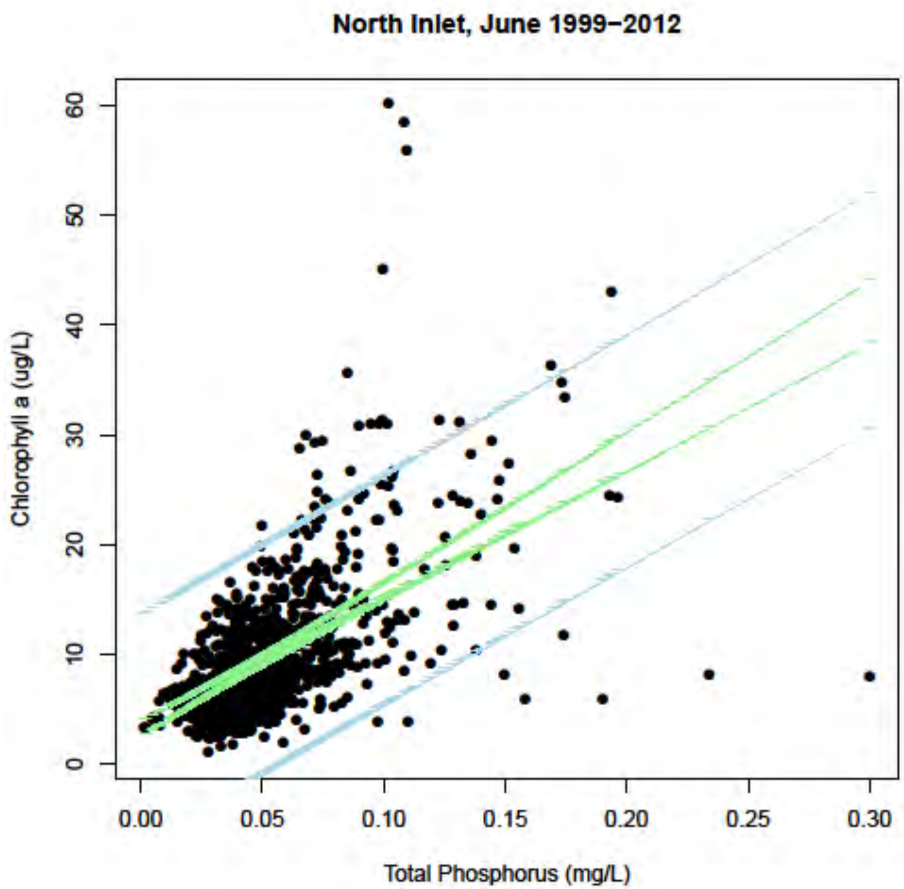
North Inlet, June 1999−2012




North Inlet, June 1999−2012
Chlorophyll a (ug/L)
Total Phosphorus (mg/L)
0
10
20
30
40
50
60
0.00
0.05
0.10
0.15
0.20
0.25
0.30

- The data distribution approach
- 75% and 85% percentiles
- Tidal creeks vs open waters
- By estuary
- Riverine vs tidally dominated estuaries

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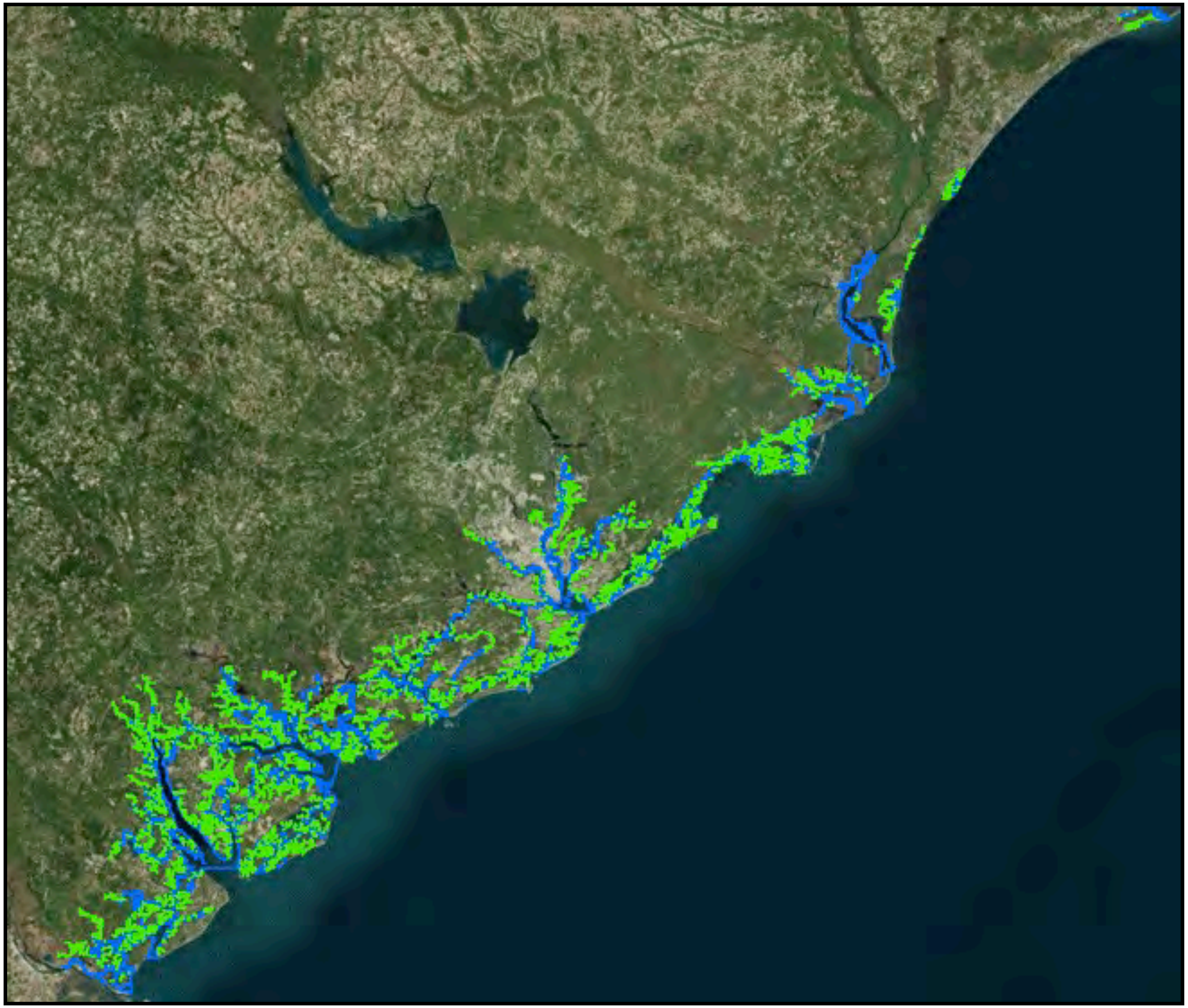
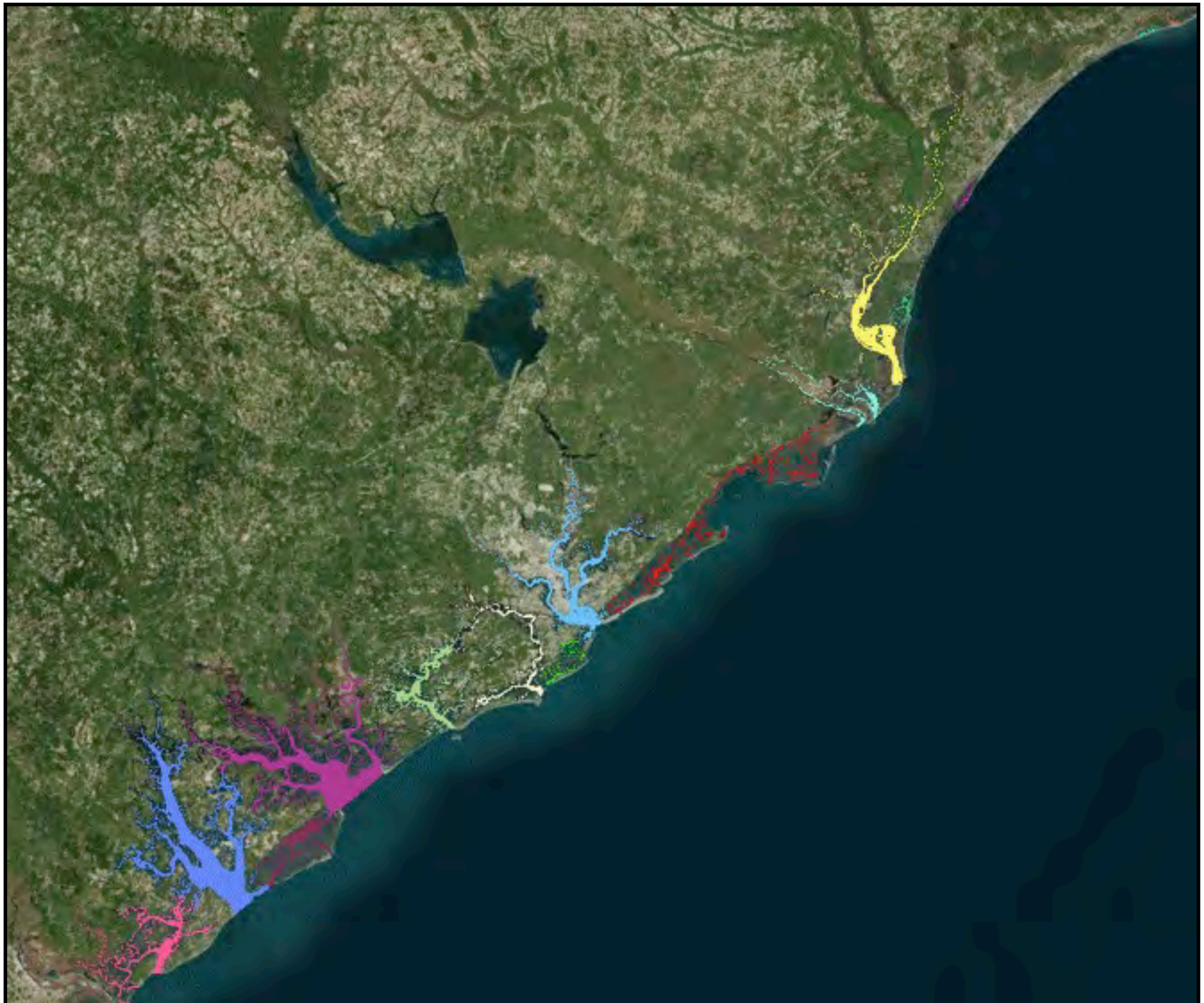


	75th Percentile/# of Samples			
Classification Scheme	**chl a (µg/L)**	**TN (mg/L)**	**TP (mg/L)**	**Turbidity (NTUs)**
Open Water Stations	12.0 / 3648	0.813 / 3962	0.0950 / 4634	17 / 4707
Tidal Creek Stations	10.0 / 5674	0.580 / 3415	0.0756 / 3816	20 / 2150
Tidal Estuaries T-Stat	9.34 / 4306	0.513 / 2275	0.0612 / 2500	21 / 671
Tidal Estuaries O-Stat	10.5 / 135	0.462 / 295	0.0690 / 506	21 / 565
Riv. Estuaries T-Stat	12.6 / 1368	0.816 / 1140	0.110 / 1316	19 / 1479
Riv. Estuaries O-Stat	12.3 / 3513	0.833 / 3667	0.0980 / 4128	16 / 4142

	85th Percentile/# of Samples			
Classification Scheme	**chl a (µg/L)**	**TN (mg/L)**	**TP (mg/L)**	**Turbidity (NTUs)**
Open Water Stations	18.1 / 3648	0.960 / 3962	0.125 / 4634	22 / 4707
Tidal Creek Stations	12.6 / 5674	0.720 / 3415	0.0960 / 3816	26 / 2150
Tidal Estuaries T-Stat	11.6 / 4306	0.580 / 2275	0.0728 / 2500	26 / 671
Tidal Estuaries O-Stat	11.5 / 135	0.589 / 295	0.0830 / 506	25 / 565
Riv. Estuaries T-Stat	16.3 / 1368	1.00 / 1140	0.140 / 1316	25 / 1479
Riv. Estuaries O-Stat	18.5 / 3513	0.971 / 3667	0.130 / 4128	21 / 4142



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	75th Percentile / # of samples			
Estuary Classification	**chl a (μg/L)**	**TN (mg/L)**	**TP (mg/L)**	**Turbidity (NTUs)**
SC	10.8 / 9376	0.700 / 7442	0.0860 / 8507	18 / 6924
Myrtle Beach	12.7 / 23	1.29 / 71	0.0890 / 73	14 / 94
Hog Inlet	- / 0	0.478 / 26	0.0670 / 44	13 / 46
Murrells Inlet	8.05 / 30	0.416 / 50	0.0580 / 79	14 / 89
Santee	17.4 / 103	0.645 / 187	0.0520 / 213	22 / 242
Winyah Bay	24.9 / 1461	1.08 / 1065	0.140 / 1079	17 / 489
North Inlet	9.18 / 3943	0.515 / 1920	0.0578 / 1929	12 / 34
Bulls Bay	11.9 / 250	0.532 / 365	0.0683 / 624	23 / 703
Charleston Harbor	11.1 / 285	0.655 / 1156	0.0885 / 1152	12 / 1429
Folly	10.2 / 59	0.380 / 92	0.0733 / 148	18 / 168
Stono	12.5 / 105	0.536 / 214	0.0790 / 304	18 / 378
Edisto	14.6 / 345	0.550 / 361	0.0740 / 423	22 / 516
ACE Basin	8.40 / 1848	0.738 / 788	0.110 / 949	23 / 1001
Frip	8.77 / 159	0.459 / 119	0.0925 / 182	18 / 196
Broad	8.87 / 532	0.560 / 563	0.0920 / 744	14 / 905
Hilton Head	11.2 / 224	0.530 / 404	0.0805 / 507	16 / 567

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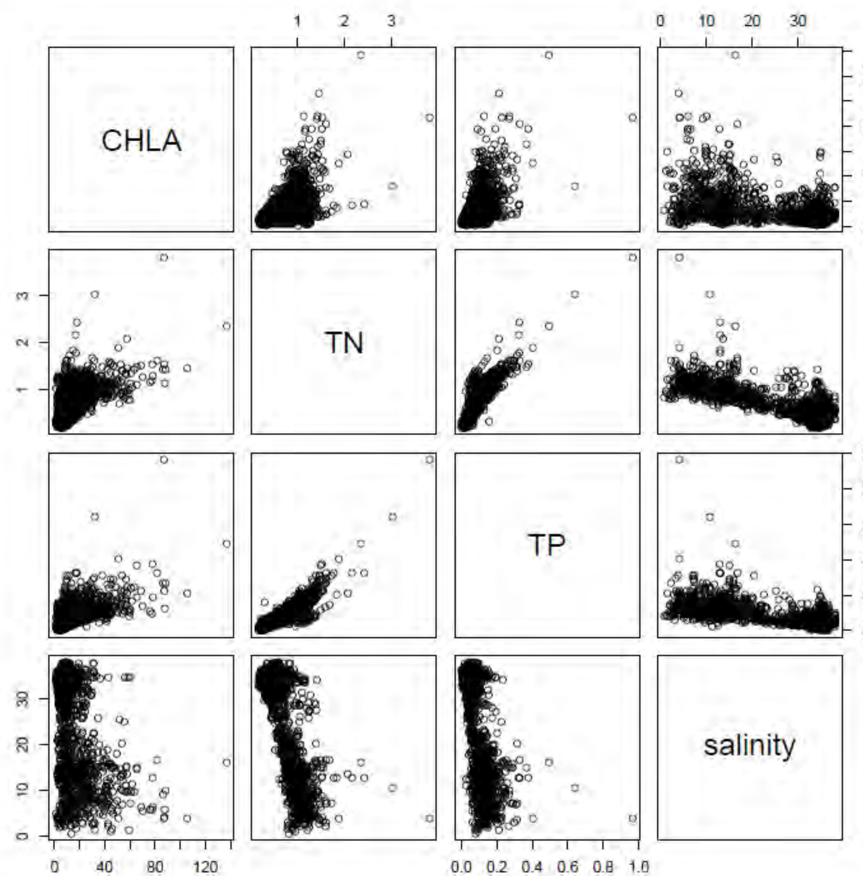
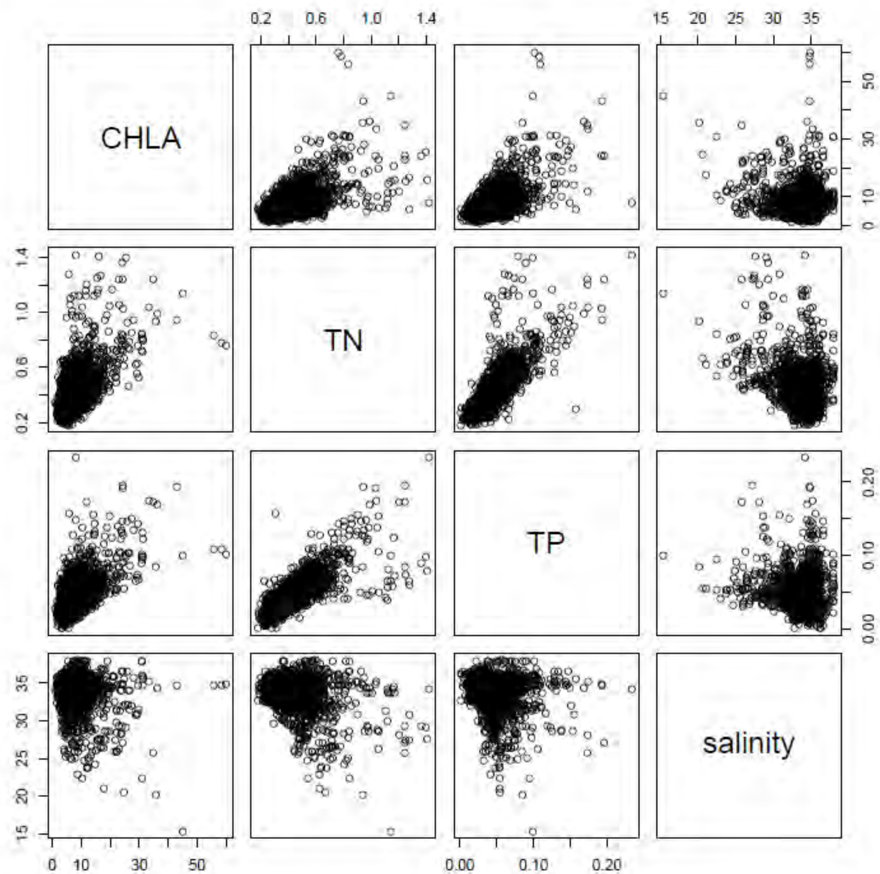
	85th Percentile / # of samples			
Estuary Classification	**chl a (µg/L)**	**TN (mg/L)**	**TP (mg/L)**	**Turbidity (NTUs)**
SC	14.3 / 9376	0.880 / 7442	0.110 / 8507	23 / 6924
Myrtle Beach	17.7 / 23	1.42 / 71	0.110 / 73	18 / 94
Hog Inlet	- / 0	0.530 / 26	0.0736 / 44	16 / 46
Murrells Inlet	9.45 / 30	0.493 / 50	0.0753 / 79	18 / 89
Santee	22.3 / 103	0.720 / 187	0.0620 / 213	27 / 242
Winyah Bay	33.4 / 1461	1.17 / 1065	0.165 / 1079	20 / 489
North Inlet	11.4 / 3943	0.577 / 1920	0.0682 / 1929	13 / 34
Bulls Bay	13.5 / 250	0.678 / 365	0.0810 / 624	28 / 703
Charleston Harbor	13.2 / 285	0.655 / 1156	0.140 / 1152	16 / 1429
Folly	13.6 / 59	0.454 / 92	0.0820 / 148	22 / 168
Stono	14.7 / 105	0.619 / 214	0.090 / 304	24 / 378
Edisto	20.2 / 345	0.670 / 361	0.0937 / 423	28 / 516
ACE Basin	10.9 / 1848	0.914 / 788	0.130 / 949	29 / 1001
Frip	11.5 / 159	0.522 / 119	0.110 / 182	23 / 196
Broad	10.3 / 532	0.710 / 563	0.120 / 744	18 / 905
Hilton Head	14.5 / 224	0.649 / 404	0.101 / 507	19 / 567

- Predictive modeling approach
  - Multiple linear regressions
  - Neural networks

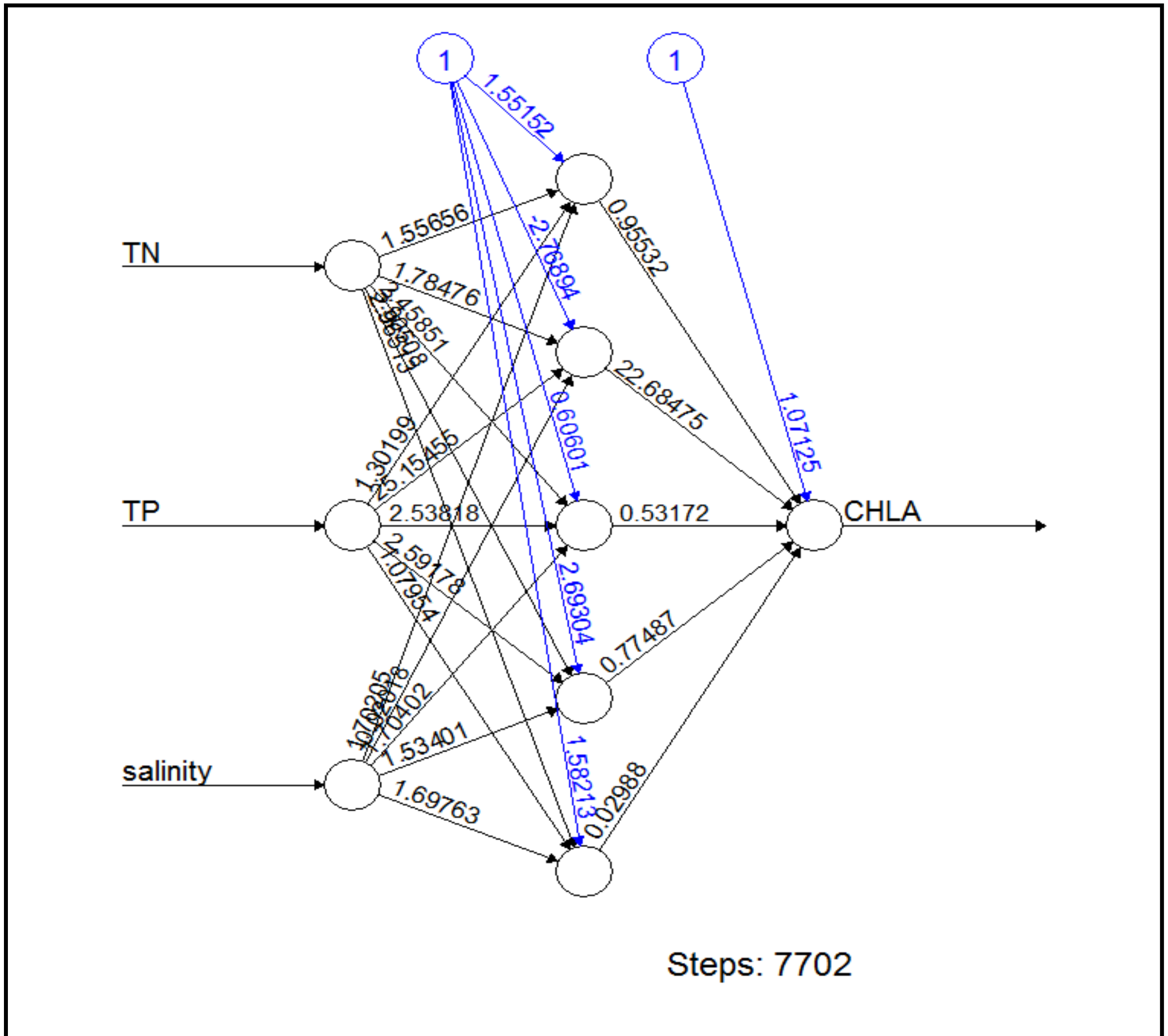
- All S.C. coastal data, May-October
- Correlation coefficients:
  - Chla~TN=0.618
  - Chla~TP=0.623
  - Chla~salinity= -0.506
- Median chla= 7.89 µg/L
- Median TN= 0.475 mg/L
- Median TP=0.0522 mg/L



- All S.C. tidal creek data, May-October
- Correlation coefficients:
  - Chla~TN=0.566
  - Chla~TP=0.596
  - Chla~salinity= -0.177
- Median chla= 6.87 µg/L
- Median TN= 0.410 mg/L
- Median TP=0.0439 mg/L



- Neural Networks (data driven models)
  - Observed data is employed to train the model
  - neural networks learn an approximation of the functional relationships between dependent and independent variables
  - Iteratively adapts its parameters to minimize model error
    - algorithm based on gradient descent


1
1
1.55152
-2.76894
0.60601
2.69304
1.58213
1.07125
TN
TP
salinity
CHLA
1.55656
1.78476
1.30199
25.15455
2.53818
2.59178
1.53401
1.69763
0.95532
22.68475
0.53172
0.77487
0.02988
Steps: 7702

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