APNEP Nutrients Workgroup Meeting[1]

Meeting No. 6 -- March 23, 2016

Attendees:

1. Ann Coan (Farm Bureau)
2. Bill Crowell (APNEP via phone)
3. Brian Pointer (DWR)
4. Cam McNutt (DWR)
5. Carrie Ruhlman (DWR)
6. Clifton Bell (Brown and Caldwell)
7. Connie Brower (DWR)
8. Dean Carpenter (APNEP)
9. Heather Patt (DWR via phone)
10. Jamie McNees (DWR via phone)
11. Jim Hawhee (DWR)
12. Jing Lin (DWR)
13. Marcelo Ardon (ECU)
14. Martin Lebo (AquAeTer)
15. Michelle Moorman (USFWS)
16. Mike Paul (Tetra Tech)
17. Pam Behm (DWR)
18. Rhonda Evans (EPA Region 4)
19. Sharon Fitzgerald (USGS)
20. Stacey Feken (APNEP)
21. Steve Kroeger (DWR)
22. Tiffany Crawford (EPA Headquarters via phone)
23. Vince Bacalan (EPA Headquarters via phone)

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[1] Meeting notes complied by Steve Kroeger and Jim Hawhee. Numbers in parentheses correspond to hours, minutes and seconds on one of two recordings (Morning, Afternoon).

1. Overview of Tetra Tech report "Albemarle Sound Classification and Analysis conducted under the Nutrient Scientific Technical Exchange Partnership Support (N-STEPS)"

Presentation by: Mike Paul, Tetra Tech

1.1. N-STEPS

- N-STEPS is an EPA program through which states can have their technical support documents reviewed, and support can be provided to states for data analysis, statistical analysis, water quality modeling, literature review, etc.
    - NSTEPS projects for North Carolina
        - First project was analysis of lakes data (2014)
        - Additonal project was to look at data from Albemarle Sound to form background on classification

1.2. Classification

- Classification[2] - An important step in developing nutrient criteria
- Classification reduces natural variability due to landuse, geology, hydrology, climate, etc.
- Classification also reduces variability in response of a system to nutrient enrichment.
    - Responses can vary in different systems due to cofactors such as turbidity, pH, fauna.

- Factors that influence classification include:
    - Water residence time
    - Watershed area
    - Verticle mixing
    - Stratification
    - Wave exposure, etc.

- A priori classification
    - EPA's guidance document (Chapter 3) uses the factors to suggest classifications on
        - Geomorphology
        - Hydrology
        - Habitat
    - A priori classificaitions are best applied when there are multiple water bodies being classified; not readily applied when there is a single estuary (i.e. Albemarle Sound)

1.3. Albemarle Sound - Sample Frame

- First step – define the area of interest
    - Class S waters
    - Orignally included adjacent sounds, e.g. Currituck Sound, Roanoke Sound, Croatan Sound – later rejected since these areas were different based on phytoplankton, water chemistry.

[2] Mike Paul makes reference to EPA's Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Waters, avialble here: https://www.epa.gov/nutrient-policy-data/nutrient-criteria-technical-guidance-manual-estuarine-and-coastal-waters

- Water chemistry and phytoplankton data served as basis for classification. These data were provided by the NC Division of Water Resources.
    - 20 sites within the Albemarle Sound proper
    - 37 sites in adjacent SB and SC waters.
- "River sites" refer to the tributaries. "Rivers-sites" is a misnomer and not intended to imply the areas have a freshwater classification. They are the side embayments to Albemarle Sound (making referece to Alligator R., Perquimans R., Little R., North R., Yeopim R; see: Figure 2. Maps of Albemarle Sound Focus Area, page 9)

1.4. Statistical classification based on water chemistry and chlorophyll-a

- Descriptive statistics: univariate and multivariate
- TREED regression used to determine if thee are functional differences
- Phytoplankton – multivariate analyses were used to see if biology can show any patterns

1.5. Multivariate Classification - Water chemistry differences

- Multivariate analyses are like a map.
    - Points close to one another have similar water chemistry
- Results color coded:
    - Open sound sites vs those in side embayments ("river sites")
    - < 1 meter vs . 1 < depth < 3 meter vs > 3 meter
- You look for spatial patterns in multivariate analyses

Questions and comments on the spatial scale.

- Sound sites have higher salinity, pH, lower total nitrogen (TN), lower total phosphorus (TP)
- Embayment sites have higher nutrients, lower salinity

Comments

- Dean Carpenter: The color (dark blue) of the sounds sites may be masking embayment sites under the sound sites. Dr.Paul agreed and commented that the embayment sites under the sound sites may be on the edge of the embayments.

- Jing Lin: comments on the x- and y-axes. The x-axis reflects a salinity nutrient gradient, whereas the y-axis reflects a turbidity gradient; is there more variation in salinity and nutrients for the river than the sound. Dr. Paul thought it was safe to interpret that river and sound sites have comparable variability in DO and turbidity, wheresas the river sites have greater variability in salinity and nutrients.

1.6. TREED Regression

- TREED regressions is a child of classification and regression trees (CART)
- In traditional CART groups are determined by statistical similarities among the groups. One attempts to minimize differences between means, or deviations between two groups.
- TREED regression separates sites based upon functional differences.
- TREED regressions in the report are based on functional relationships between TN and chlorophyll and TP and chloropyll a.
- Varialbles that separated similar nutrient-chlorophyll responses were salinity, temperature and maximum depth.

Steve Kroeger placed this graph in this meeting summary to illustrate a TREED regression:

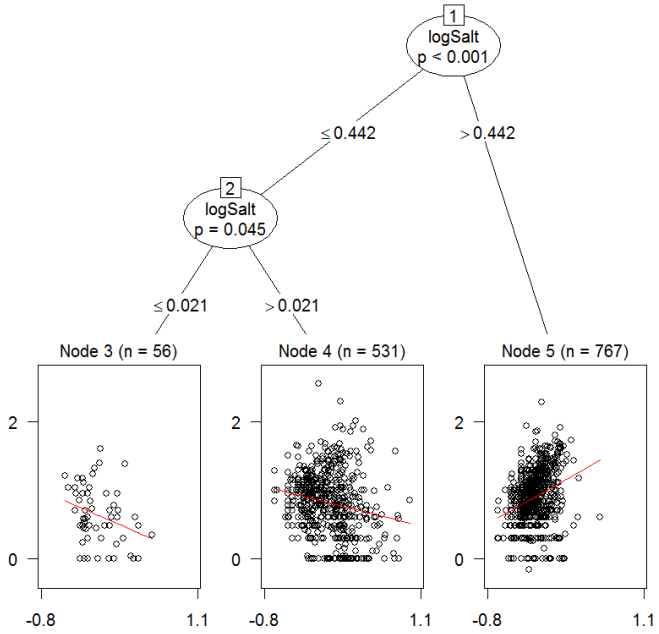


Figure 1. TREED regression of chlorophyll-a as a function of TN concentration using log-transformed salinity (this is Figure 4 in the Tetra Tech report**)**

Note there are two major groups: Group 1 denotes (3 and 4) and Group 2 is Node 5. These two groups break when when salinity is 2.8 ppt. ($2.8 \text{ ppt} = 10^{0.442}$ -note that salinity in the graph was log transformed). There is a positive relationship (slope of red regression line) between TN (x-axis) and chlorphyll-a (y-axis) when salinity is greater than 2.8 ppt.

Summary of TREED Regressions:

- Salinity: Positive relationship between chlorophyll-a and TN in higher salinity waters. No or perhaps negative relationship between chlorophyll-a and TN in lower salinity waters. Steepest (positive) relationship between chlorophyll-a and TP in higher salinity waters, but lower salinity sites also have positive relationships between chlorophyll-a and TP.
- Temperature: Warmer waters (or seasons) have steeper relatioshipships between chlorophyll-a and nutrients (TN and TP). This is likely a seasonal classification, not spatial.
- Water depths: Samples from the medium depths were associated with the strongest chlorophyll responses to TN and TP than the shallowest (<0.2m) and the deepest areas.
- When samples were coded as either river or sound, Sound samples had a steeper, positive response to TN and a negative response to TN, whereas the River samples had a steeper, positive response to TP than the Sound sites**.**

Question –

- Marcelo Ardon – *What are the salinity units in ppt?*

Answer – units were ppt, and log-transformed.

Why were the breaks in salinity in the TREED regressions different for TN and TP? For TN the first break was 0.4, whereas for TP the breaks was 0.29 (not a big difference).

Answer – Dr. Paul does not know why there were differences in the salinity breaks between TN and TP, but these breaks are subtle, and were based on statistics, not ecology.

1.7. Analysis of Phytoplankton Data

- Used Nonmetric Multidimential Scaling (NMS- an ordination method used to make a "map". Results close to one another have similar species composition).
- NMS of the samples revealed changes in algal species composition between the sound proper and side embayments. These may be due to changes in salinity and pH.

1.8. Summary of Classifications

- The classifications support an open sound and embayment (river) separation. This is due to differences in water chemistry, phytoplankton and some functional differences in nutrient-chlorophyll relationships.

1.9. Descriptive statistics on classifications (sound vs. embayment).

- Frequency distributions were summarized using cumulative distribution functions and box and whisker plots.
    - Results:
        - Nutrients higher in rivers than sound
        - Chl-a concentrations are similar
        - Secchi depths slightly higher in sound
        - DO higher in sound
        - Turbidity similar

1.10. Exploratory Analysis - Stressor-Response (nutrient vs chlorophyll-a)

- Exporatory stressor-response relationships were examined using linear regression between log transformed data for TN, TP, chlorophyll-a. Dissolved oxygen values were not log transformed.
- Two averging techniques were used: 1) long term averages of all samples for a site (Figures 15 and 16 in the report) and 2) annual averages of samples for each site (Figures 17 and 18 in the report).
- Grab sample pairs were not used in the regressions because that would overweight sites that have more samples. Dan Conley[3] has looked at various averaging methods and how those affect relationships between causal and response variables. Site year averages work well.
- Jing Lin asks a question on the differences between TREED analysis and stressor-response graphs. Subsequent discussion addressed that each approach used different summaries of the data: TREED analyses used data-pairs whereas the regressions used two averaging approaches: 1 - long-term site averages and 2 - site-year averages. A summary of the results from these approaches is in the table below:

	Chl-a and TN	Chl-a and TP	DO and TN	DO and TP

[3] http://lucci.lu.se/people_conley.html

Regressions				
Long term avg.				
All sites	0	0	—	—
Sound sites	0	0	0	0
River sites	0	+	—	0
Site year avg.				
All sites	0	0	—	—
Sound sites	+	0	—	—
River sites	0	+	+	+
TREED			No TREED analyses were completed with dissolved oxygen	
Salinity > 2.8	+	+		
Salinity < 2.8	—	+		

0 = no relationship; + = positive; — negative; Chl-a and DO were response variables. TN and TP were causal variables.

1.11. Albemarle NSTEPS Report - Summary

- Sound vs. adjacent embayment classification seems defensible based on water chemistry and biology (phytoplankton).
- Nutrient concentrations vary by these two classes (sound vs. embayment) but chorophyll-a does not.
- Functional differences exist in terms of preliminary stressor-response relationships
  - Chla increases to TP in adjacent embayments (rivers).
  - DO declines to both TN and TP in adjacent embayments, increases in sound

1.12. Questions and Discussion

- Clifton Bell: - Results showed increasing DO with increasing salinity – why?; MP not sure why. Perhaps organic loads being differenent between embayments and sound; BOD and SOD may be factors as well. Jing Lin -- asks about oxygen saturation, and Dr. Paul thought doing an analysis by saturation is a good idea.
- Jim Hawhee – Correlation is something to be considered. What are the rho values on the linear regression plots? What do these mean? Dr. Paul – rho values describe the spread of data along the regression line. Rho values range from -1 to 1. Zero represents no correlation.
- Clifton Bell - Correlations do not imply cause and effect. Dr. Paul field data will never confirm cause and effect.
- Sharon Fitzgerald - One way to reduce variability is to include seasonality.
- Martin Lebo - One pathway not shown are internal sources. The embayments receives freshwater with draingages with low DO, colored waters, and small cities in the watersheds. You would expect low DO and higher nutrients from these sources.
- Marcelo Ardon - taking a step back, results are consistent with the literature

- Sharon Fitzgerald --- Discusses the Redfield ratio and identifying limiting nutrients. Dr. Paul mentions a paper[4] by Bill Lewis and Wayne Wurtsbaugh.

2. Housekeeping

Jim Hawhee asked the group members to introduce themselves. He then covered a number of housekeeping items, including revisitation of the ground rules agreed upon by the group during 2014.

3. North Carolina's assessment methods

Cam McNutt, DWR Modeling and TMDL Unit

- Water quality assessment methods are used to determine whether or not surface water bodies are meeting water quality standards.
- Assessment methods are approved by the Environmental Management Commission (EMC), not the U.S. Environmental Protection Agency (EPA).
- Standards are approved by the EMC, not the EPA.
- EPA can add sites to 303(d) list
- There are five assessment categories: 1 through 5. Category 5 is where sites are placed that are not meeting water quality standards, and is referred to as the 303(d) list or impaired water body list.
- Five 303(d) assessment methods:
    1. Numeric (physical/chemical parameters such as chlorophyll-a)
    2. Biological (communities of bethos or fish)
    3. Pathogen
    4. Shellfish harvesting
    5. Fish consumption
- Numeric
    - Written as for results “not to exceed” a numeric standard
    - EPA allows for some exceedances (10%)
    - 10% exceedance with 90% confidence is the standard North Carolina uses.
    - The 2016 Category 5 list contains sites not meeting standards for copper, DO, turbidity, Ph (low and high), and chlorophyll a.
- Biological Assessment Methods
    - Fair, Poor or Severe biological rating -- Cat 5
    - 339 benthic impairments
- Pathogen
    - 5 samples in 30 data (geomean >200; or more that 20% exceeding 400)
- Shellfish
    - Based on Division of Marine Fisheries growing area
    - 565 areas exceeding shellfish harvesting criteria
- Fish consumption
    - Advisory by Department of Health and Human Services (DHHS)
    - Fish tissue data present
- Changes from 2014 include new additions like 21 benthic sites (many are from RAMS)

[4] Control of Lacustrine Phytoplankton by Nutrients: Erosion of the Phosphorus Paradigm: http://onlinelibrary.wiley.com/doi/10.1002/iroh.200811065/abstract

During the discussion, Cam clarified how clarity and turbidity assessments were conducted (just turbidity/TSS, no use of light meters). It was asked whether EPA accepts TMDLs when exceedance criteria are not written into code, i.e., duration and frequency components that are part of the assessment methodology. They do. Also asked was whether any temporal or spatial averaging was done for the parameters for which we have standards (chlorophyll a, pH, turbidity…)? Not presently. Vertical averaging also asked about. Calculations based on surface sampling.

4. North Carolina's estuarine monitoring methods

Brian Pointer, DWR Water Sciences

- Statewide the ambient monitoring systems has 318 stations. These are mostly streams with monthly monitoring, most sites have a long period of record.
- 110 sites have data since 1968
- Albemarle Sound monitoring conducted by Washington Regional Office (WARO). At one time there were 8 people conduding monitoring; now there are 3.
- Sample collection methods include road crossings for streams and estuarine stations sampled via boats. Photic parameters: integrated sampling 2x Secchi depth
- 61 sites are sampled by WARO

During discussion, it was asked to what level phytoplankton are classified. Generally, as specific as possible, often to the genus level. The history of the phytoplankton monitoring program, beginning in the Chowan River basin, was discussed. It's becoming more important to understand species composition in relation to chlorophyll a, including its spatial extent.

LUNCH

5. Spatial Extent of Albemarle Sound

Jim Hawhee; **See *Figure 2*; page 9**

Jim discussed the need for clarity regarding the spatial area to which recommendations would apply. Handouts for this meeting include a map ("Albemarle Sound: Designated Uses") which was developed as part of discussions in 2014. The 2014 map differs from the map on page 5 in the Tetra Tech report "Albemarle Sound Classification and Analysis conducted under the Nutrient Scientific Technical Exchange Partnership Support (N-STEPS)" (March 14, 2015). There are two noteworthy differences between the maps. The 2014 map does not distinguish waters classified as SB between "rivers" and Albemarle Sound proper. Additionally, the western boundary in the Tetra Tech report is a few miles east from the boundary in the 2014 map. Jim states the map in the Tetra Tech report is the one to use as a common reference for the development of nutrient criteria.

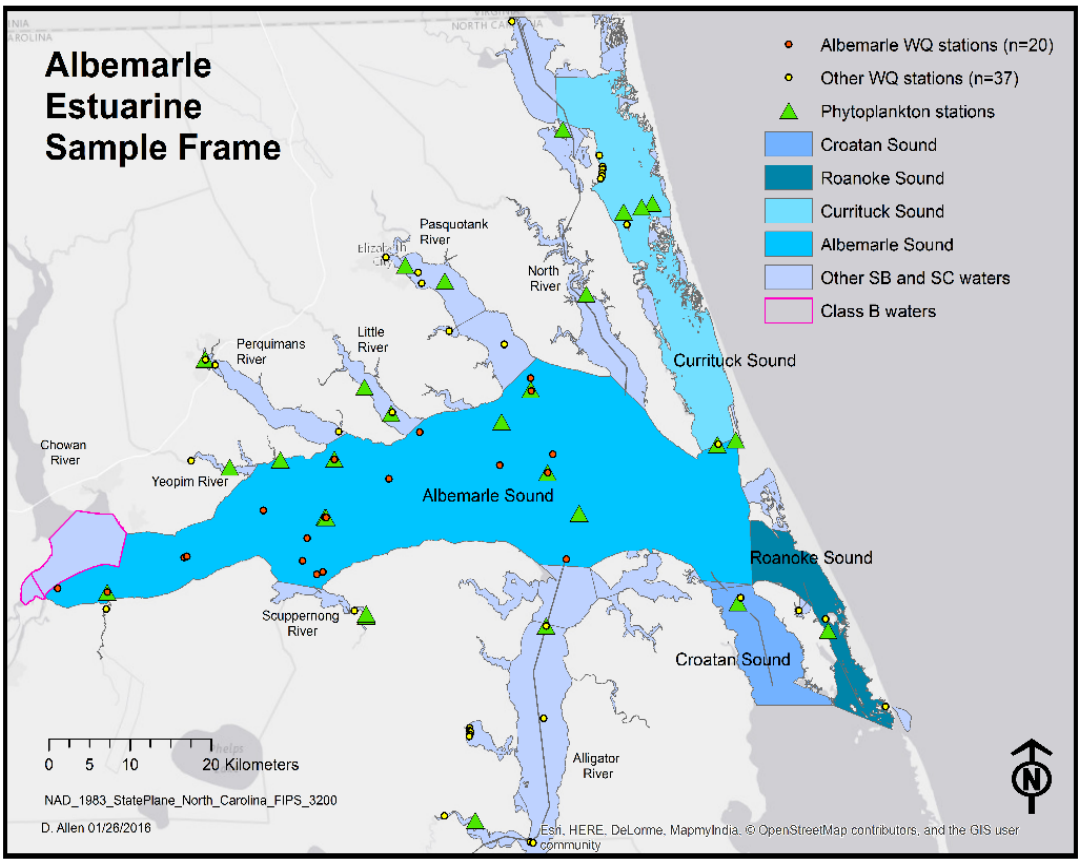


Figure 2. Maps of Albemarle Sound Focus Area
Top: 2014 Map. Bottom: Map in Tetra Tech report

Discussion focued three items:

1. SB is a primary recreation classification: Connie Brower noted that the SB classification is for primary recreation; Jim Hawhee replies that the workgroup, in its intial discussions, focused on the extent of the waters delineated by the SB classification and not on its use as primary recreation.
2. Does the study area include the tributaries/embayments? Various workgroup members discuss whether or not the study area extends into the tributaries or whether the focus is on Albemarle Sound proper. Anne Coan, Martin Lebo and Jing Lin note that there will be differences in water quality in the tributaries than the sound (e.g. fresher water). Jim replies that whether or not to include the tributaries/embayments in their recommendations is up to the workgroup.
3. Does the study area include other sounds, e.g. Currituck Sound, Roanoke Sound, Croatan Sound? No.

6. Proposal and discussion of path forward to conclude Phase I.

Jim asked the group to take about 5 minutes and look through 3 pages that were provided: 1) timeline, 2) suite of information that can be provided by the DWR dataset, 3) individual recommendation worksheet (strawman proposal) proposed for use to recommend appropriate response parameters and causal criteria.

After reviewing the materials provided, workgroup members offered a number of observations. Concerns were expressed in proposing both response and casual parameters simulataneously, as casual recommendations might hinge on a consensus recommendation for response parameters. Also, group members discussed a preference to discuss ecological goals, targets, and the current condition of Albemarle Sound before proceeding with recommendations. A plan for proceeding was discussed, with separate meetings planned to discuss Albemarle Sound ecology, response criteria recommendations, and causal criteria recommendations. Amendments to the draft criteria recommendation worksheet were also discussed. SAV ecology and extent, fisheries, and algal species information were among the detailed information requested by the workgroup.

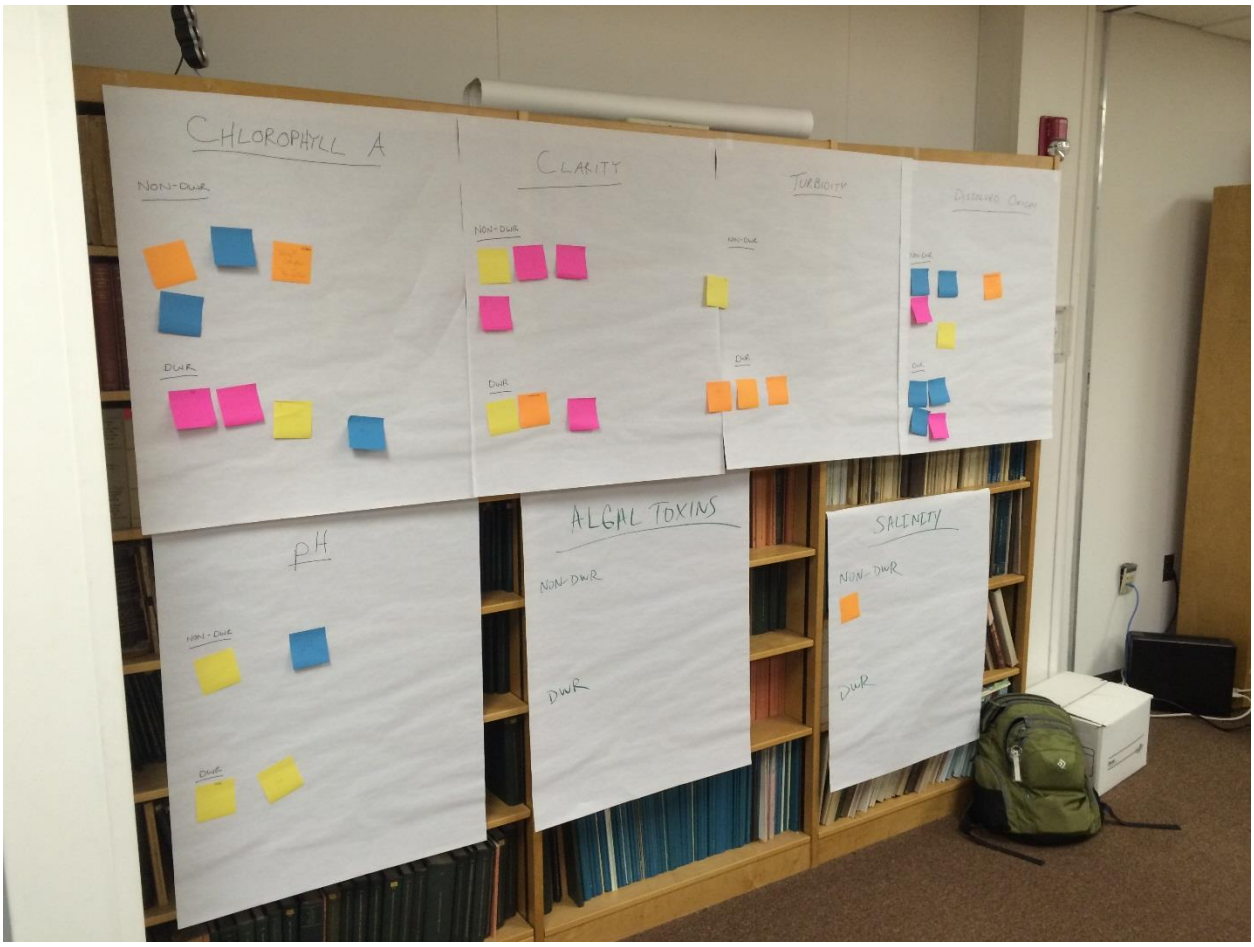
7. Discussion and prioritization of response parameter for further investigation

(Prior to the meeting, workgroup members were asked to complete a worksheet on which they were instructed to "preliminarily rank which response parameters you think have the best potential for criteria development in Albemarle Sound." Responses were compiled, organized by rank, and provided to the group to facilitate discussion during this exercise.)

Before the nonbinding ranking exercise, workgroup members were asked to review all responses and offer comment to the group. The ranking and relative values of various response parameters were discussed. Dissolved oxygen was discussed as it relates to fish survival and the oxygen requirements of various organisms. It was also noted that Albemarle Sound is less stratified than other systems and that wind mixing and temperature appear to have a large influence on oxygen levels.

After some further discussion, workgroup members were asked to place sticky notes on hanging sheets of paper to indicate their prioritization of response parameters. Blue sticky notes indicated the first

priority (blue ribbon), pink indicated second priority (red ribbon), yellow indicated third priority (bronze medal), and orange indicates other parameters of interest (honorable mention). Prioritization was also noted between DWR and non-DWR staff.



In roughly descending order of priority, the compiled results were as follows:

Dissolved Oxygen
Non-DWR: 2 first place, 1 second place, 1 third place, 1 honorable mention
DWR: 3 first place, 1 second place

Chlorophyll a
Non-DWR: 2 first place, 2 honorable mentions
DWR: 1 first place, 2 second place, 1 third place

Clarity
Non-DWR: 3 second place votes, 1 third place vote
DWR: 1 second place, 1 third place, 1 honorable mention

pH

Non-DWR: 1 first place, 1 third place
DWR: 2 third place

Clarity/Turbidity (on the line)
Non-DWR: 1 third place
DWR: 1 honorable mention

Turbidity
DWR: 2 honorable mention

Salinity
Non-DWR: 1 honorable mention

Algal toxins
No votes

8. Housekeeping and adjournment

Jim asked for follow-ups regarding workgroup members interested in a field trip on Albemarle Sound coordinated by APNEP, with some members indicating an interest.