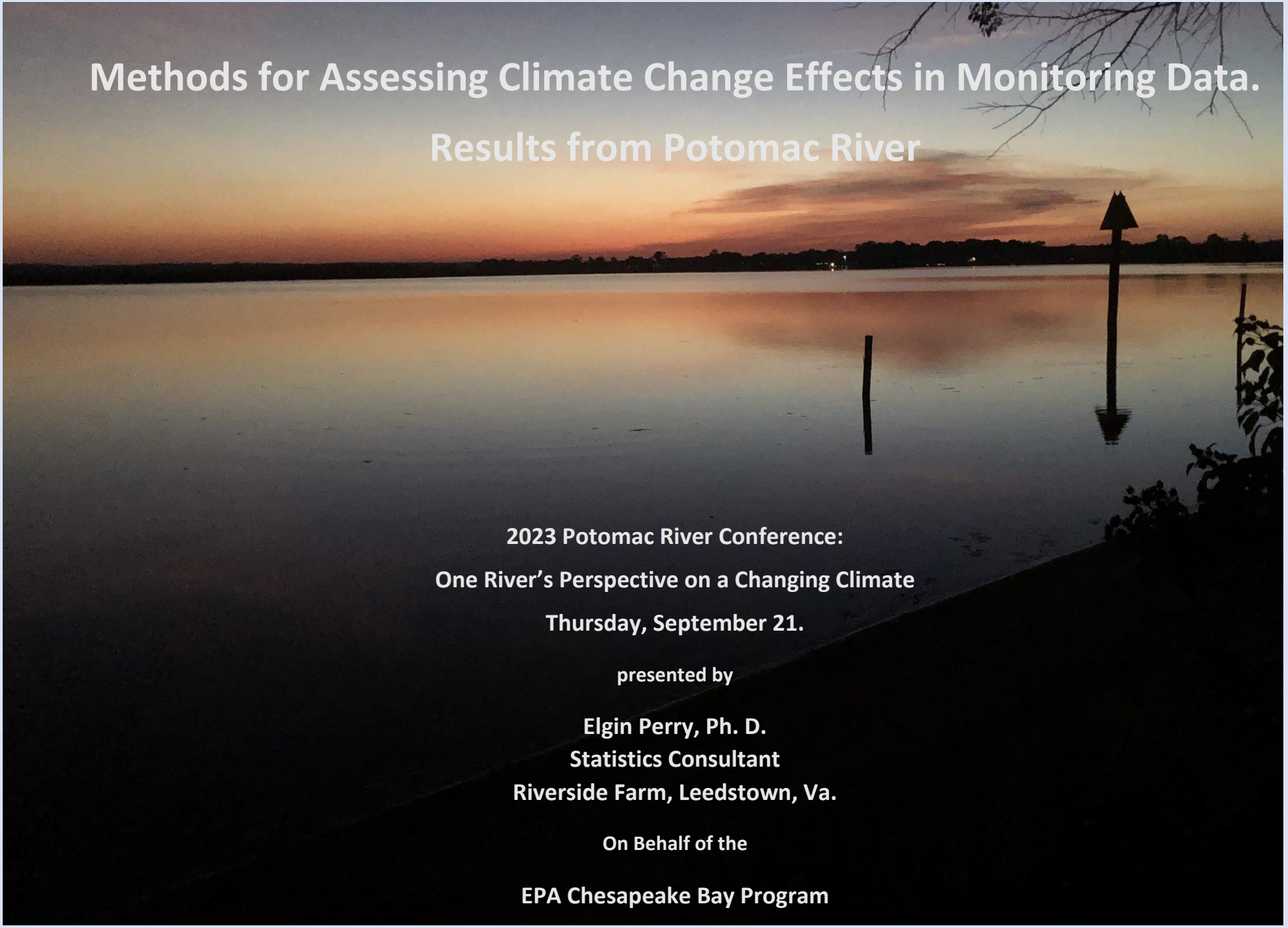


Methods for Assessing Climate Change Effects in Monitoring Data.

Results from Potomac River

2023 Potomac River Conference:

One River's Perspective on a Changing Climate

Thursday, September 21.

presented by

Elgin Perry, Ph. D.
Statistics Consultant
Riverside Farm, Leedstown, Va.

On Behalf of the

EPA Chesapeake Bay Program

Road Map:

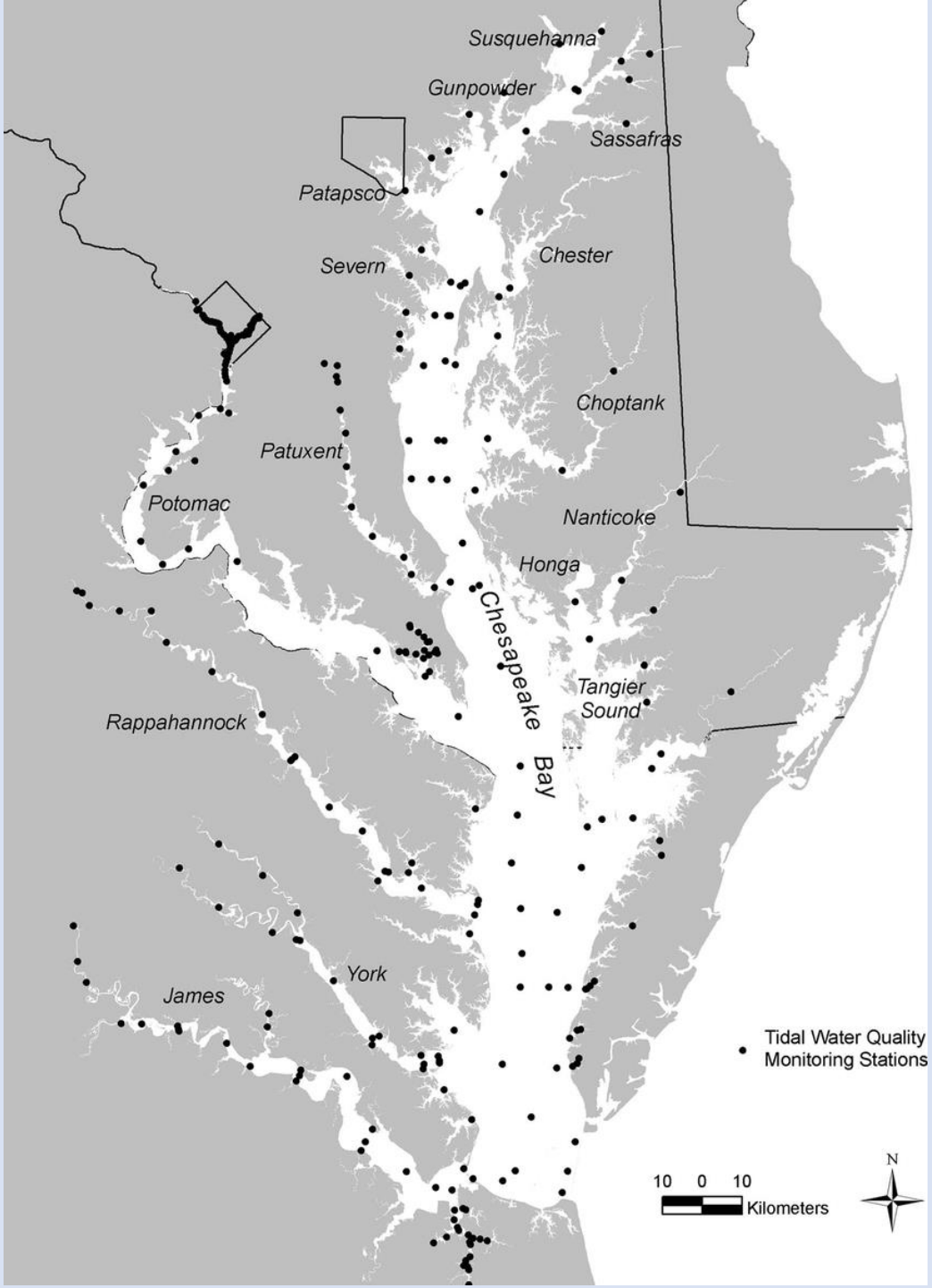
1. Quick Introduction to CBP trends package *baytrends* methods and results.

2. Motivation for applying Cluster Analysis to *baytrends* results

3. *Baytrends* Cluster Analysis Methods

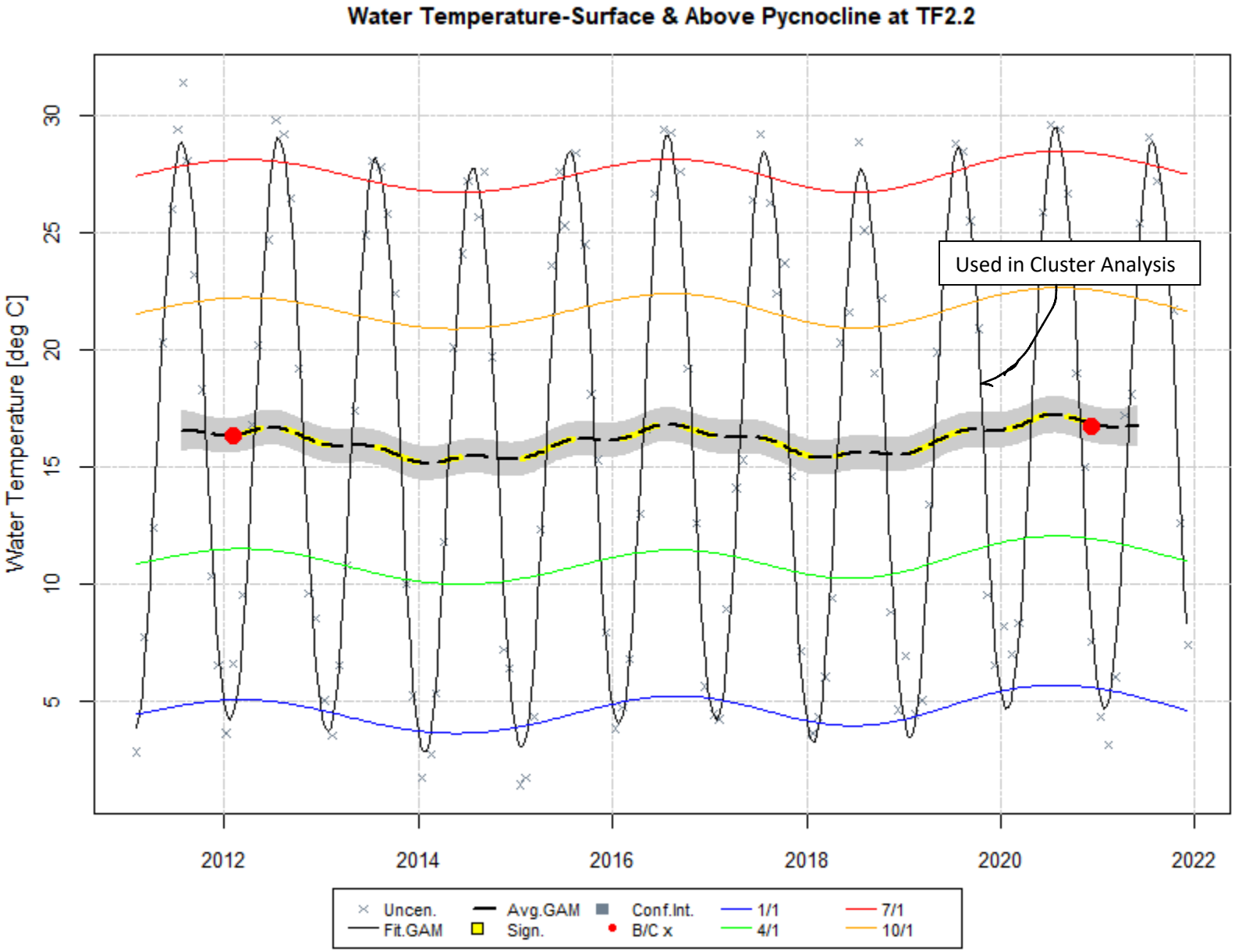
4. Overview of types of cluster results

5. Example: Surface Water Temperature from Potomac Tidal Network.



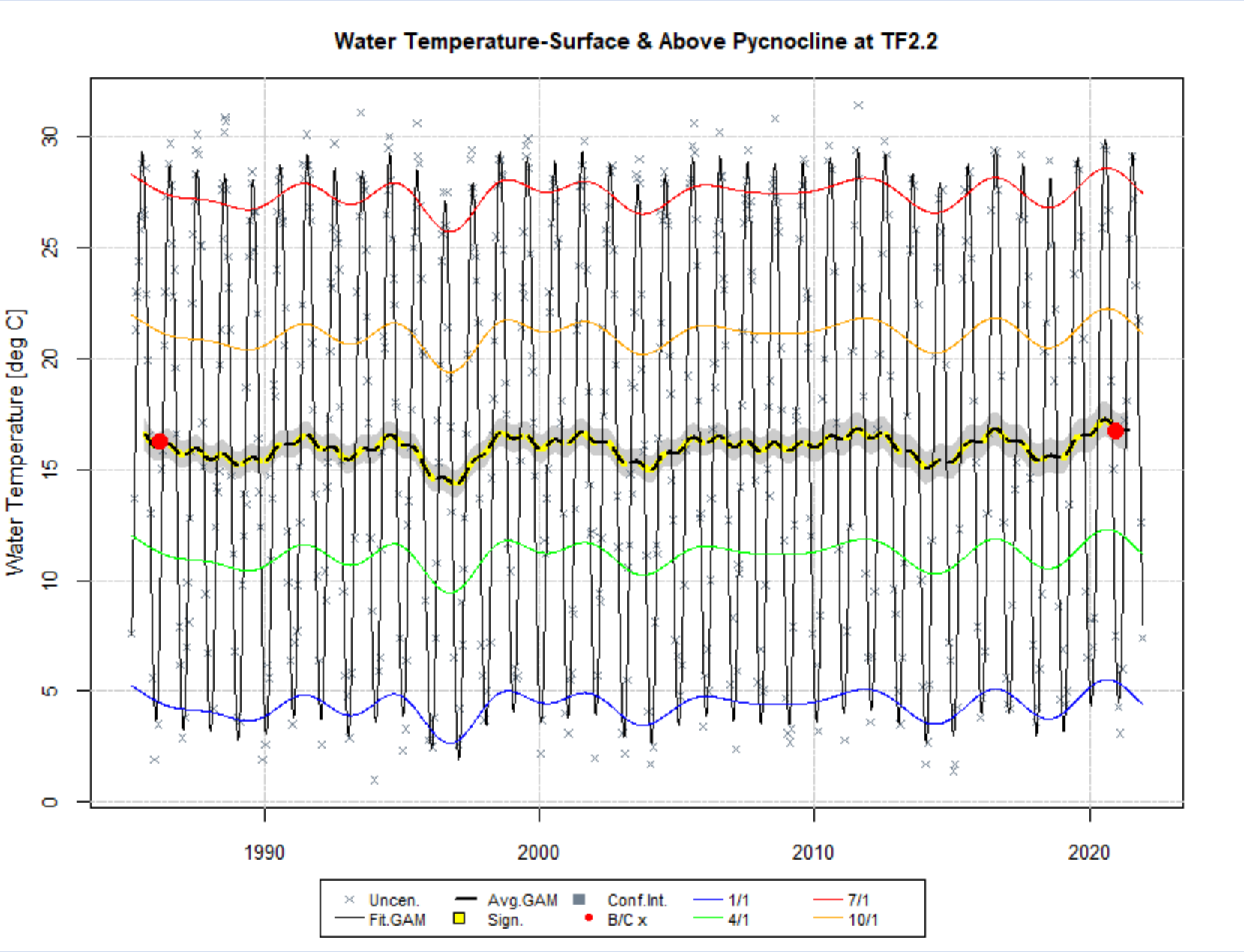
Source For Data:

The address for DataHub will be changing to exclusively https://datahub.chesapeakebay.net on October 1, 2023.



Generalized Additive Model (gam) Terms:

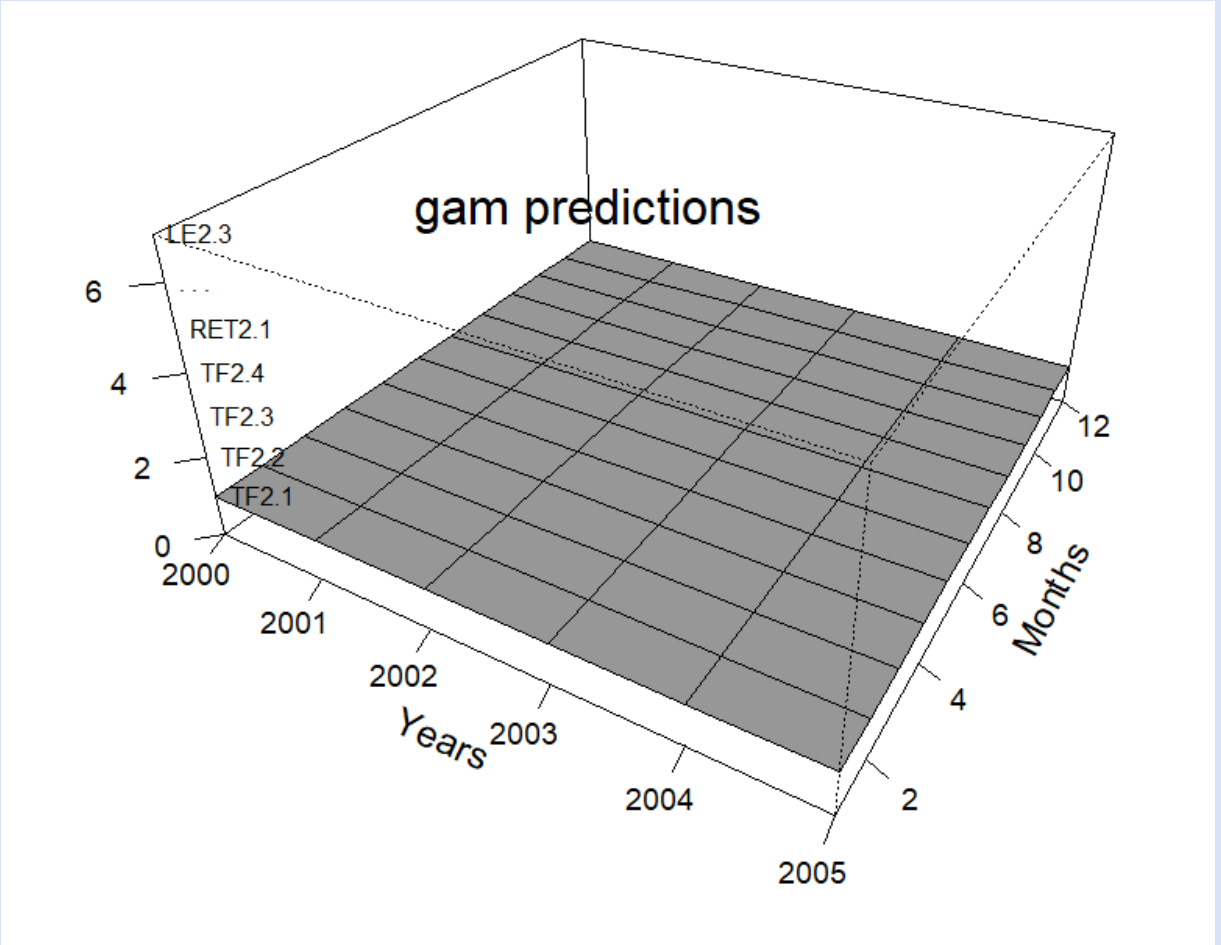
wTemp = Intercept + s(longTermTrend)+s(season) + interaction.smooth(Trend x Season)


Water Temperature-Surface & Above Pycnocline at TF2.2
Water Temperature [deg C]
0
5
10
15
20
25
30
1990
2000
2010
2020
Uncen.
Fit.GAM
Avg.GAM
Sign.
Conf.Int.
B/C x
1/1
4/1
7/1
10/1

Cluster Data:

Using the gam, obtain an estimated value for the

1. **15th of each month,**
2. **for each year in the period of record**
3. **for each station in the area of interest.**



Store these as a 3-D data Structure

Convert to 2-D Data Structure of Items and Profiles.

		Profile					
ITEMS	station	Wtemp 1994	Wtemp 1995	Wtemp 1996	Wtemp 1997	Wtemp 1998	Wtemp 1999
	TF2.1	16.2	15.7	14.3	14.9	16.3	16.5
	TF2.2	16.3	15.7	14.4	14.9	16.3	16.3
	TF2.3	16.0	15.5	14.5	15.1	16.2	16.1
	TF2.4	15.4	15.4	15.4	15.4	15.4	15.4
	RET2.1	15.2	15.2	15.2	15.2	15.2	15.3
	RET2.2	15.2	15.2	15.3	15.3	15.3	15.3
	RET2.4	15.2	15.2	15.2	15.2	15.2	15.3
	LE2.2	15.1	15.1	15.2	15.2	15.2	15.2
	LE2.3	15.0	15.0	15.0	15.0	15.0	15.1

Baytrends Cluster Methods

Cluster Methods:

- **Agglomerative Clustering**
- **Ward's Method to Form Clusters**

Graphical Output

- **Dendogram to display tree of grouping structure**
- **Profile plots to assess characteristics of each group**
- **Maps of Groups**
- **Season x station plots**

User Options

- **User chooses Years, Months, and Stations to analyze.**
- **User defines Items and Profiles by choosing from: Years, Months, and Station**
- **User chooses scaling of Profile**
- **User chooses number of Groups to interpret**

Variations on Clustering

Item	Profile	Scaling	Question
Station	Year	None	What stations have similar long term means?
Station	Year	Mean Adjust	What stations have similar long term trends? How does Water Quality respond to Flow?
Station	Month	Mean Adjust	What stations have similar seasonal patterns?
Station:Year	Month	None	Does Seasonality change over Years within Station?
Year	Station	None	Does the Estuary profile differ between high flow and low flow years? Is trend consistent across the estuary?
Month	Station	None	On average over years, how does upstream-downstream profile change with season?

1. Status Cluster: Items:Station Profile:Year Scale: None Water Temperature

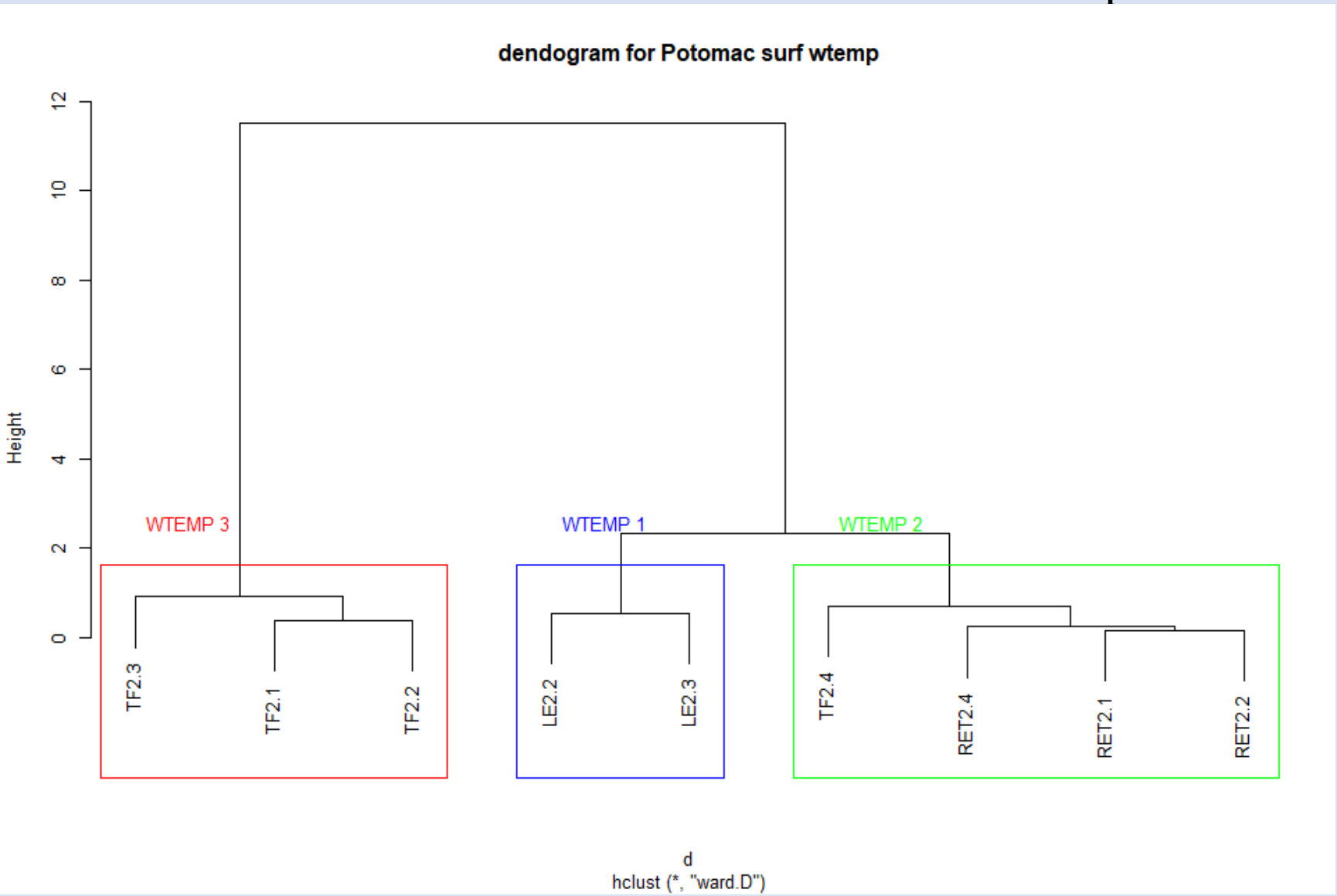


Figure 3.A: Dendogram showing distances between station pairs computed using the dist() function for Potomac River.

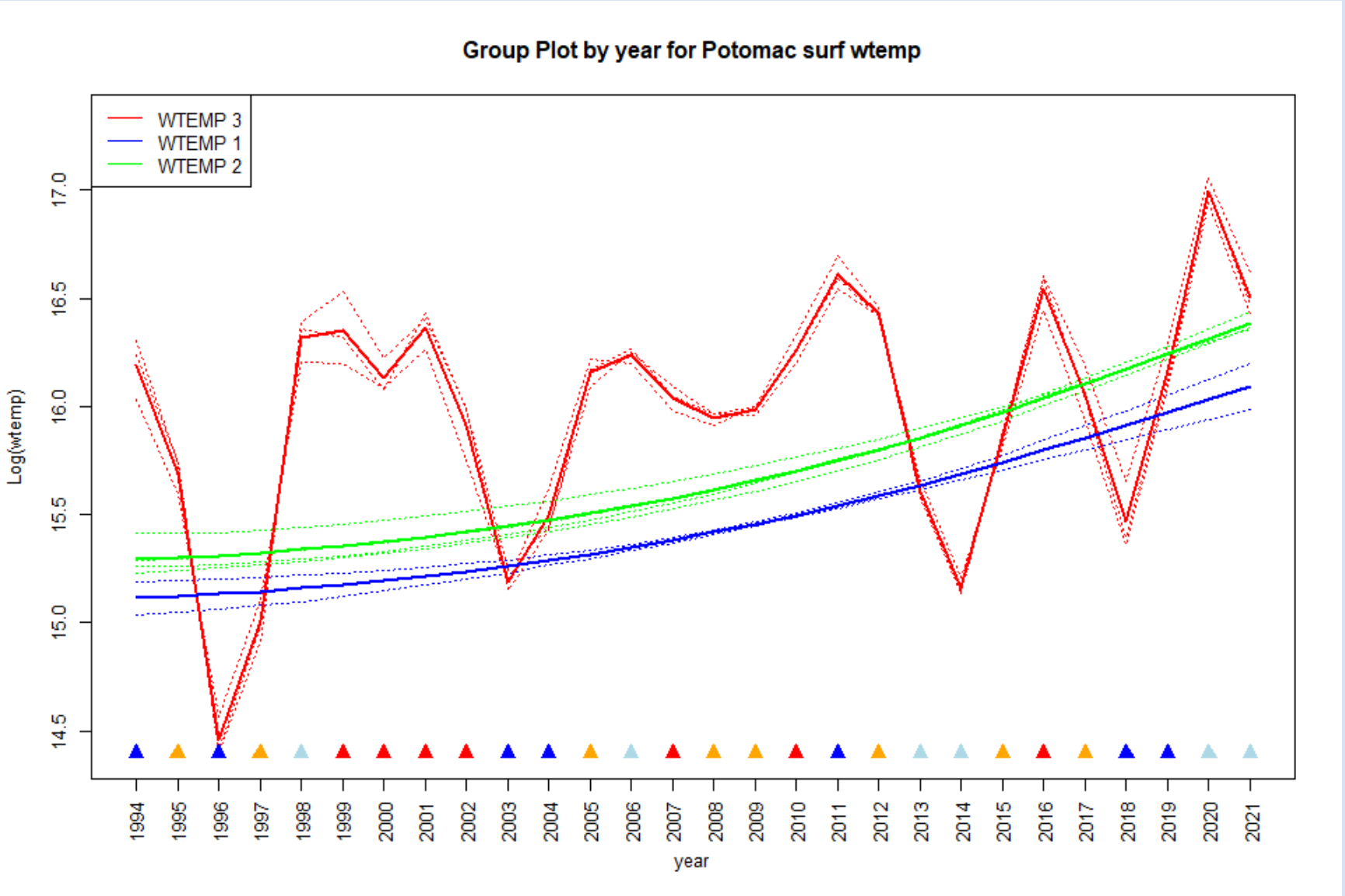
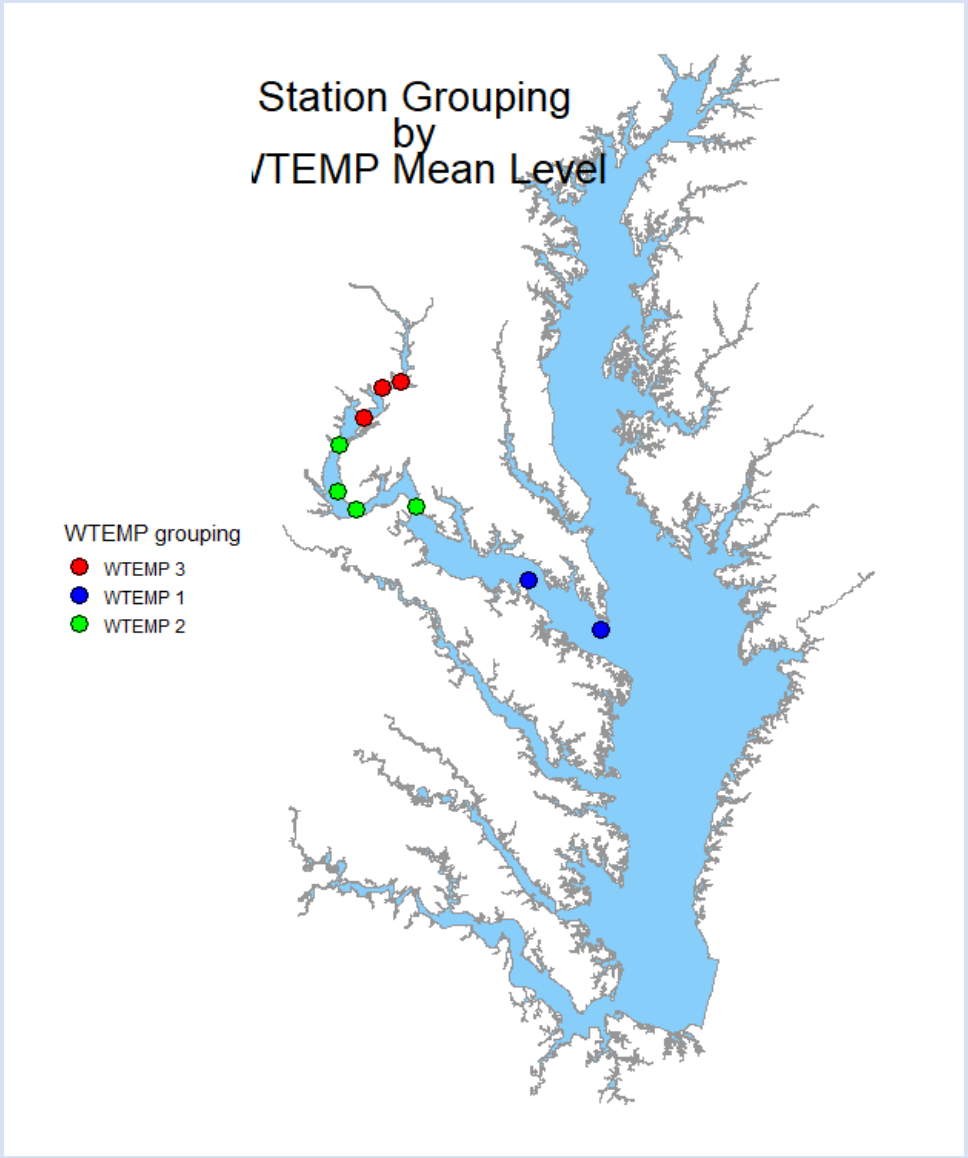
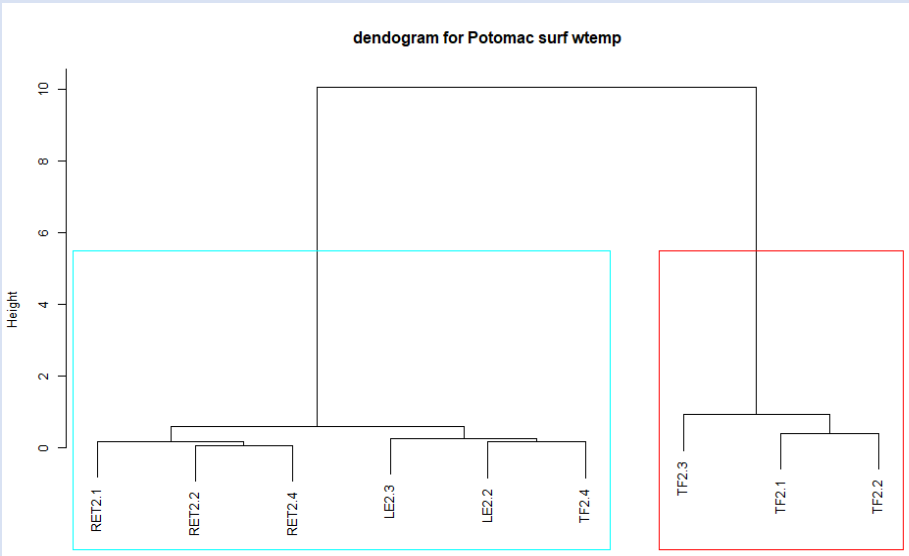
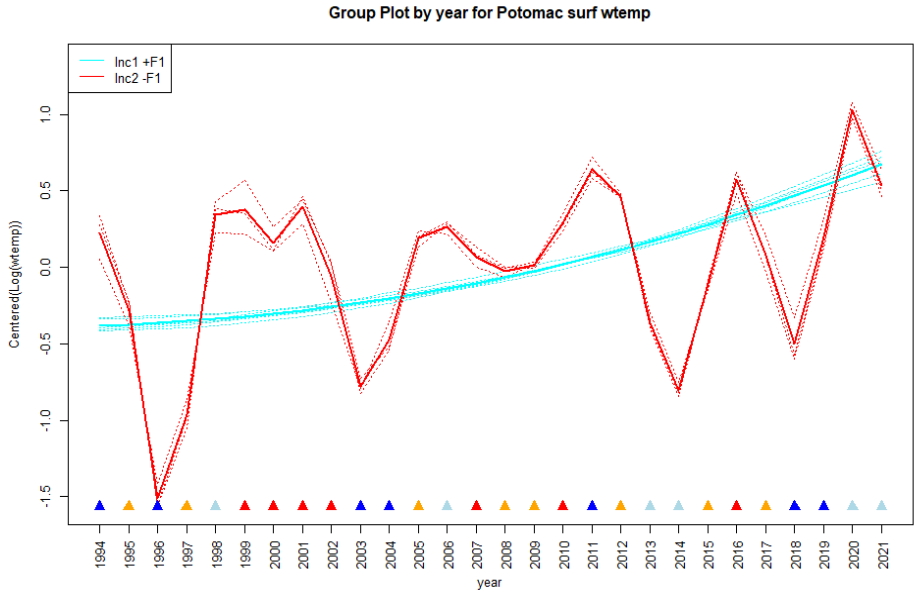


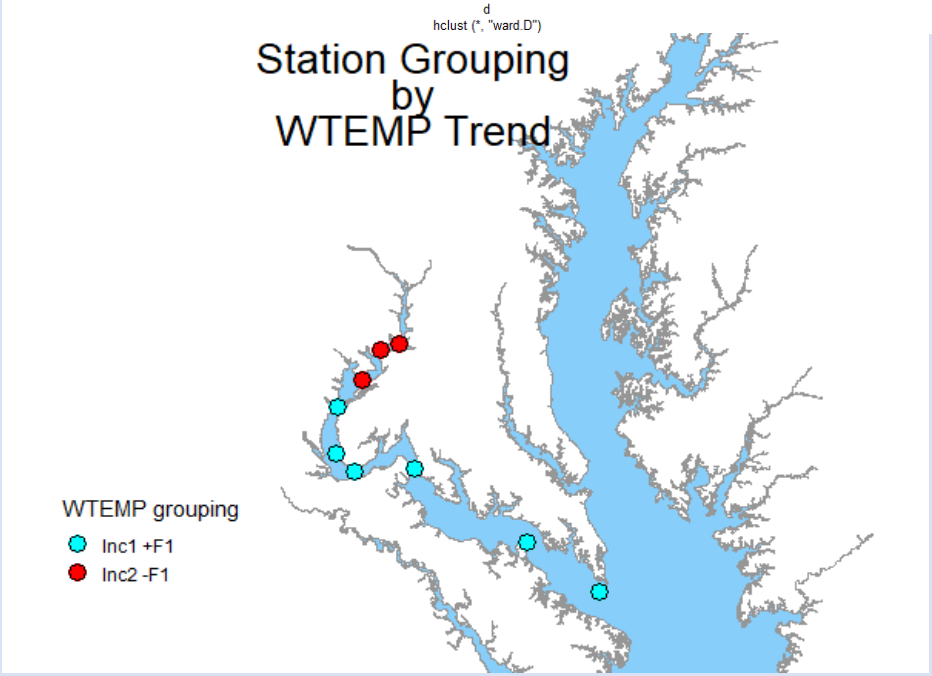
Figure 3.B: Year means plotted with station groups segregated by color. Multiple dash line traces within group show variability among station within groups.


Station Grouping
by
/TEMP Mean Level
WTEMP grouping
WTEMP 3
WTEMP 1
WTEMP 2

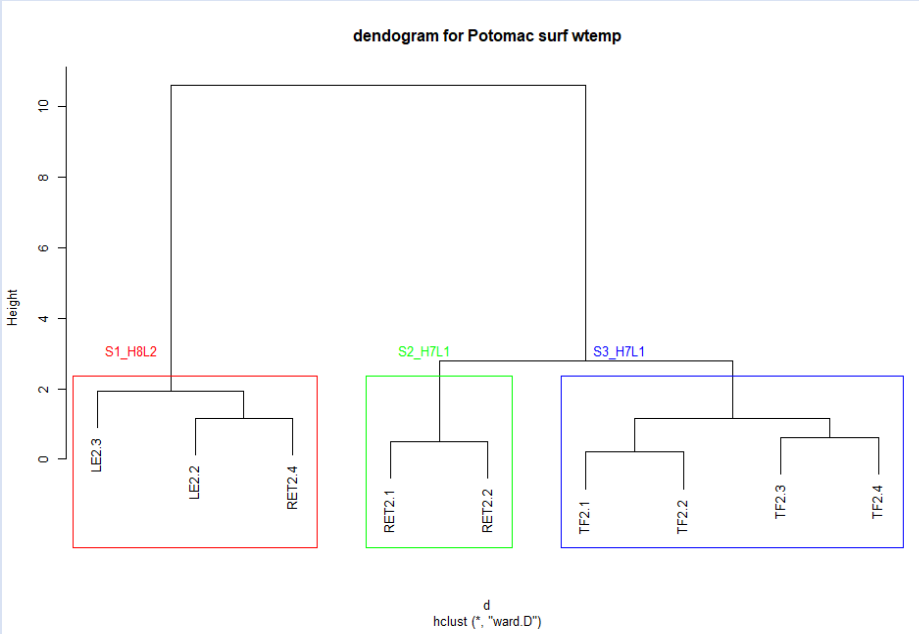
2. Trends Cluster: Items:Station Profile: Year Scale: Mean Adjusted

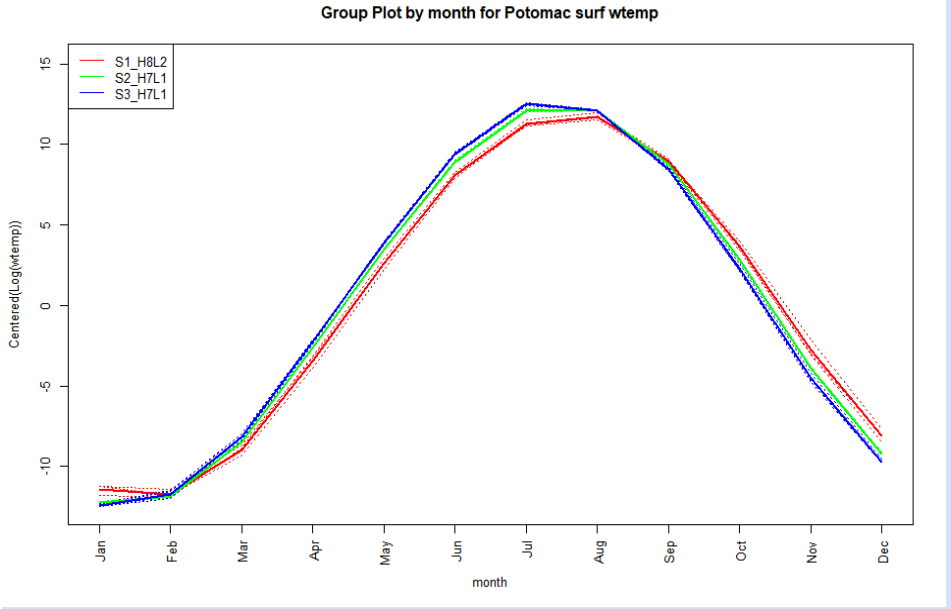


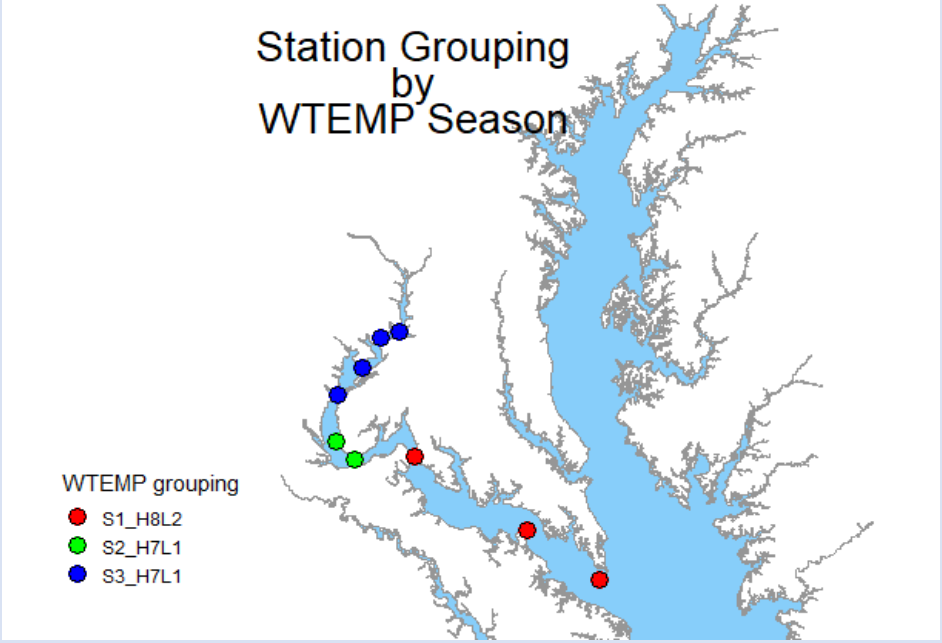




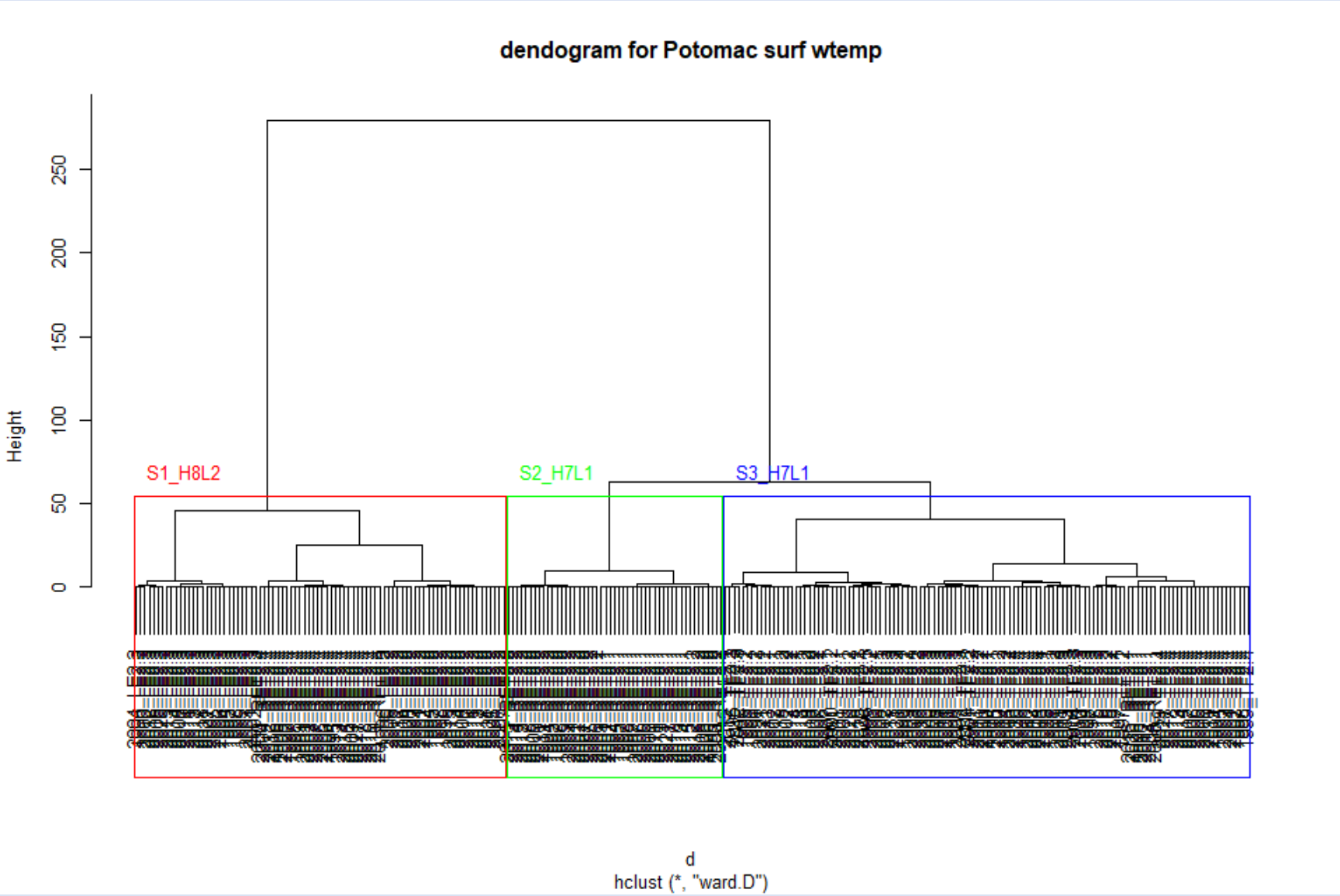
3. Seasons Cluster: Items:Station Profile: Month Scale: Mean Adjusted

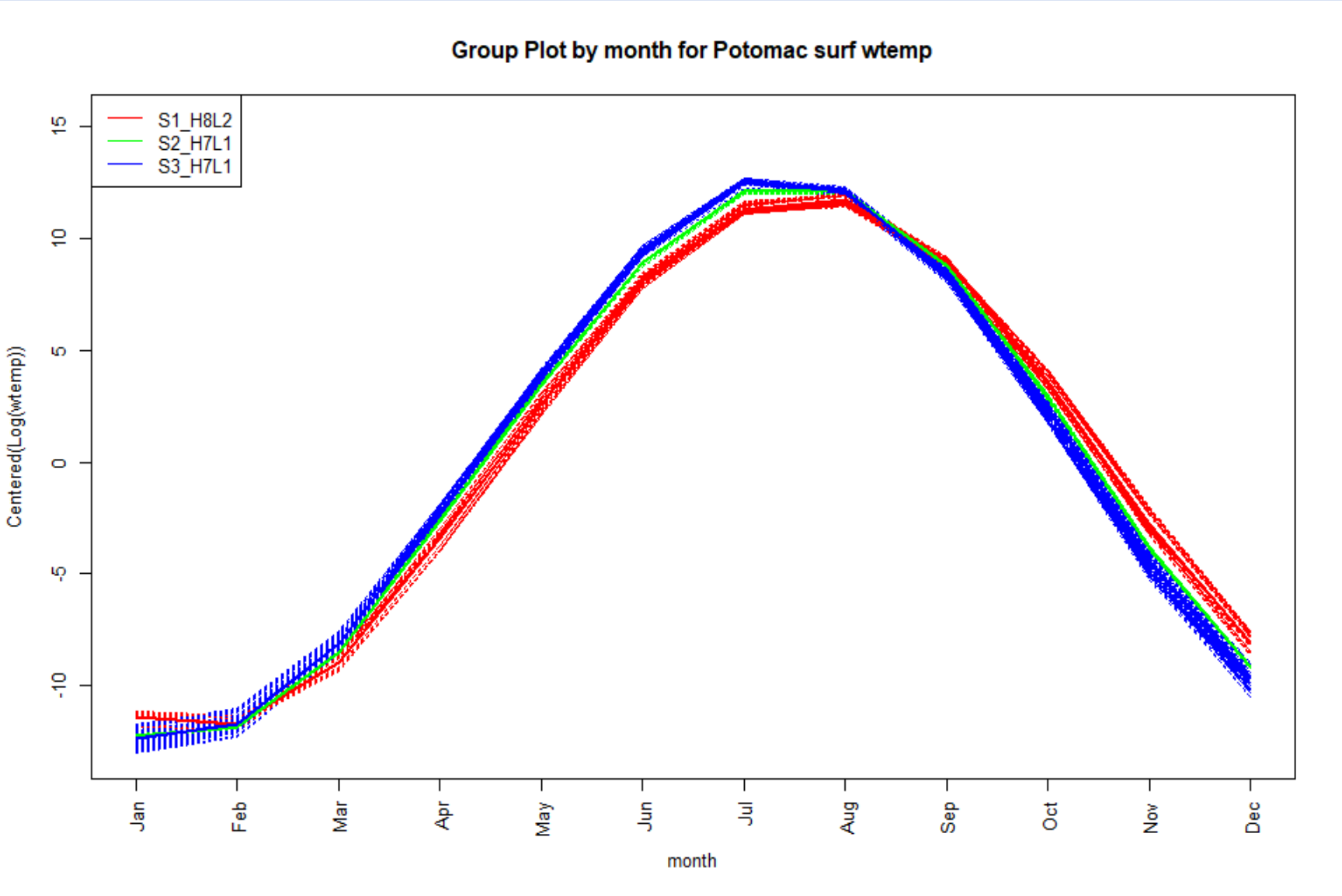




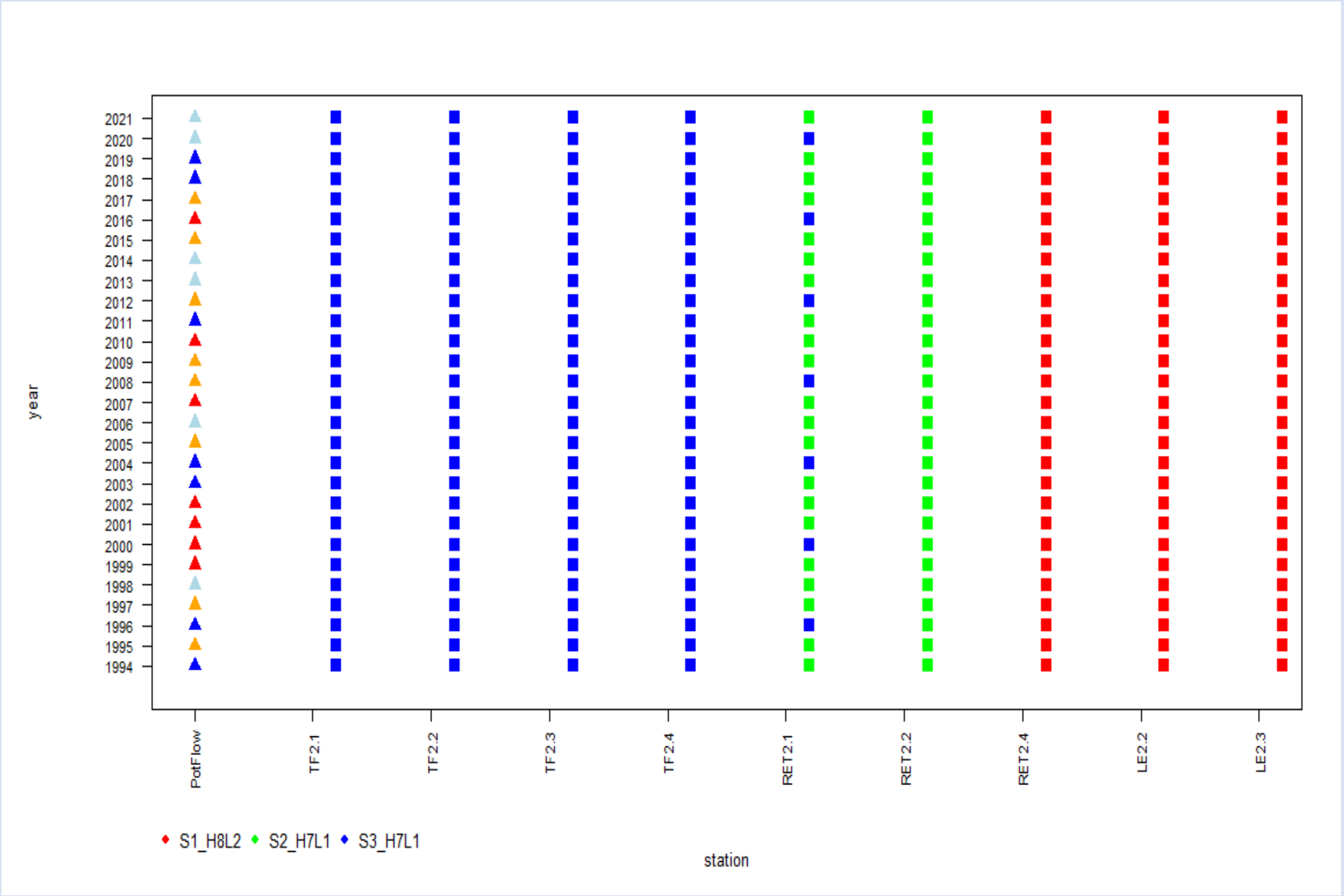


4. Climate Change Cluster: Items:Station-Year Profile: Month Scale: Mean Adjusted

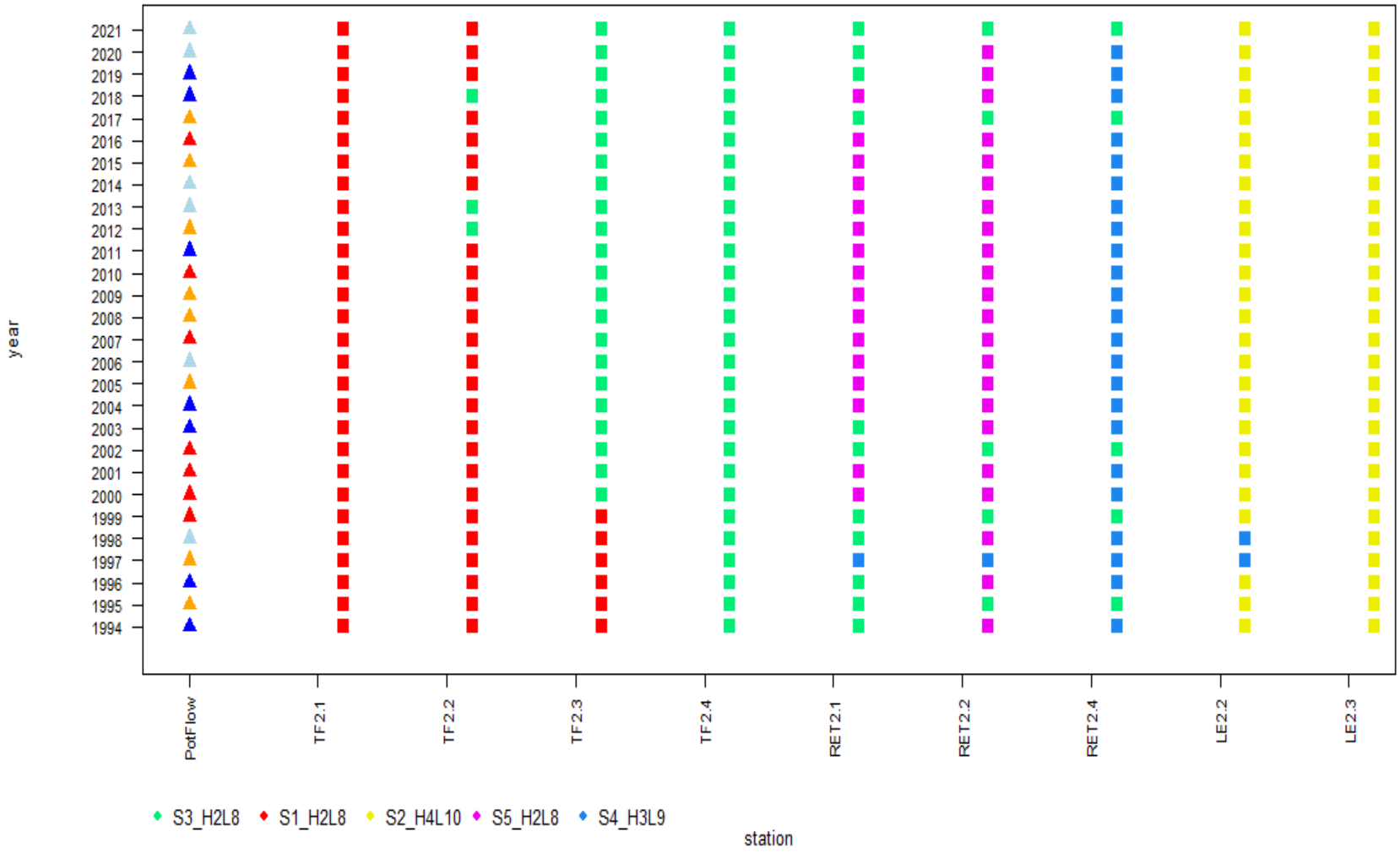



Group Plot by month for Potomac surf wtemp
S1_H8L2
S2_H7L1
S3_H7L1
Centered(Log(wtemp))
15
10
5
0
-5
-10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

Changing Seasonality of Water Temperature in the Potomac Estuary.



Changing Seasonality of Total Nitrogen in the Potomac Estuary.



Advantages of baytrends Cluster Approach:

- **Organizes GAMs results to tell a Status and Trends story.**
- **Allows data to self-organize.**
- **Test existing concepts for explaining trends.**
- **Explore new Concepts (e.g. changing seasonality, spatial trends)**


Questions before I leave?