



# 2015 Fall Chesapeake Bay Water Clarity

Presentation for the Scientific, Technical Assessment  
& Reporting (STAR) Team, January 28, 2016

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Satellite Oceanographer  
NOAA, NESDIS

October 12, 2015 NASA  
MODIS TERRA image



# Citizen and Newspaper Reports of Extremely Clear Waters

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**The Virginian-Pilot**  
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## The Chesapeake Bay is looking strangely clear. But why?

By Dave Mayfield  
The Virginian-Pilot  
Nov 29, 2015

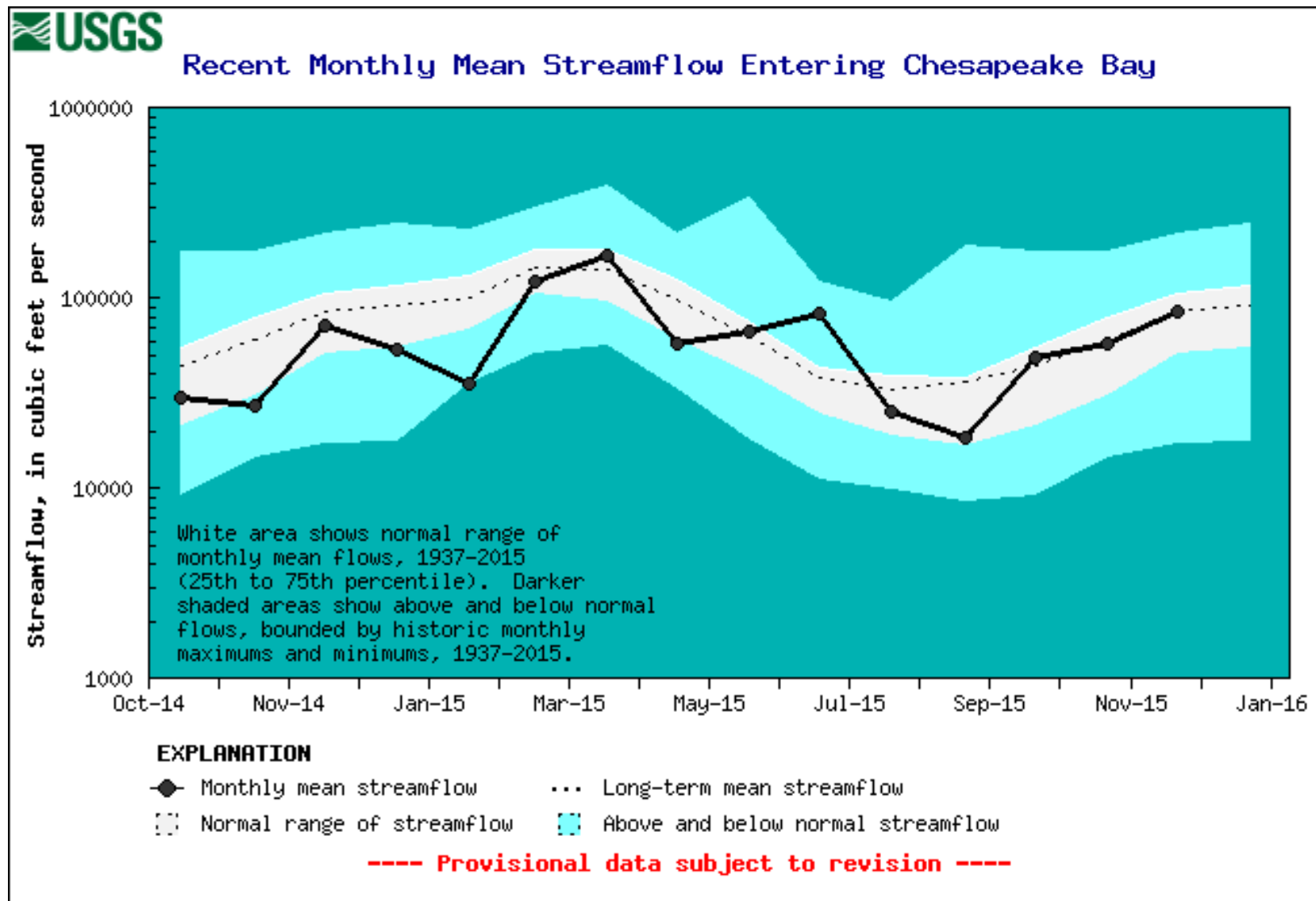


Bill Portlock | Chesapeake Bay Foundation

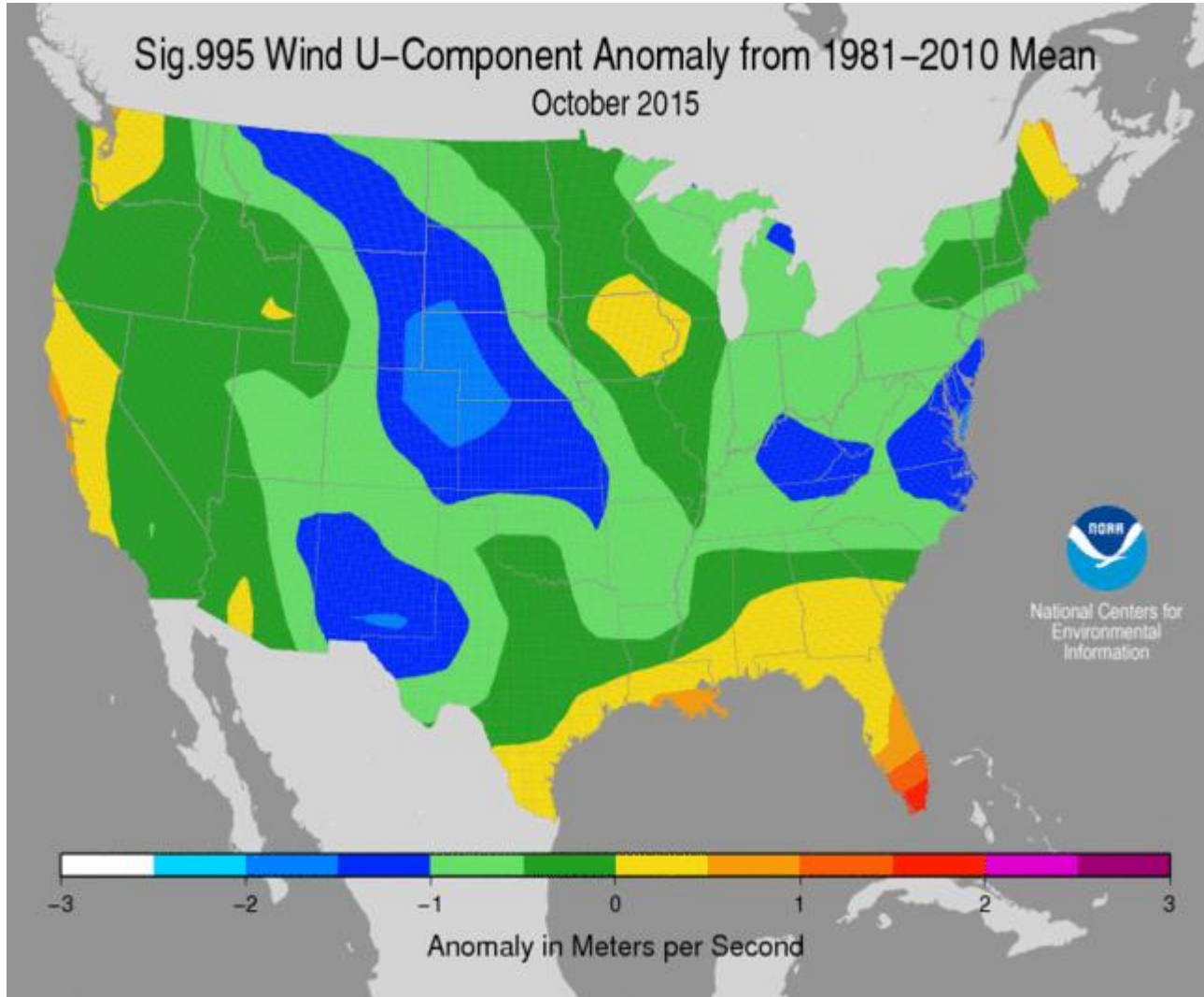
The northern tip of Goose Island, north of Tangier Island in the Chesapeake Bay, was photographed Nov. 17, 2015, from a helicopter by Bill Portlock, senior educator for the Chesapeake Bay Foundation.



# Flow Mostly Average or Below Average for 2015



# Recent Wind Anomalies



Month	Year	Color
December	2015	Dark Blue
November	2015	Dark Blue
October	2015	Dark Blue
September	2015	Dark Blue
August	2015	Yellow
July	2015	Dark Green
June	2015	Dark Green
May	2015	Neutral
April	2015	Dark Green
March	2015	Yellow
February	2015	Yellow
January	2015	Dark Green
December	2014	Light Green
November	2014	Orange
October	2014	Yellow
September	2014	Light Green
August	2014	Light Green
July	2014	Yellow
June	2014	Dark Blue
May	2014	Yellow
April	2014	Dark Blue
March	2014	Dark Green
February	2014	Light Green
January	2014	Dark Green
December	2013	Light Green
November	2013	Yellow
October	2013	Light Green
September	2013	Dark Green
August	2013	Light Oran
July	2013	Dark Green
June	2013	Yellow
May	2013	Dark Green
April	2013	Dark Blue
March	2013	Orange
February	2013	Dark Green
January	2013	Dark Green

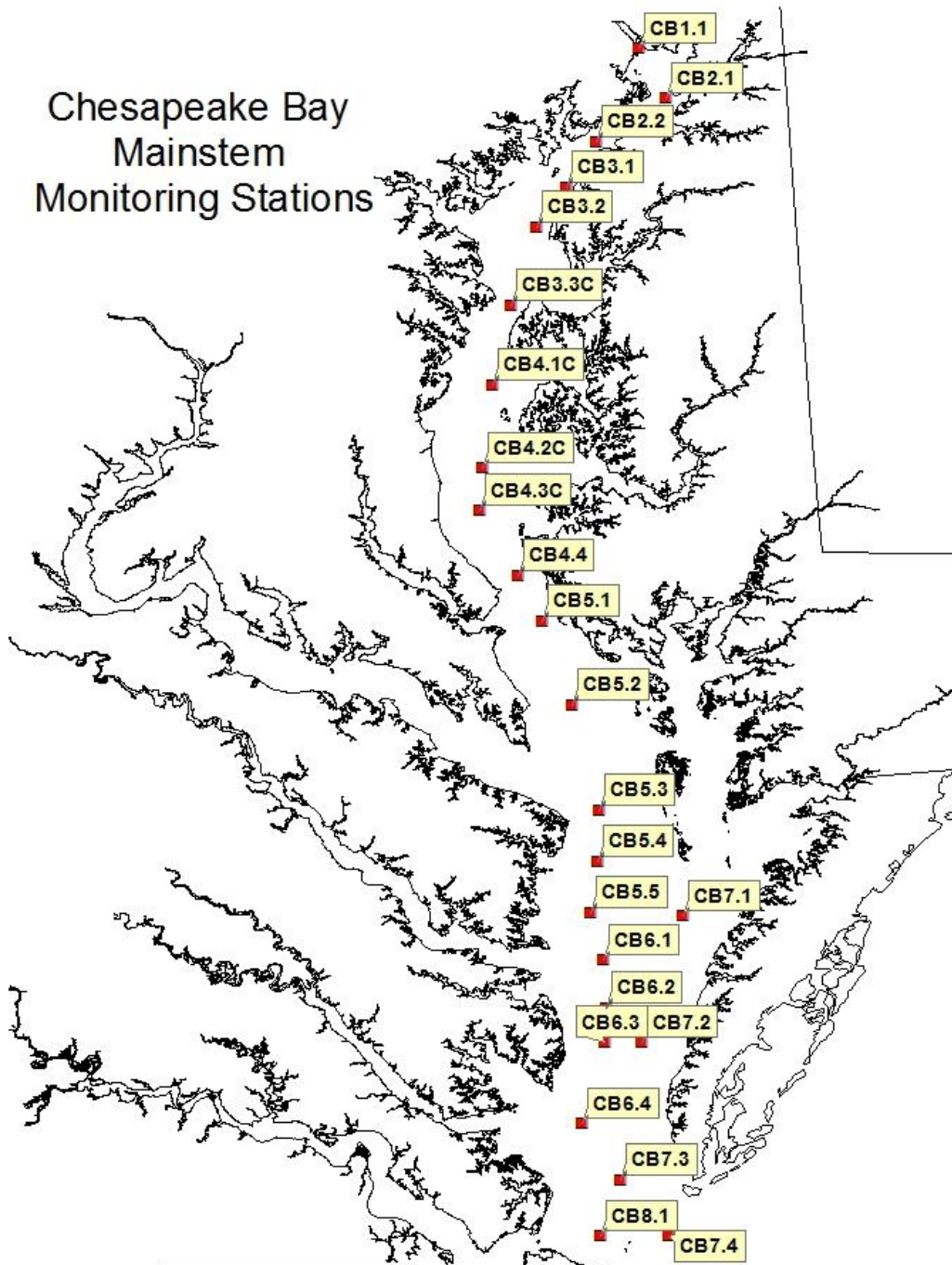
# Reports of Abundant Submerged Aquatic Vegetation in 2015

- Numerous inquiries from citizens regarding channel clogging from 'nuisance' SAV
- Biologists reporting increases in wild celery, hydrilla, widgeon grass
- Grasses found in some places where they have not been found before



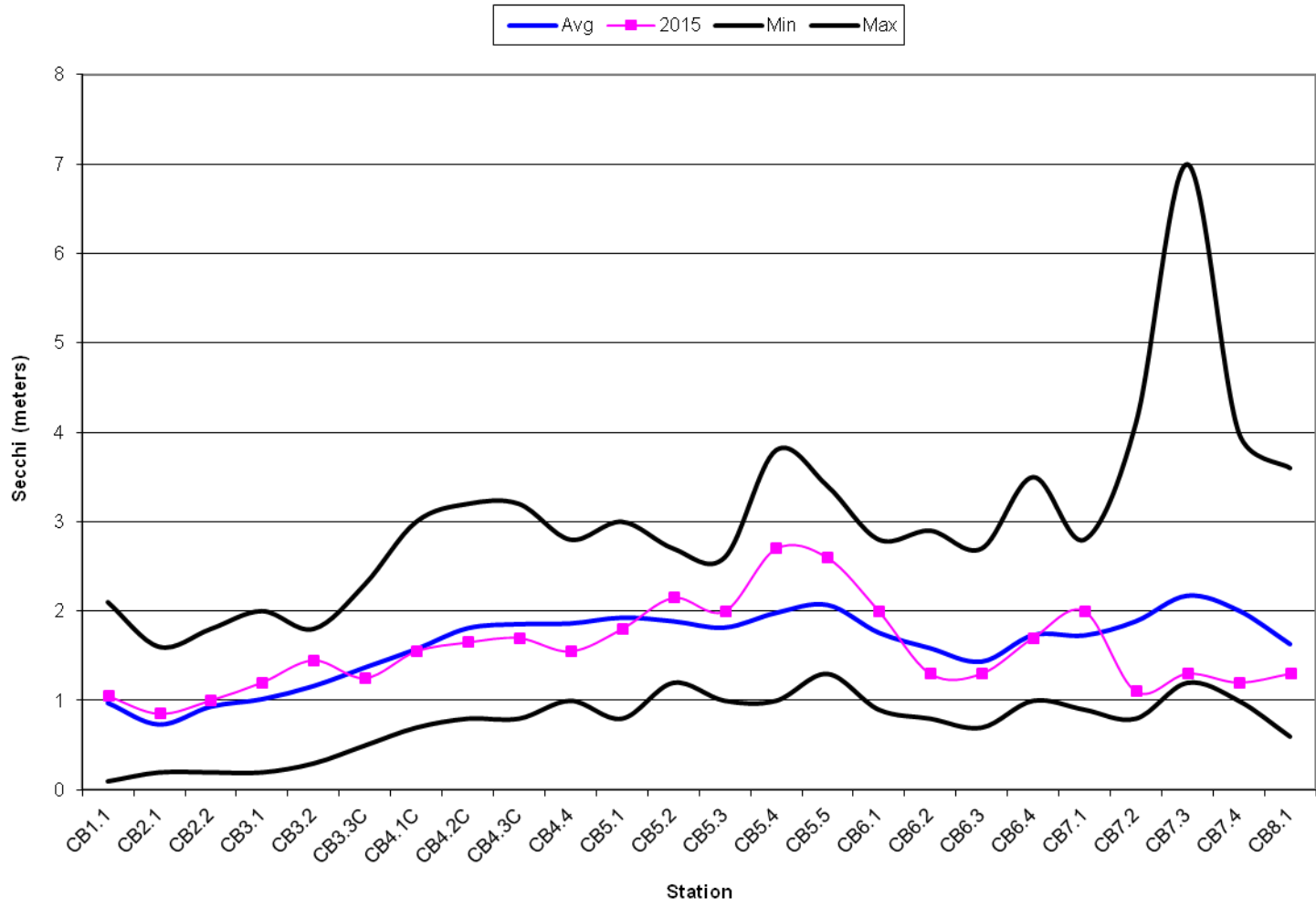
MD DNR Biologist, Mark Lewandowski  
Photo by: Barbara Haddock Taylor, Baltimore Sun  
A Baltimore Sun 2015 Picture of the Year

# Chesapeake Bay Mainstem Monitoring Stations



- Stations visited by boat once or twice monthly
- Water Quality Profiles
- Sediment, Chl, Nutrients analyzed at laboratories

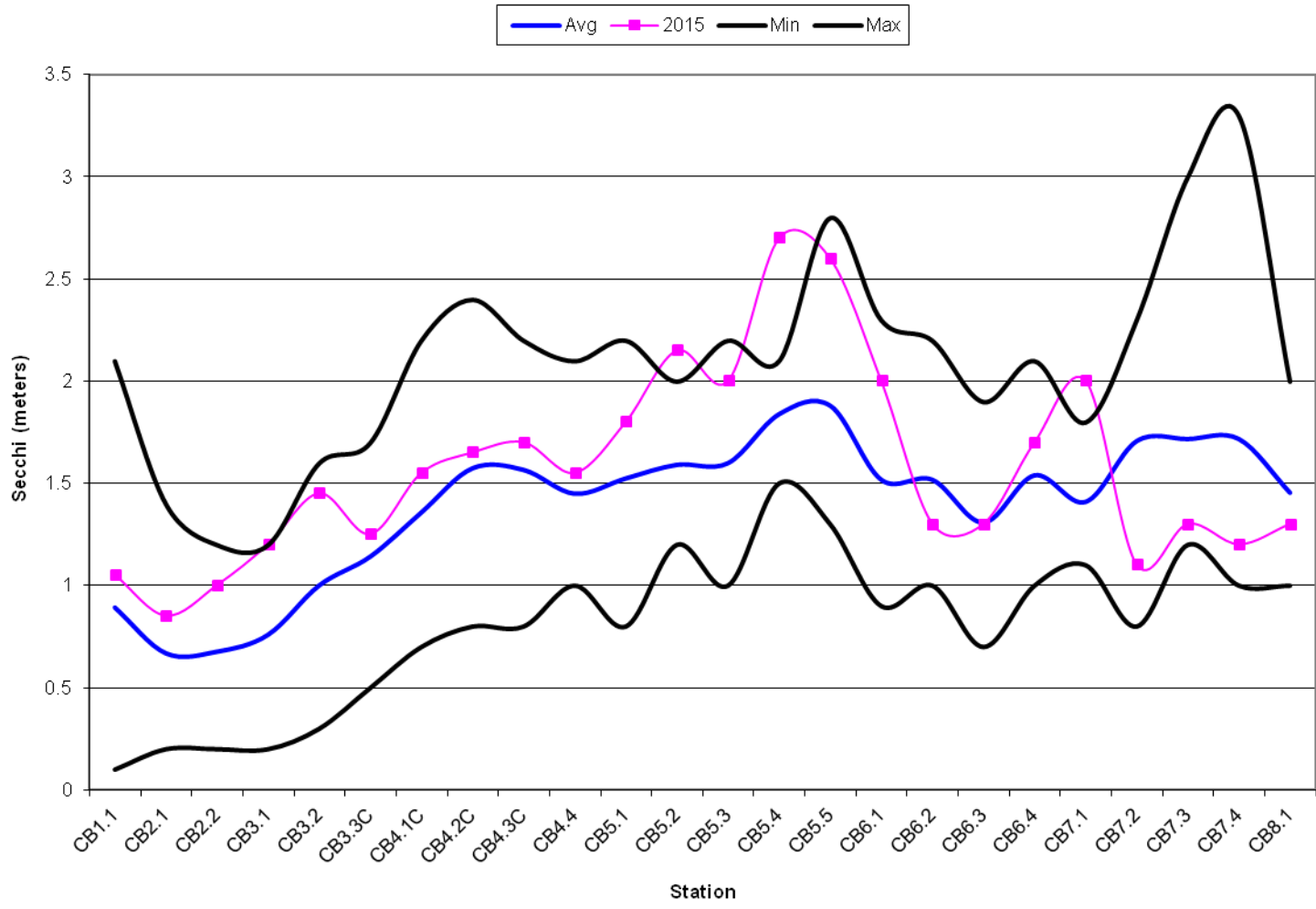
October 2015 Secchi versus 1985-2014 October Average and Range



Susq.      Bay Bridge      PAX      MD/VA      Rapp.      York      Mouth



October 2015 Secchi versus 2004-2014 October Average and Range



Susq.

Bay Bridge

PAX

MD/VA

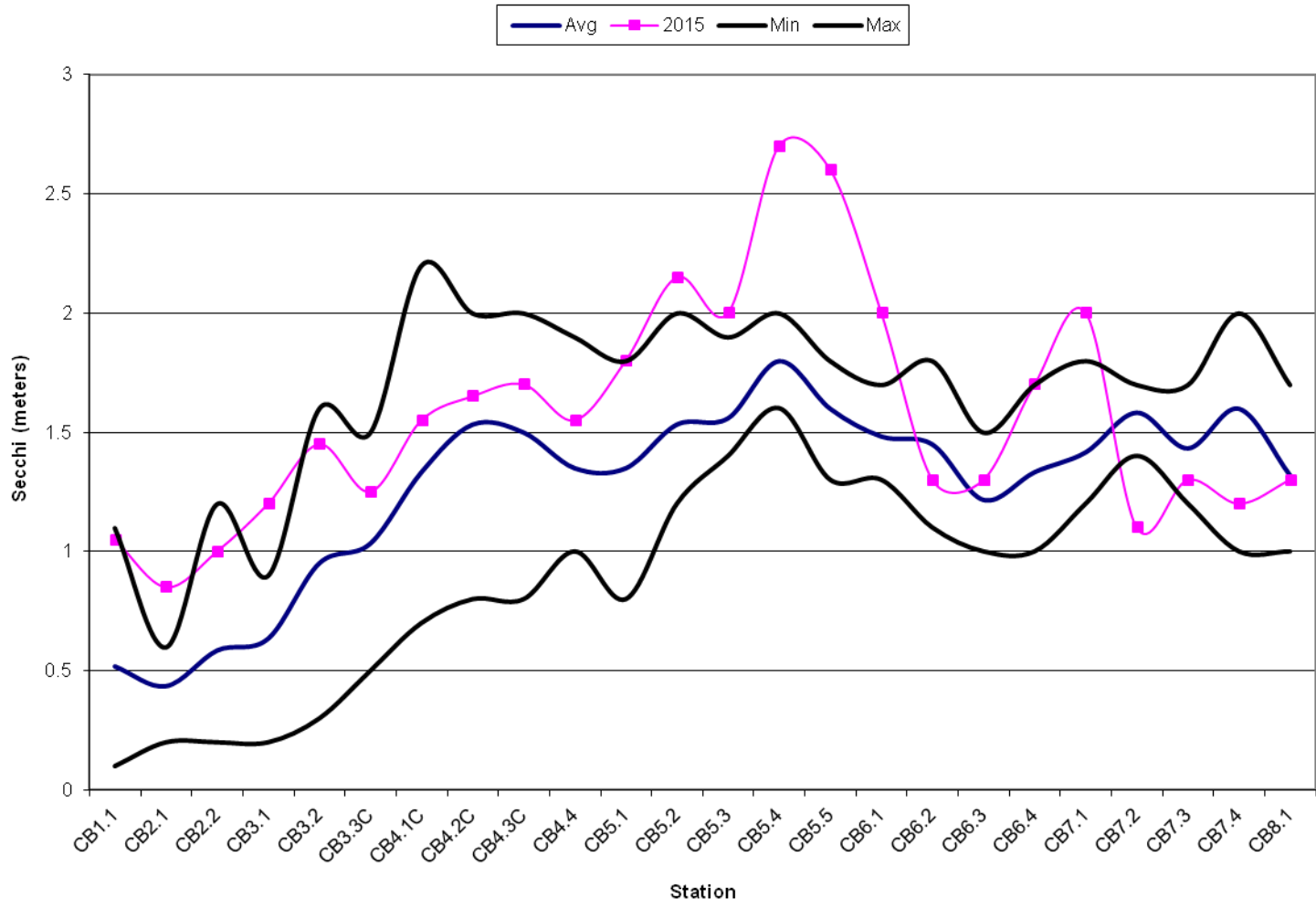
Rapp.

York

Mouth

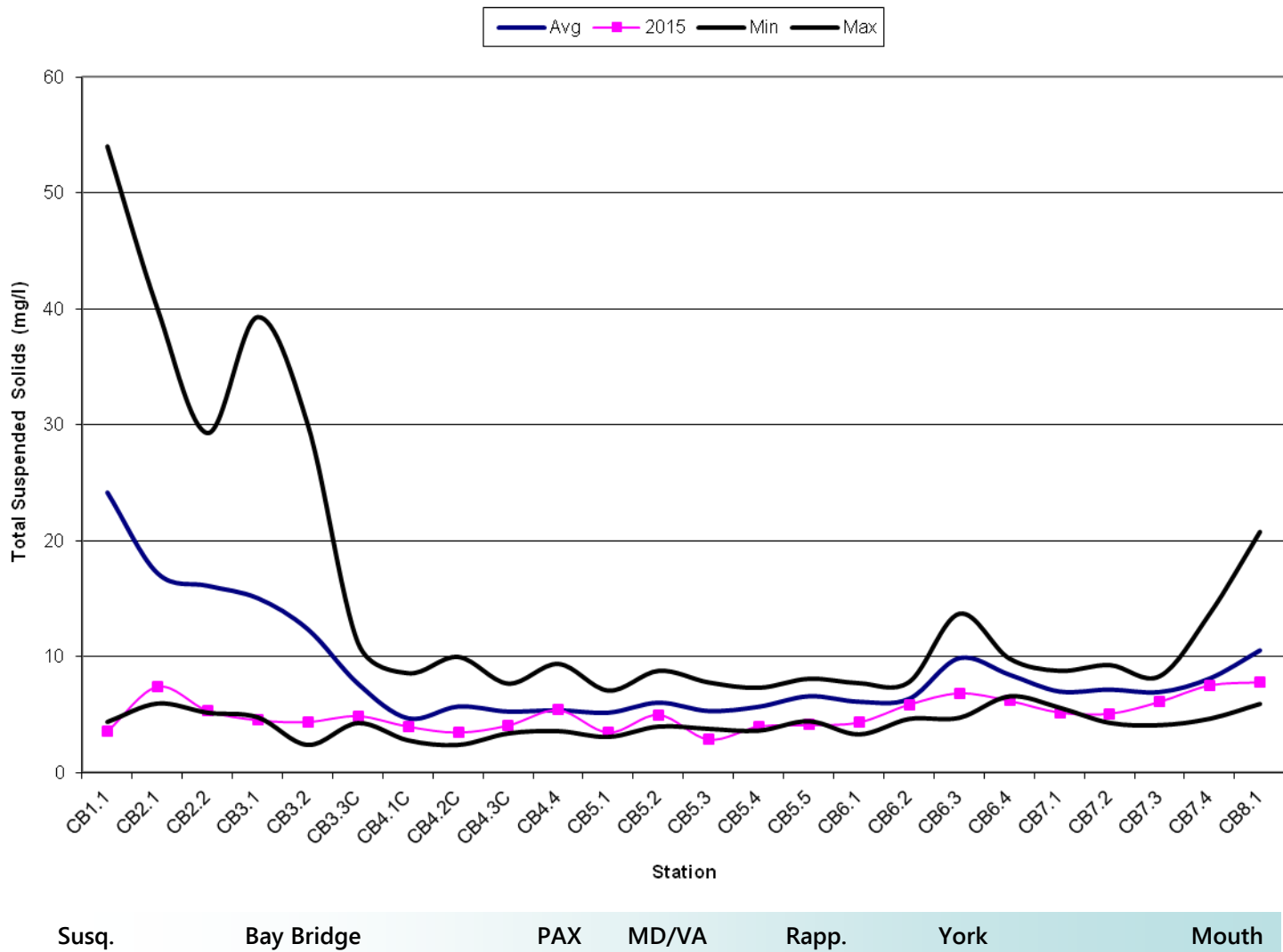


October 2015 Secchi versus 2010-2014 October Average and Range



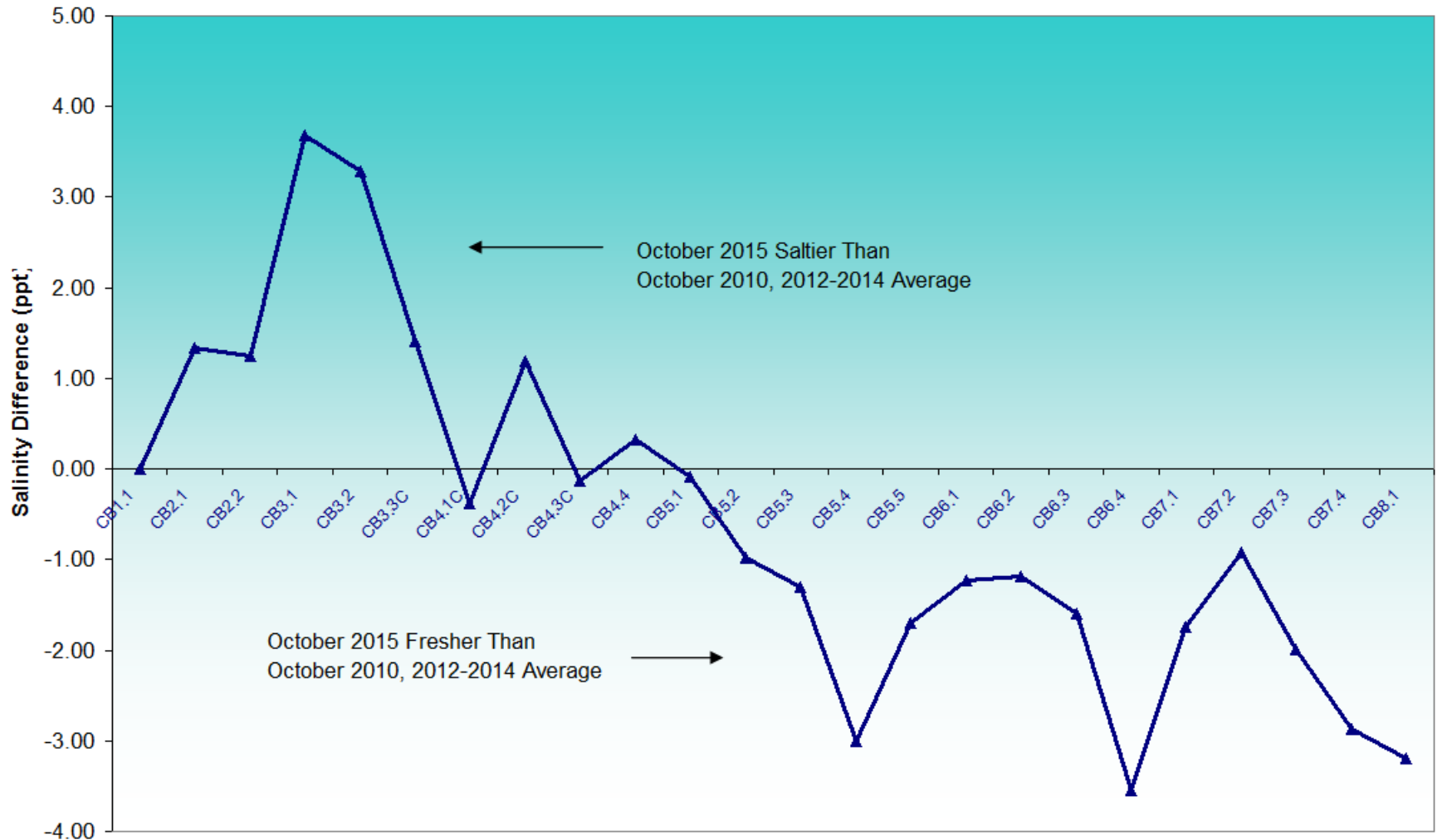
Susq.      Bay Bridge      PAX      MD/VA      Rapp.      York      Mouth

October 2015 TSS versus 2010-2014 October Average and Range



# October 2015 Surface Salinity Difference From October 2010, 2012-2014 Average

2011 Removed From Average Due to T.S. Lee



Maryland tributary stations (WT/ET) on average 1ppt greater than previous 4 years

# Maryland DNR Continuous Monitoring Data and the Choptank River Complex



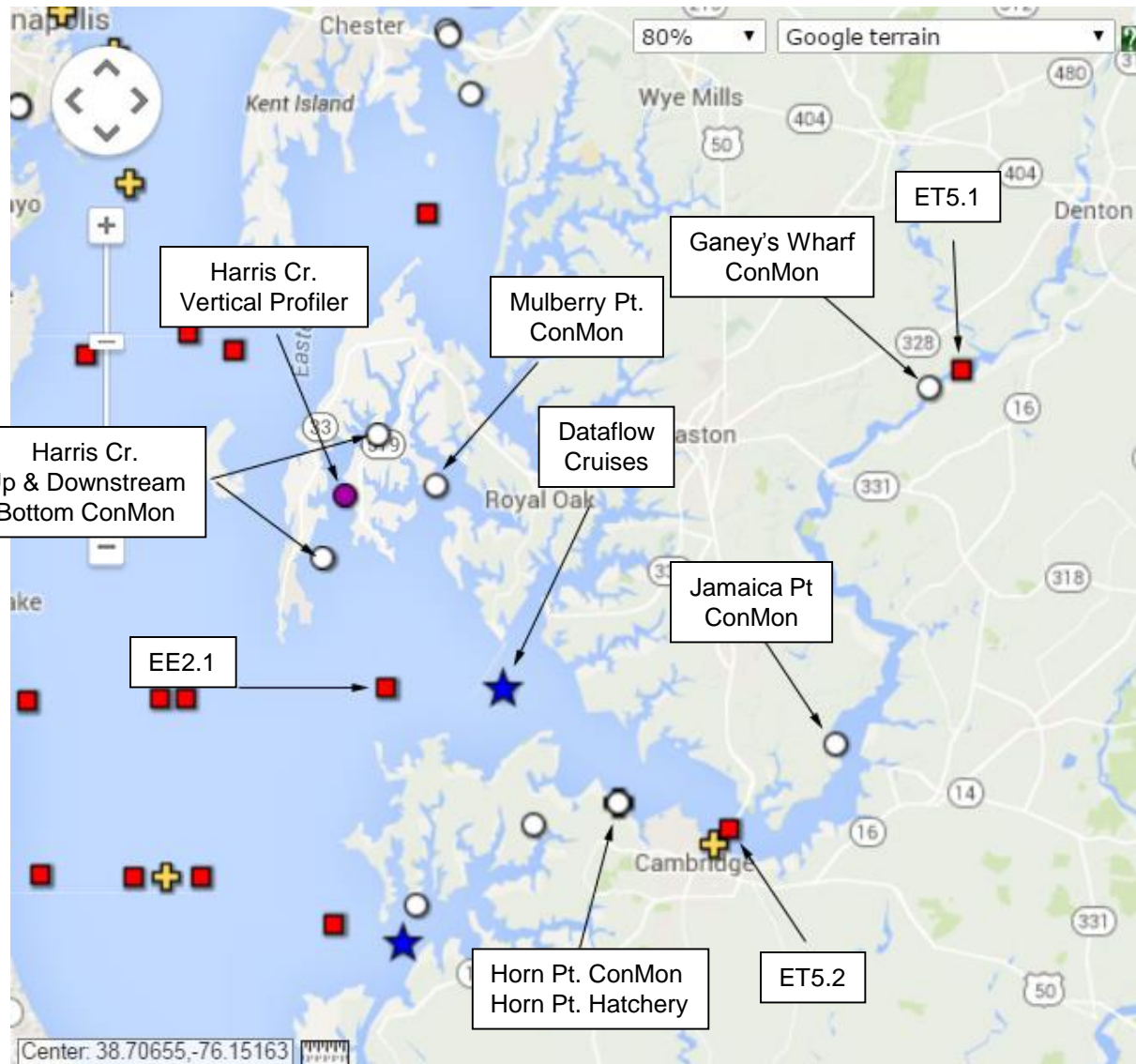
Vertical Profiler, Harris Creek

- Continuous Monitoring (ConMon)
  - Readings every 15 minutes
  - Dissolved Oxygen, Turbidity, Chl, ph, salinity, water temperature
  - Most sites deployed for 3 years
  - Some sentinel sites exist
- Vertical Profiler
  - Water column profile every hour
  - Same parameters as ConMon
  - Readings at every half meter
  - Deployed in Harris Creek for past 4 years

Maintenance on each is performed every two weeks, and calibration samples are taken at those times.



# Summary of MD DNR Tidal Choptank River Water Quality Data



## DNR Harris Creek Sites

- Upstream (0.3m off bottom)  
(Sept 13-Jan14; Apr14 – Dec14; Apr15)
- Downstream (0.3m off bottom)  
(Sept 13-Jan14; Apr14 – Dec14; Apr15)  
*Wtemp, salin, cond, chl, turb, pH, depth every 15 minutes  
Biweekly profiles, nutrients, chl, sediment, & alkalinity*

## •Vertical Profiler (Depths 1,2,3,4,4+)

- June 26, 2012 - January 22, 2013
- April 30, 2013 - December 19, 2013
- March 27, 2014 - December 16, 2014
- Wtemp, salin, cond, chl, turb, pH, every hour  
Biweekly profiles, nutrients, chl, sediment, & alkalinity*

## DNR Long-Term Sites (1985-Present)

- EE2.1; ET5.2; ET5.1
- Monthly WQ profiles; Sediment, Nutrient, Chl samples at surface & depth*

## DNR ConMon Sites (~Apr-Oct 2006-08)

- Ganey's Wharf; Jamaica Pt.; Horn Pt.
- Mulberry Pt.
- 1-meter below surface;  
*Wtemp, salin, cond, chl, turb, pH, every 15 minutes  
Bi-weekly profiles, surface nutrients, chl, sediment*

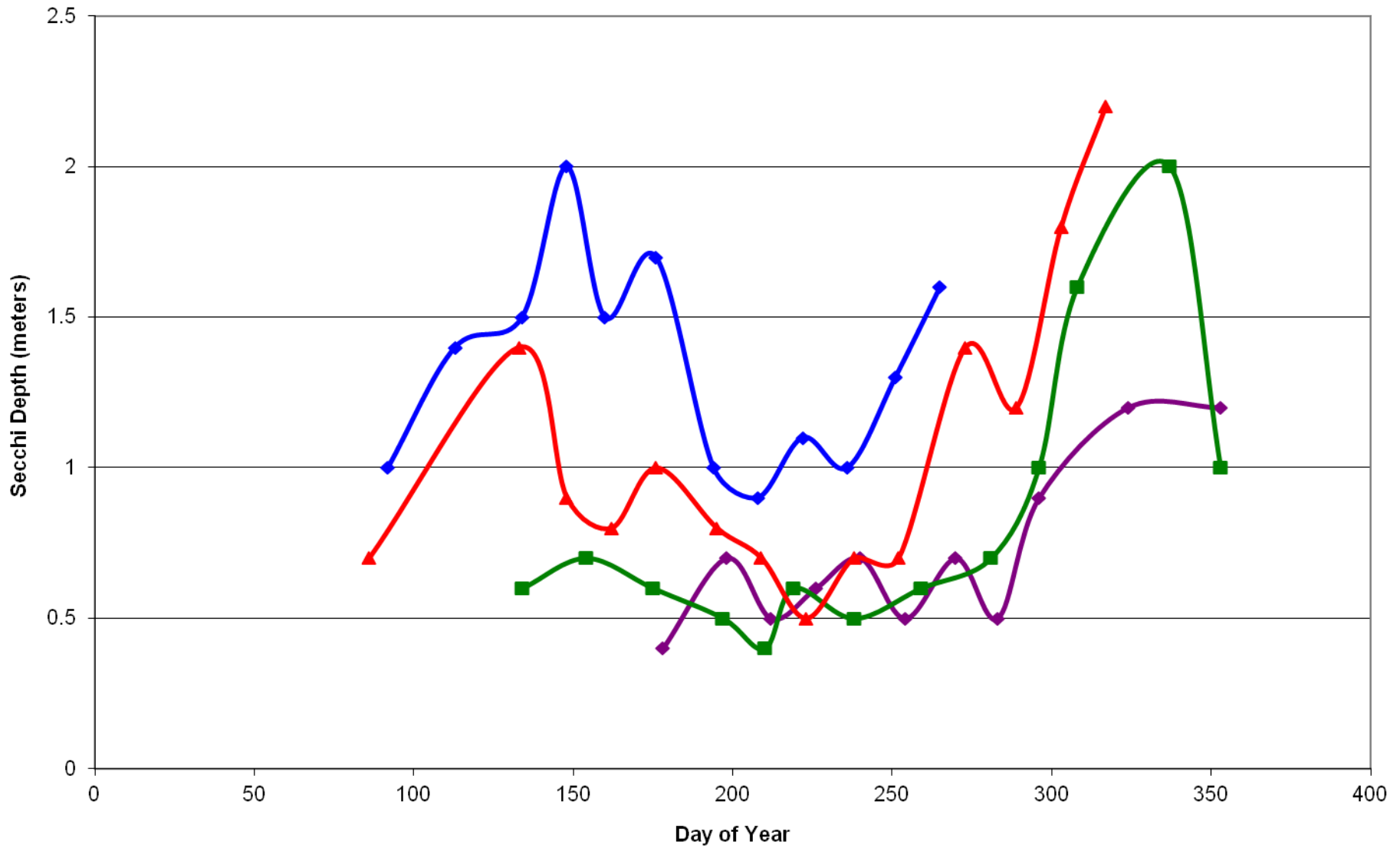
## DNR Choptank Dataflow (Apr-Oct 2006-08)

- Monthly cruises throughout extent of river and creeks with a four second sample rate of surface waters. 10 calibration sites with profiles, nutrient, sediment, chl samples*

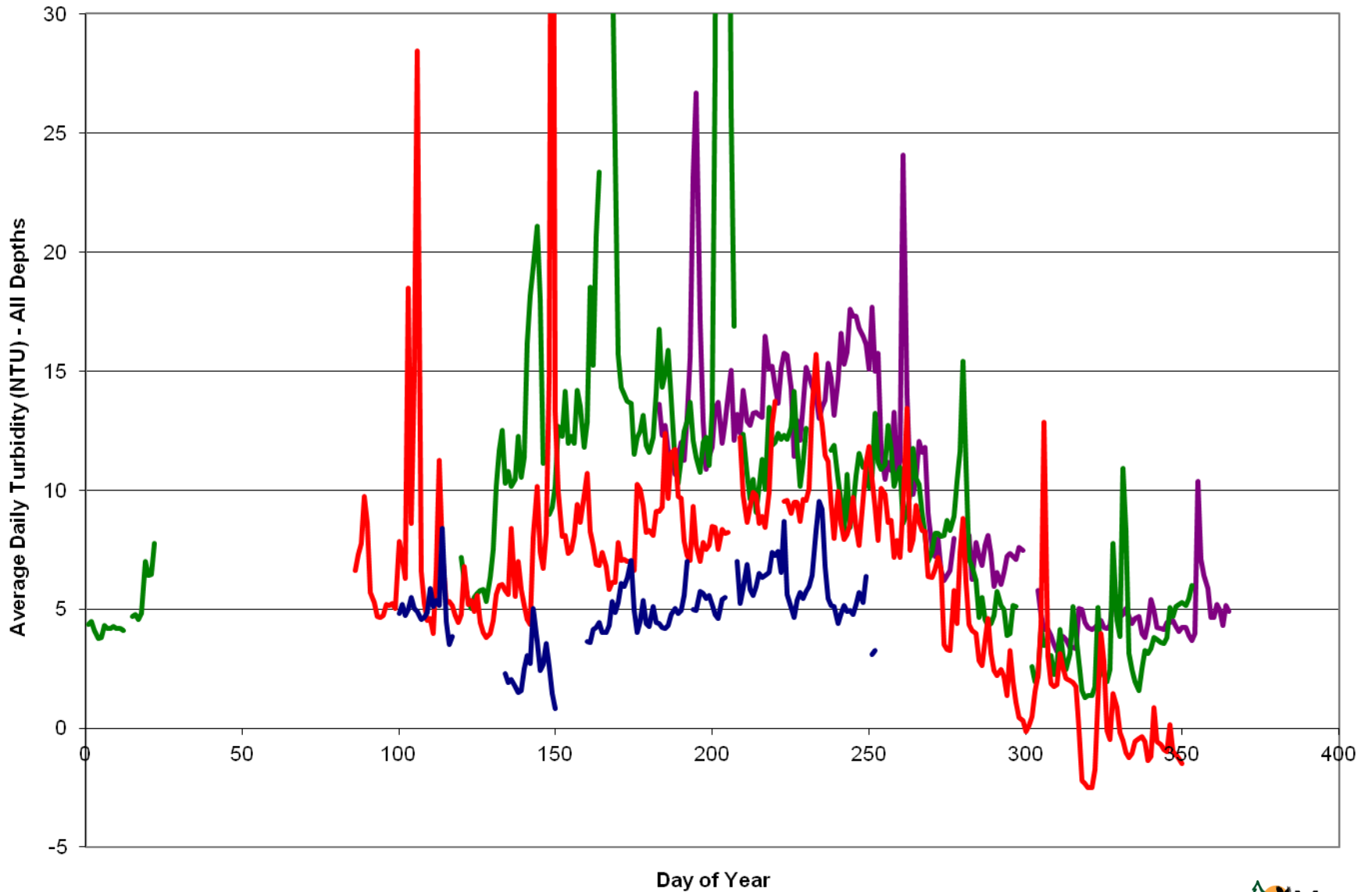
## Other Efforts

- Horn Pt. Hatchery ConMon  
<http://www.umces.edu/hpl/choptank-river-horn-point>  
*(wtemp, cond, chl, salin.)*
- Green Eyes Chop River Bridge ConMon (?)
- NOAA site 8571892 (*Met, Water Level, Wtemp*)
- Gooses Reef (Surface/Bottom WQ; Met)

# Harris Creek Profiler Site

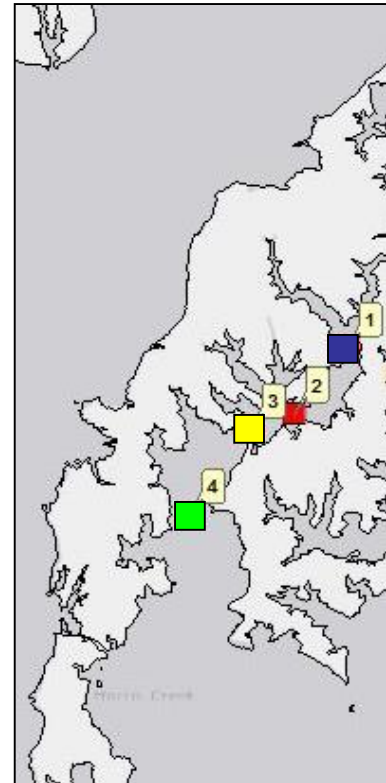
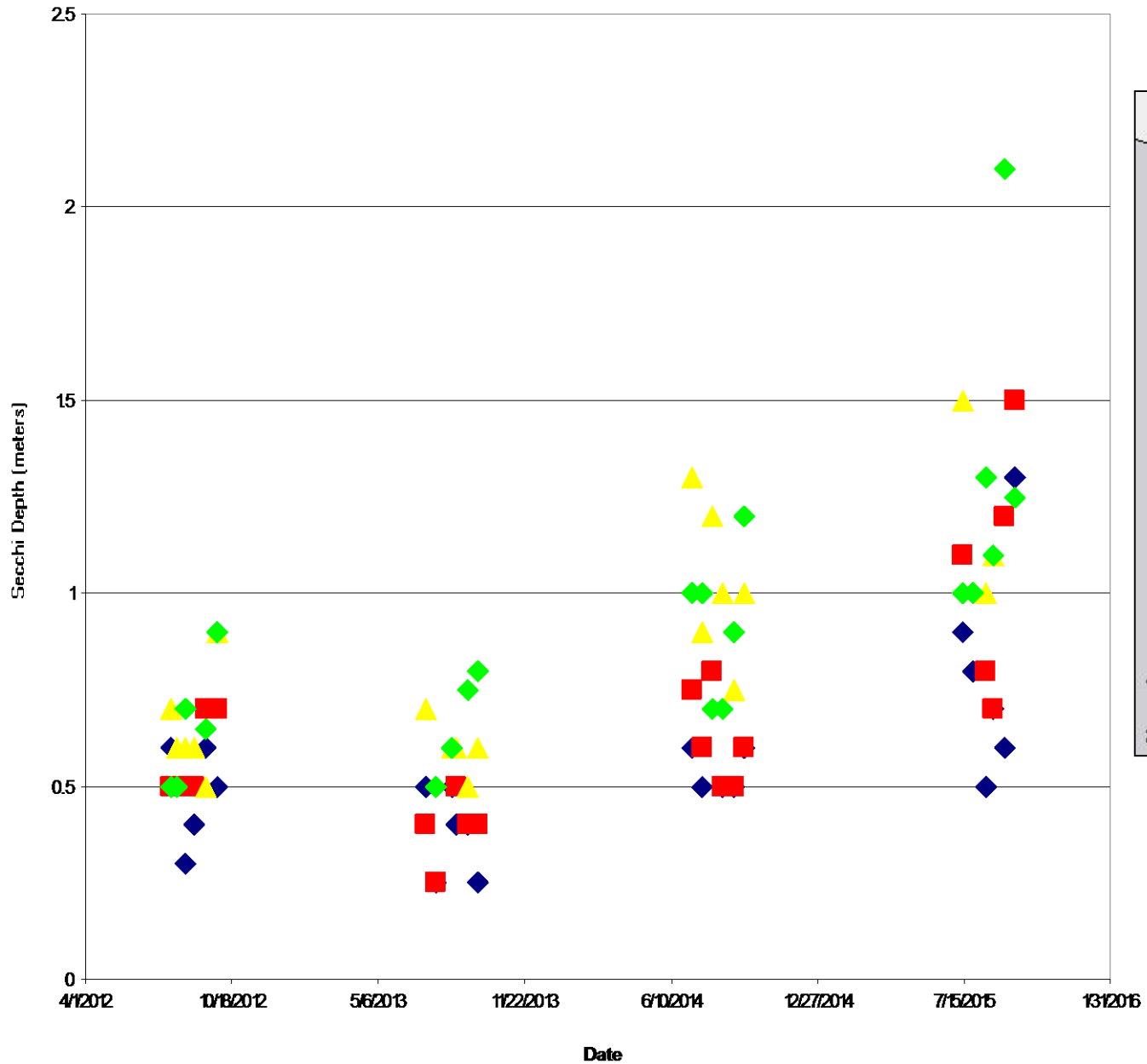


# Harris Creek Profiler Turbidity



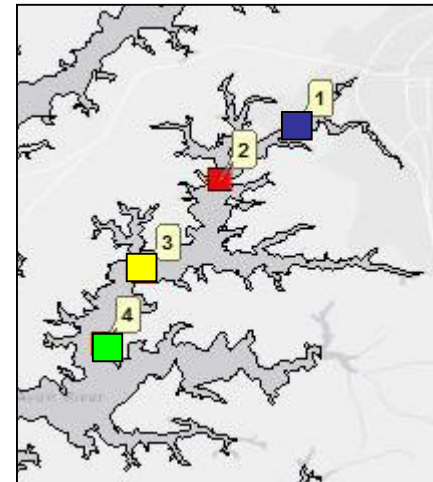
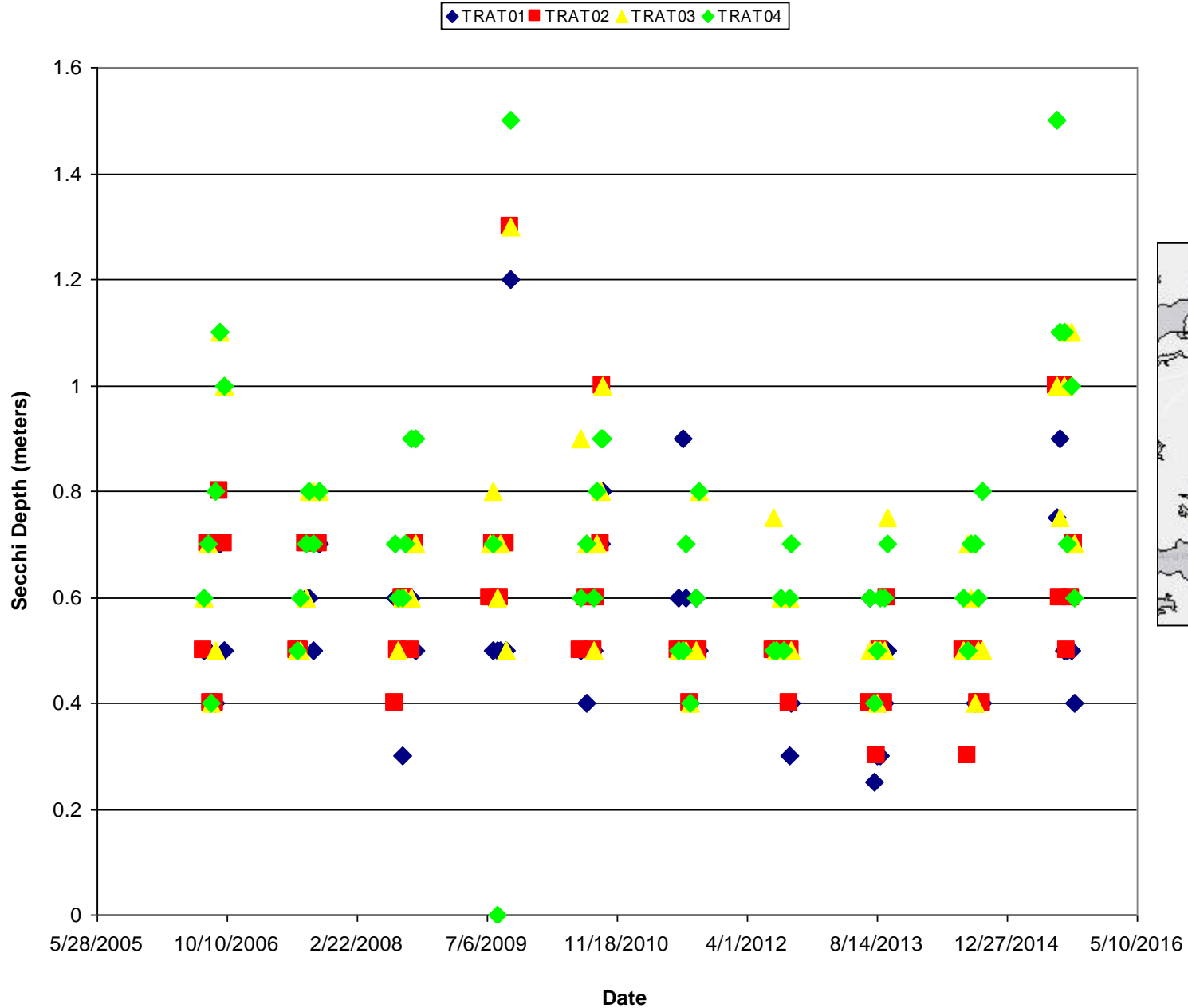
# Harris Creek - Secchi

◆ HART01 ■ HART02 ▲ HART03 ◆ HART04



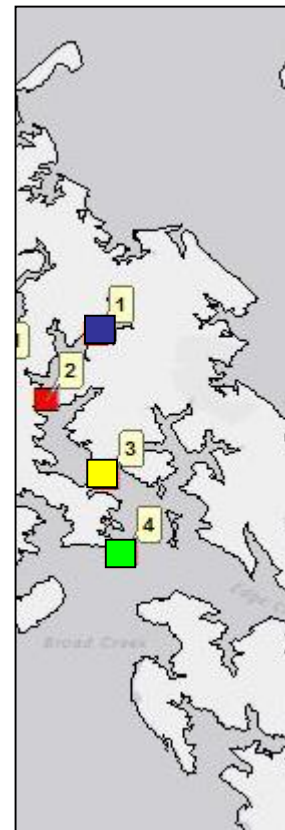
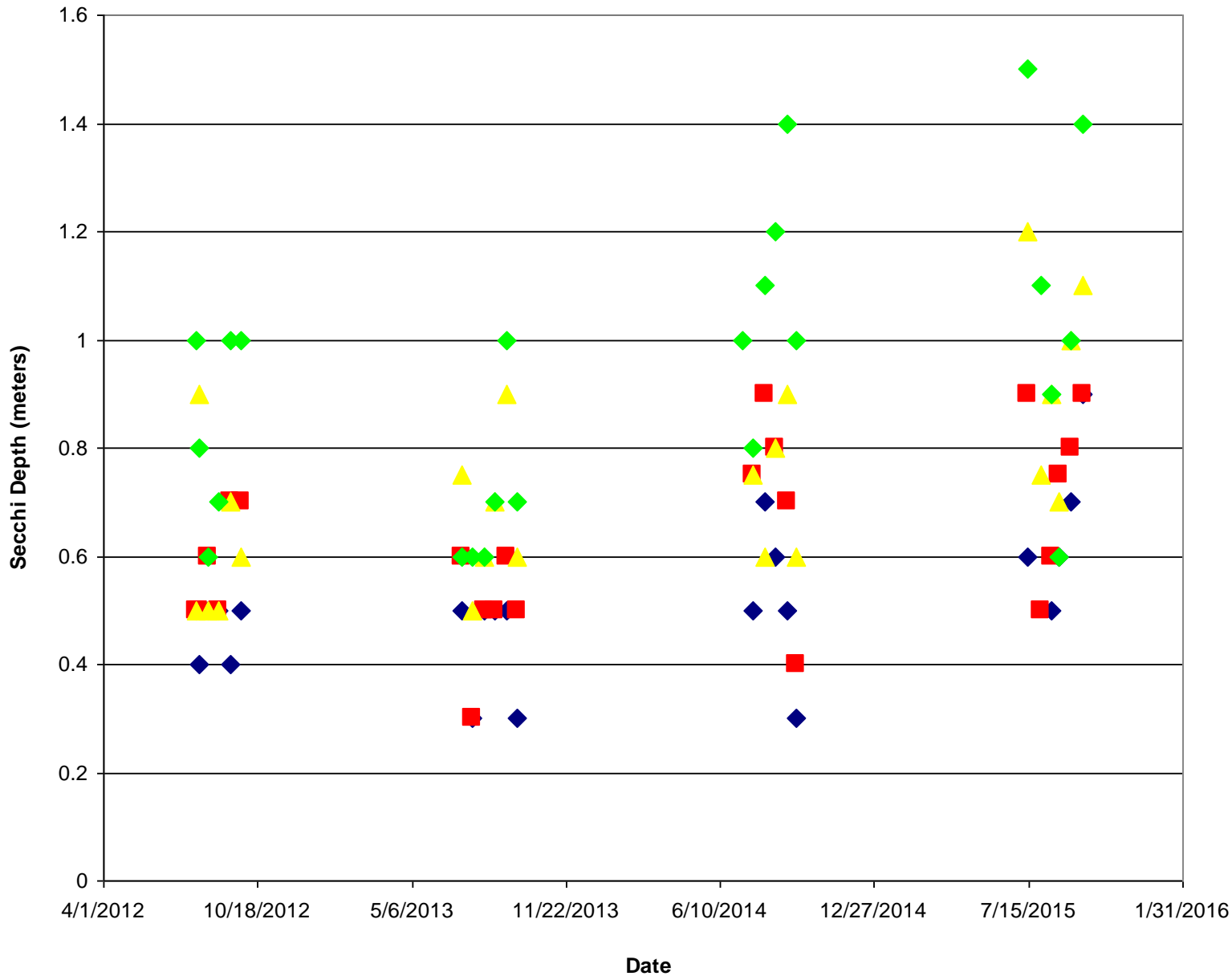


# Tred Avon River - Secchi

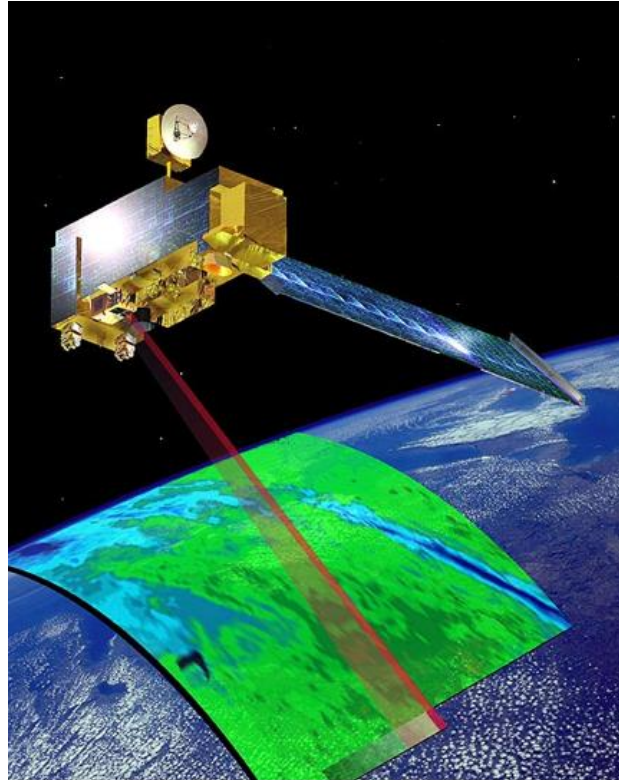


# Broad Creek - Secchi

◆ brot01 ■ brot02 ▲ brot03 ◆ brot04



# NOAA Satellite Analysis of Chesapeake Bay Water Clarity



# Satellite Turbidity Background

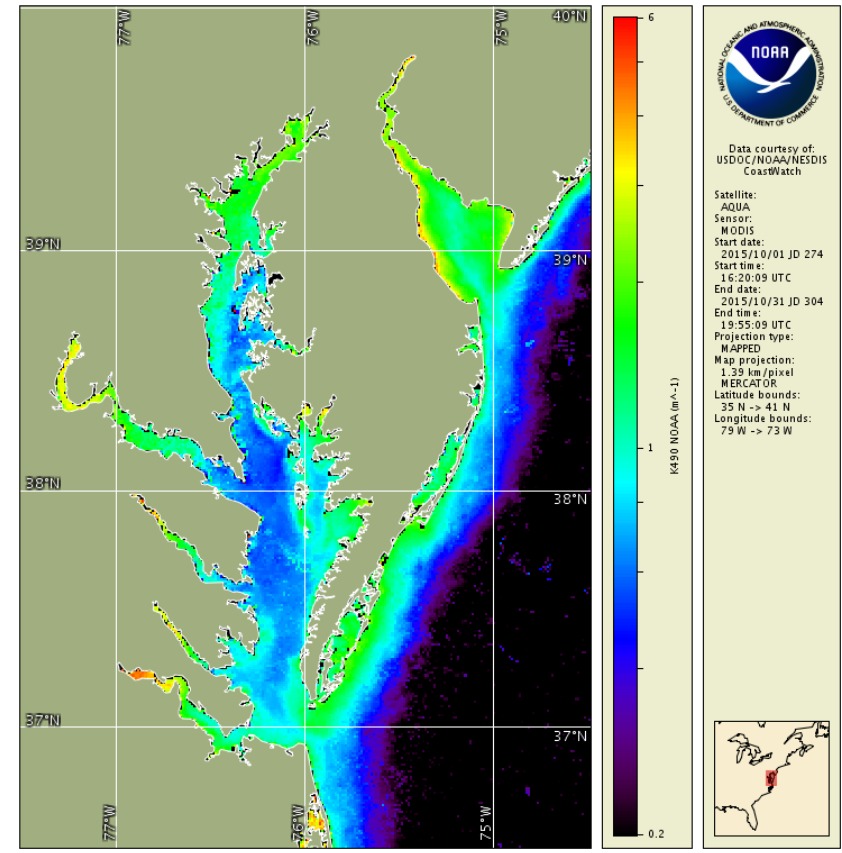
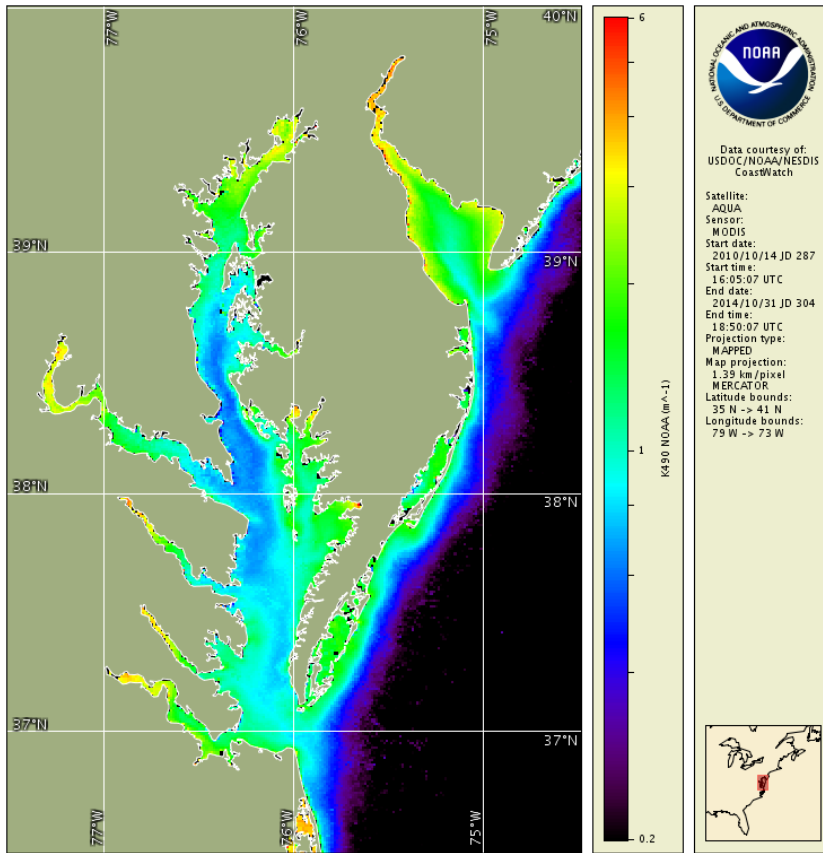
- **Specifically designed for accurate measurement in Chesapeake Bay**
- Measurement: Diffuse Light Attenuation Coefficient ( $m^{-1}$ )
- Definition: reduction in diffuse light over a distance in the water (at wavelength 490 nm)
- Geophysical basis: upper water column particles reflect sunlight back to the satellite instrument
- Depth of measurement: varies with amount of particles in the water, approximate range 0.1 – 2.0 m, on average 1.0 m
- Measured by NASA Aqua satellite
- Instrument: Moderate Resolution Imaging Spectroradiometer (MODIS)
- Passes over Chesapeake Bay once per day
- Clouds obscure measurement
  - Weekly or monthly averages more statistically meaningful than daily overpass
- Algorithm: Wang et al., Journal of Geophysical Research, 2009





# Satellite Turbidity (Clarity): October

high values more turbid, low values more clear

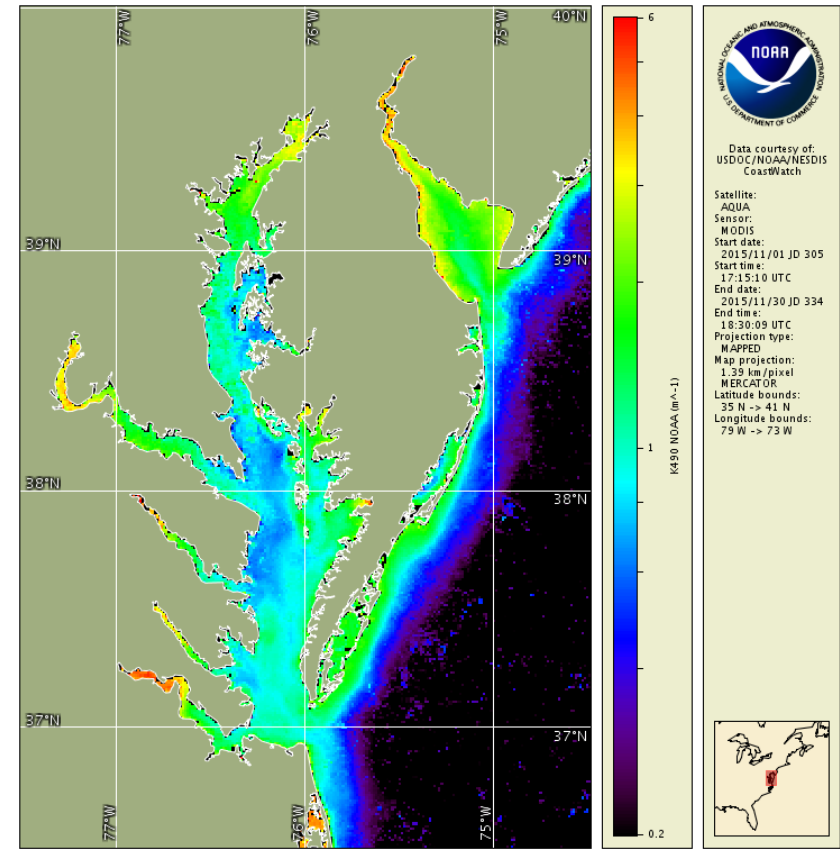
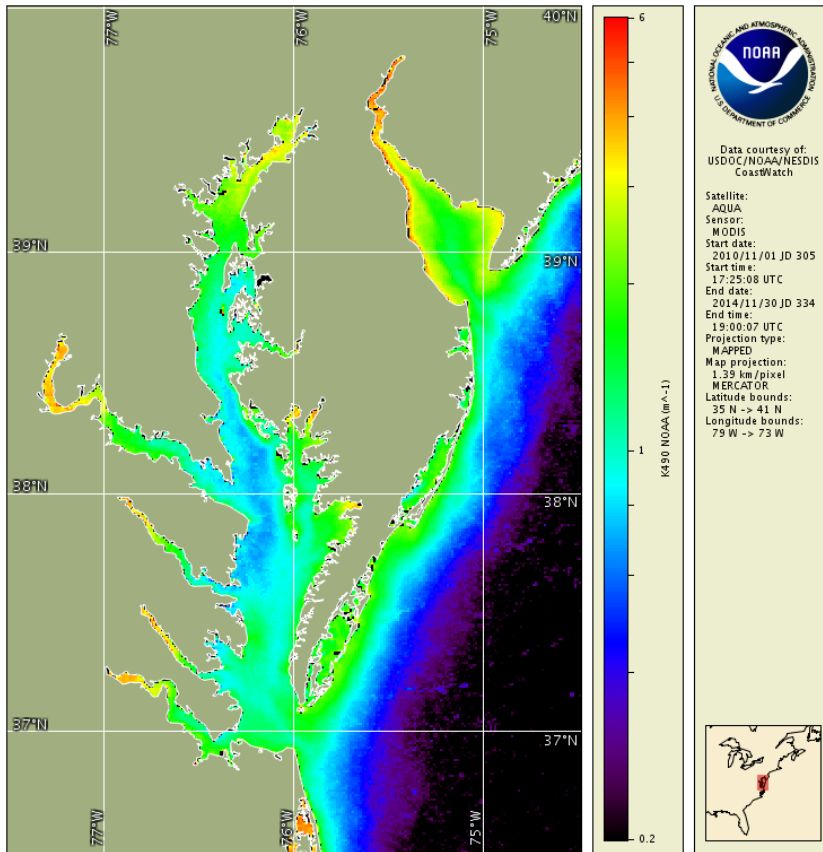


October monthly climatology: 2010-2014

October monthly average: 2015

**October 2015 is clearer than average October of previous 5 years**  
(climatology excludes Oct 2011 due to remaining high sediment from Tropical Storm Lee)

# Satellite Turbidity (Clarity): November high values more turbid, low values more clear



November monthly climatology: 2010-2014

November monthly average: 2015

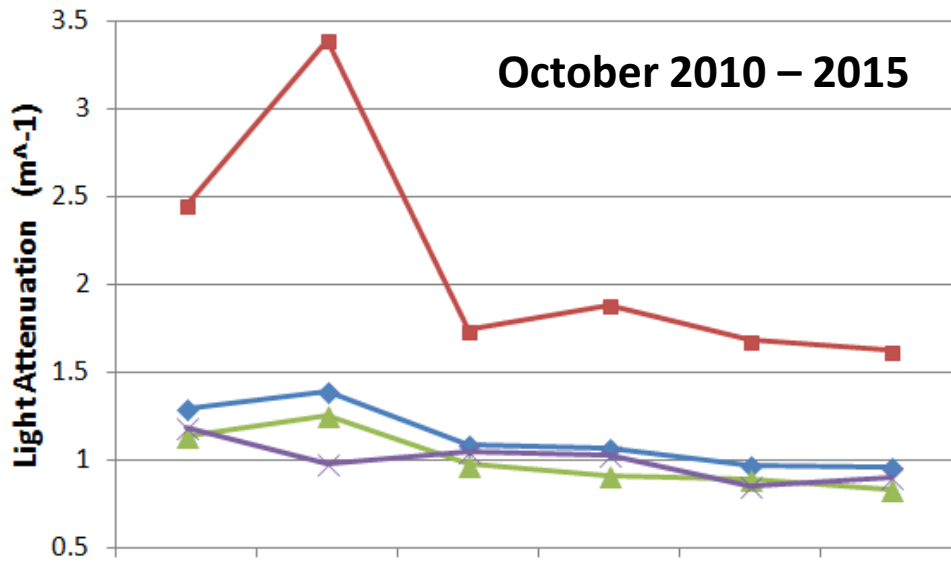
**November 2015 is clearer than average November of previous 5 years**  
(climatology excludes Nov 2011 due to remaining high sediment from Tropical Storm Lee)

# Satellite Time Series

## Monthly average by year: 2010 – 2015

Oct monthly avg:

2015 is lowest year for main stem, upper bay, & middle bay

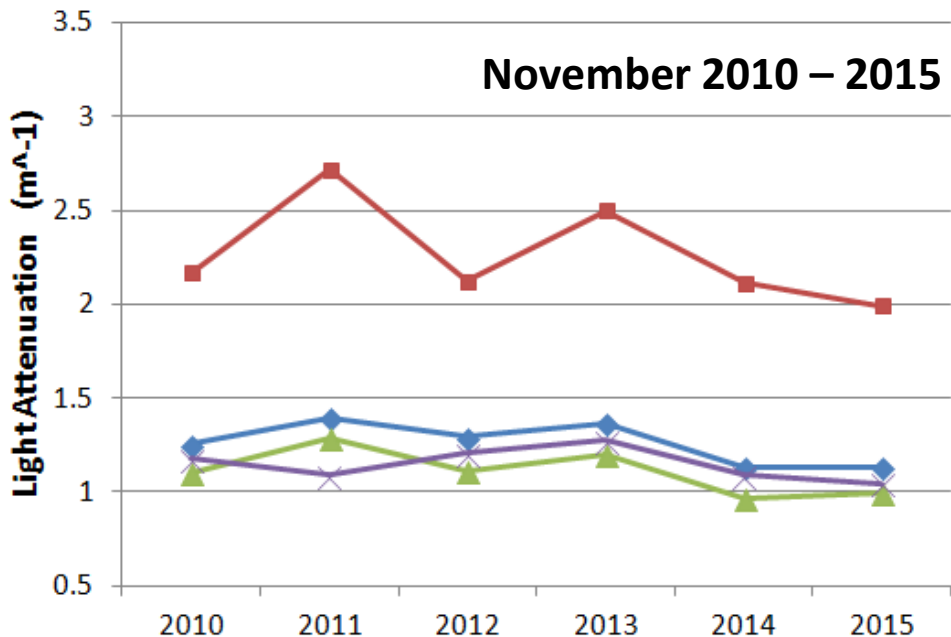


- ◆ Main Stem
- Upper Bay
- ▲ Middle Bay
- × Lower Bay

Nov monthly avg

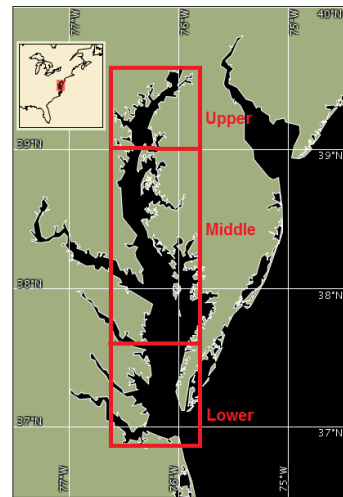
2015 is lowest year for upper bay.

2014 & 2015 are lowest for main stem.



- ◆ Main Stem
- Upper Bay
- ▲ Middle Bay
- × Lower Bay

Regional averages:

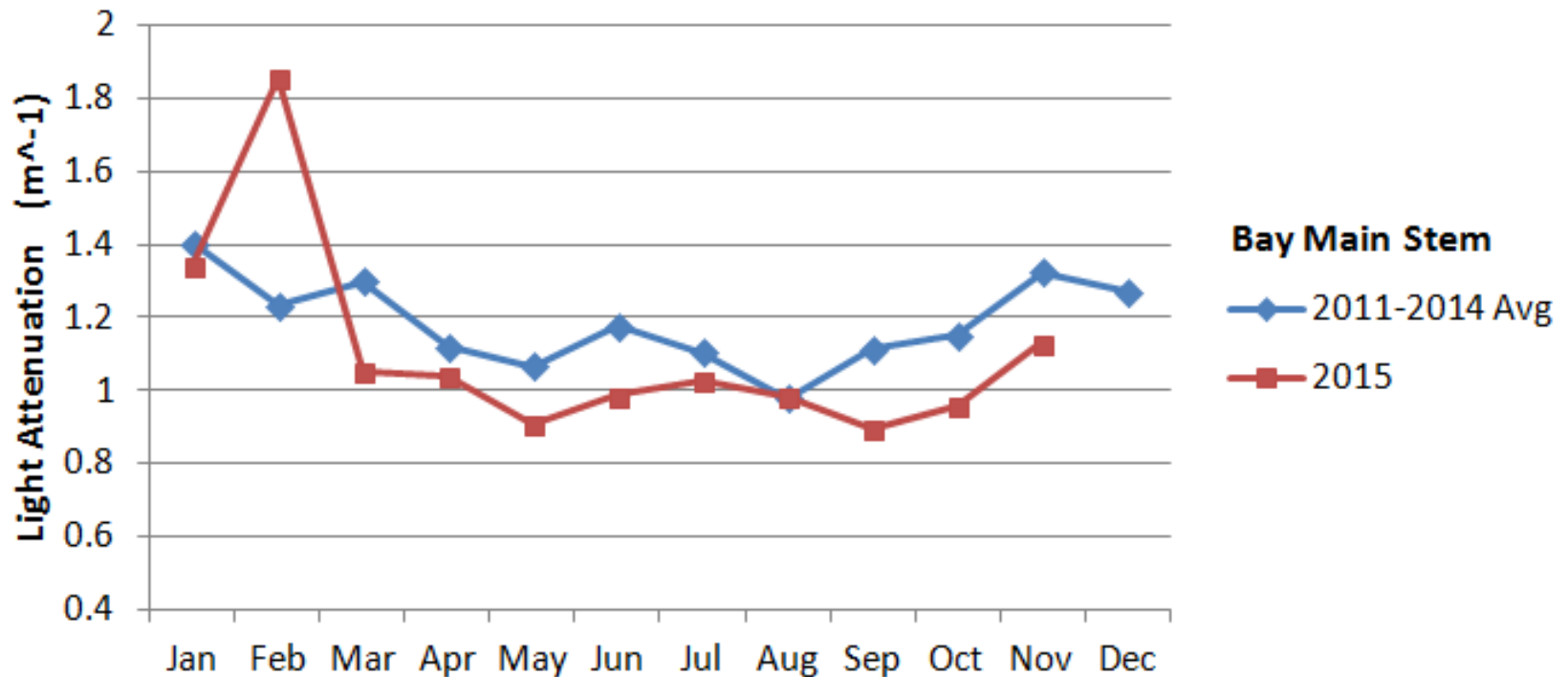


Main Stem = all 3 regions



# 2015 is mostly a low turbidity year

Chesapeake Bay Satellite Turbidity  
Current Year vs. 4-year Average



**Note:** 4-year average shows that Bay turbidity is **high in winter and summer** and **low in spring and fall**.



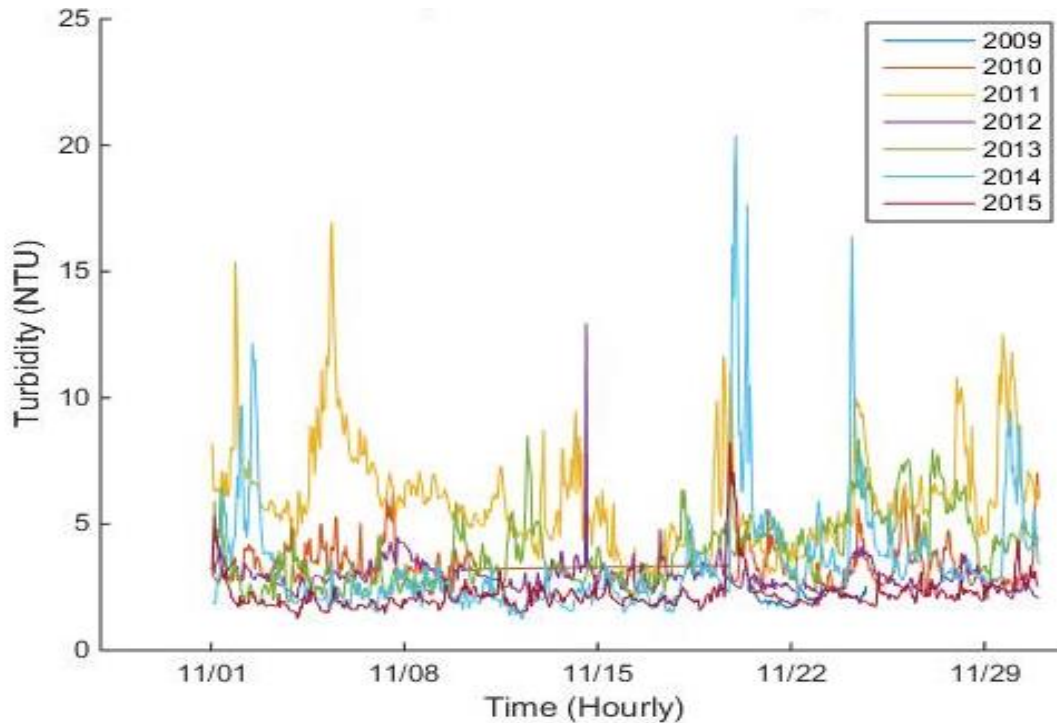


# NOAA Chesapeake Bay Interpretive Buoy System (CBIBS)



Range: 0 – 100 NTU  
Wavelength: 700 nm  
Sensitivity: 0.013 NTU

# Annapolis November Turbidity over Time



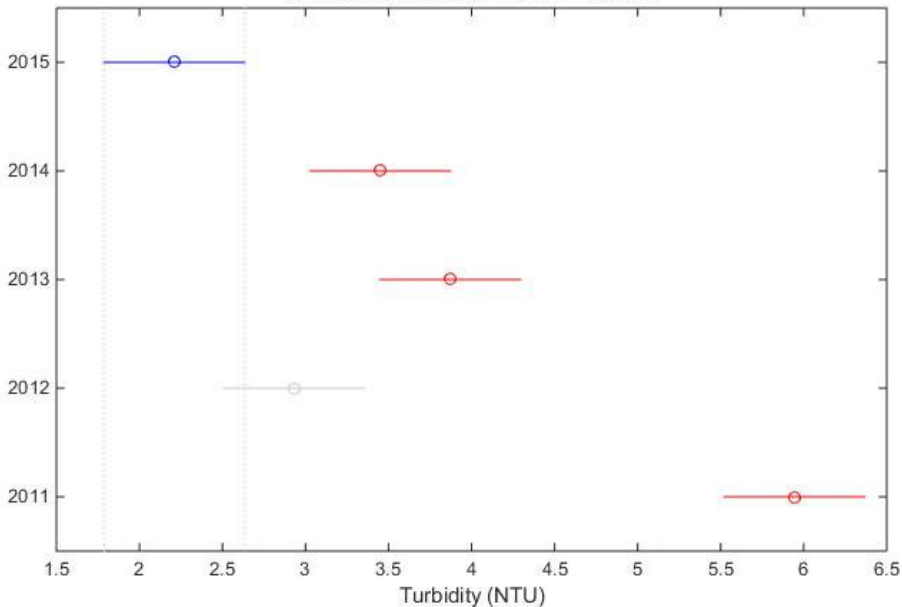
**Annapolis Monthly November Turbidity**

	Min	Max	Median	Mean	STD
2009	1.67	2.77	1.98	2.04	0.25
2010	2.1	7.04	3.19	3.36	0.78
2011	2.72	16.96	5.61	5.94	2.05
2012	1.91	12.95	2.87	2.93	0.60
2013	1.78	8.49	3.61	3.87	1.35
2014	1.21	20.39	2.82	3.45	2.30
2015	1.26	8.24	2.08	2.21	0.67

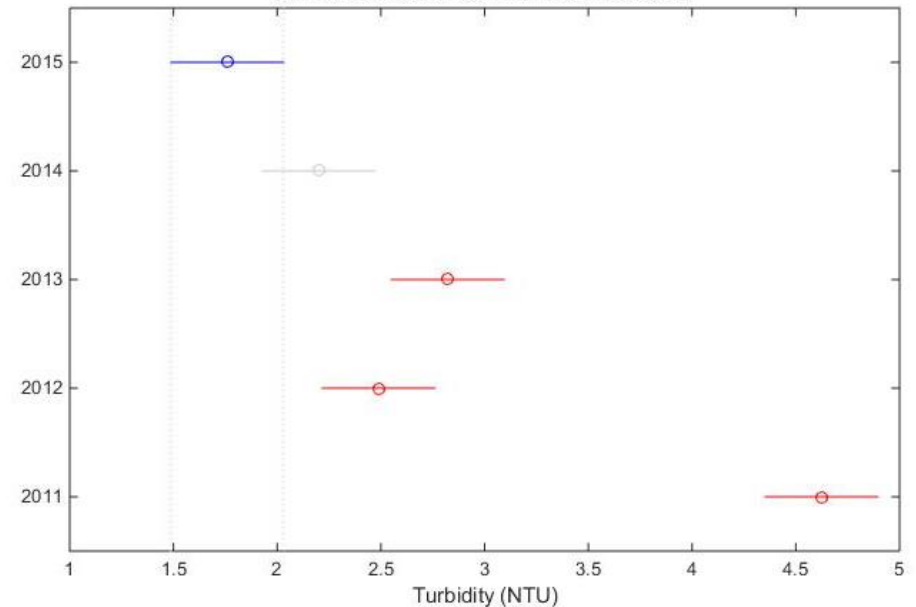
# Annapolis Statistical Results

- Multiple comparison between various years using the one-way analysis of variance (ANOVA) results with 95% confidence levels.
- Average daily mean (left) and average daily minimum turbidity (right)

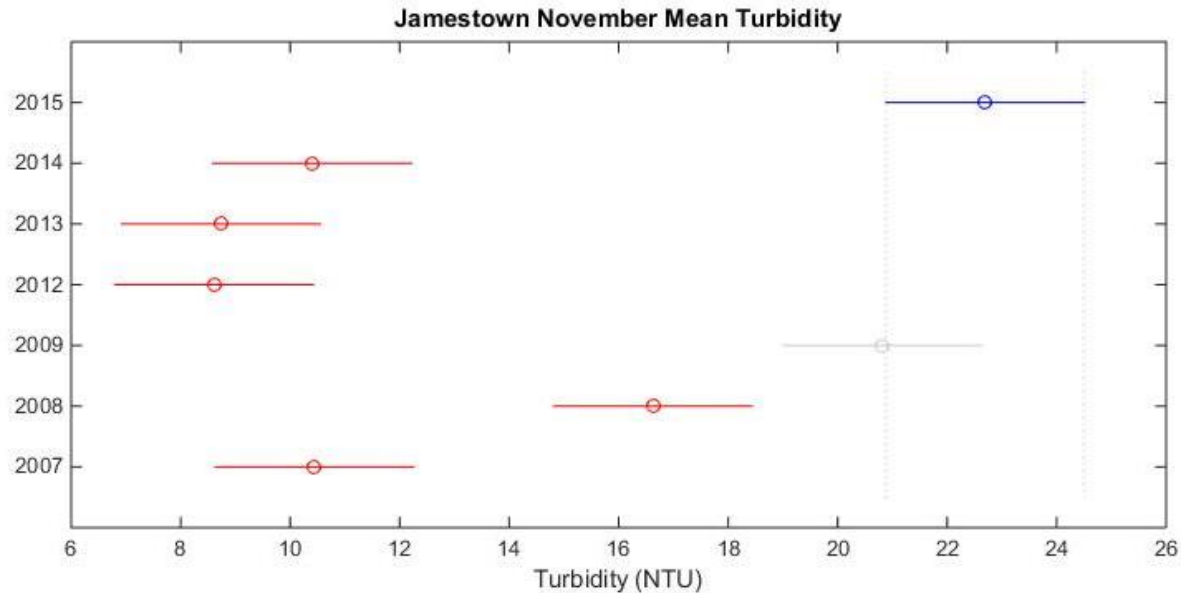
Annapolis November Mean Turbidity



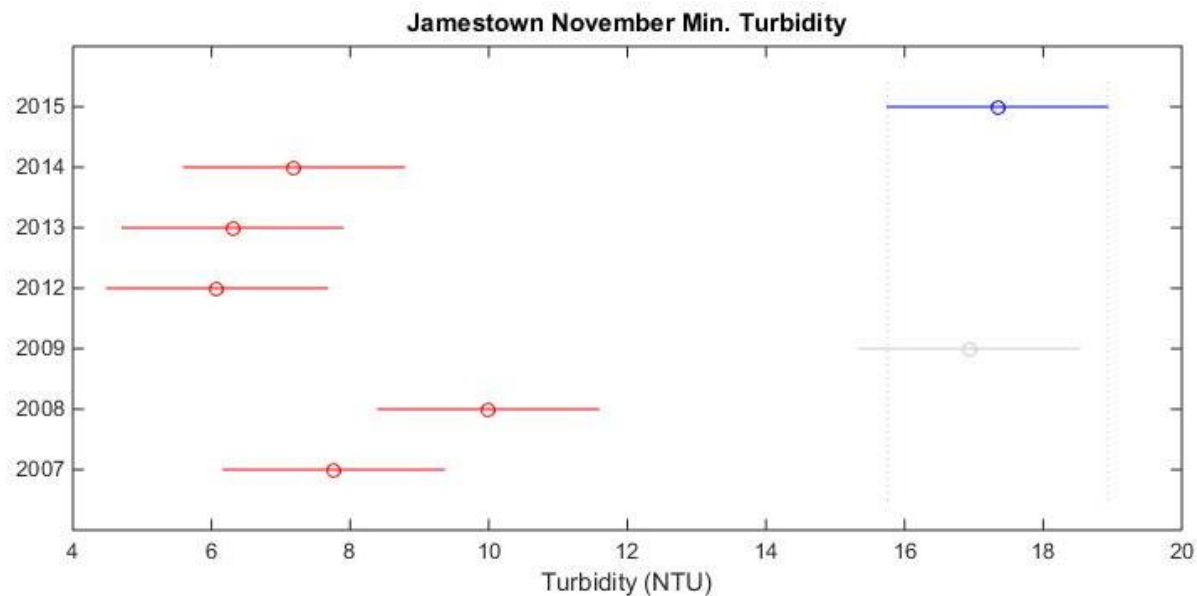
Annapolis November Minimum Turbidity



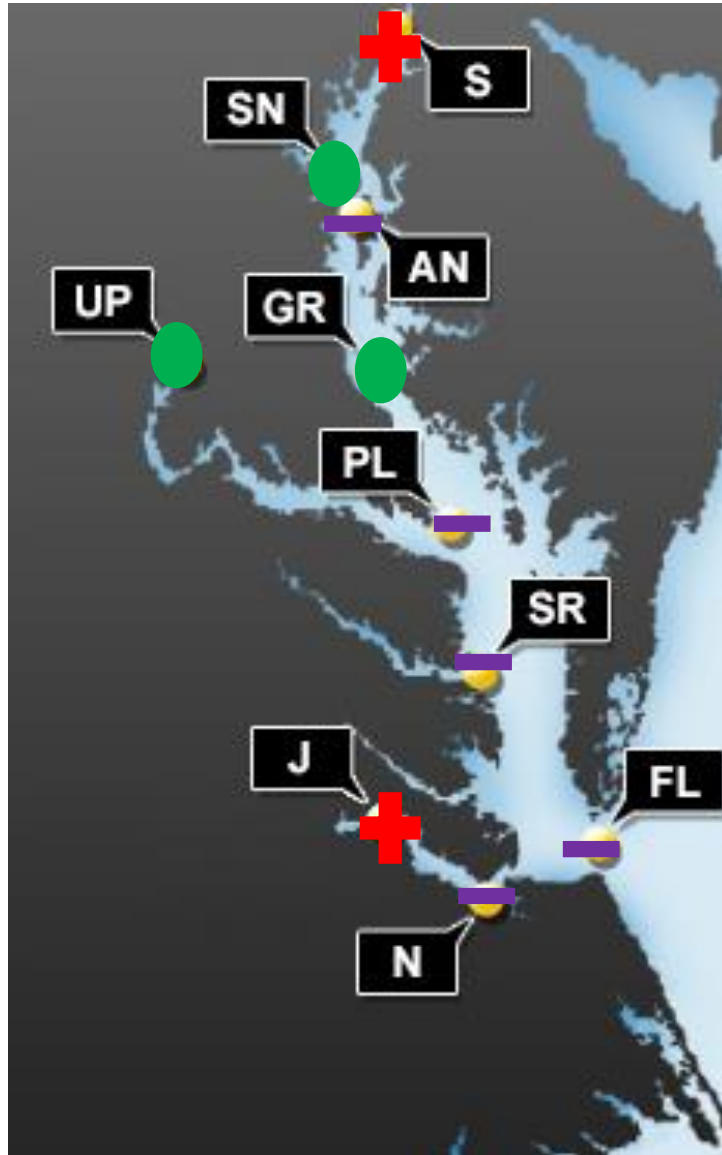
# Jamestown Statistical Results






The Bay was NOT clearer everywhere in Nov. 2015 than prior years!



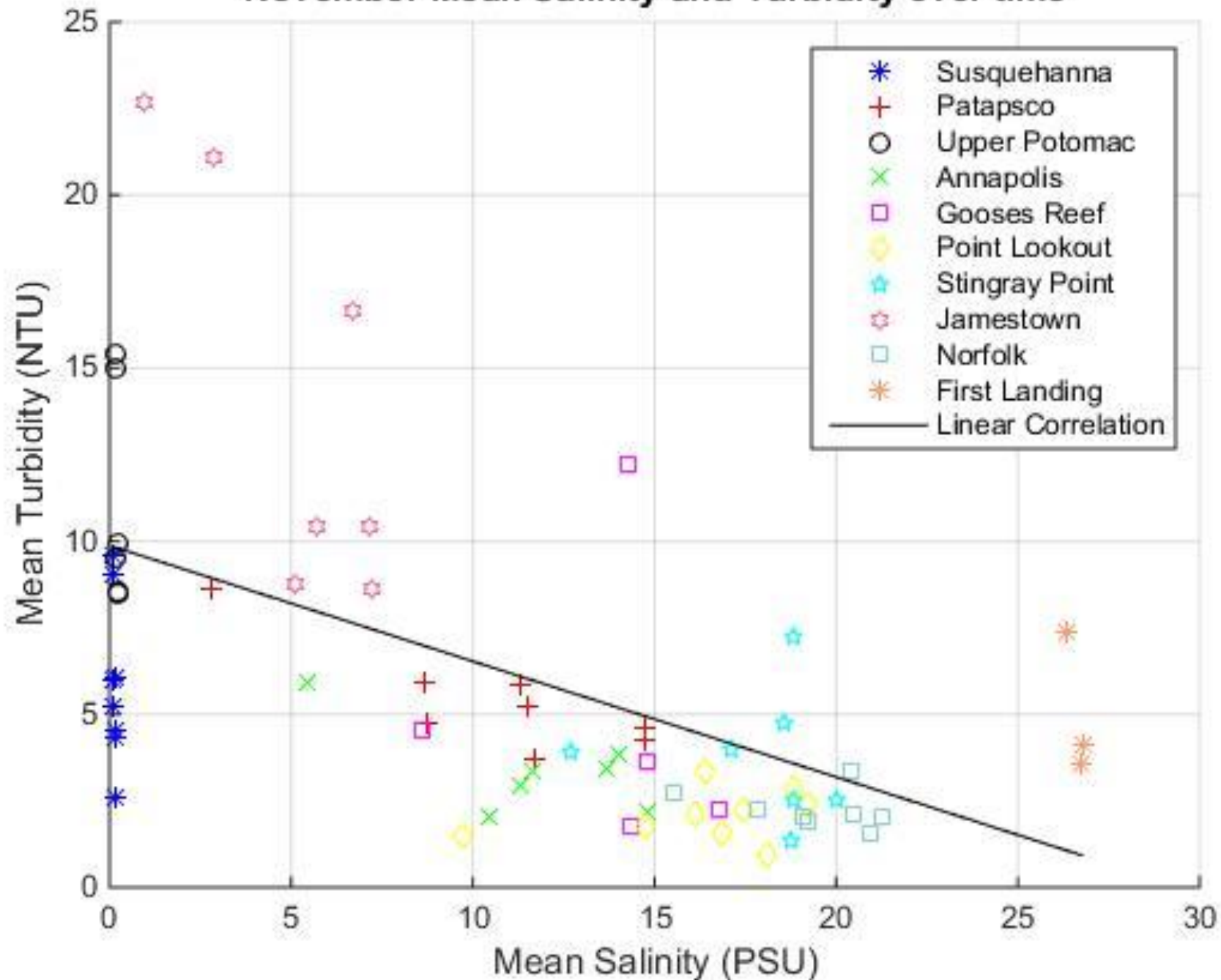
# CBIBS Nov. 2015 Turbidity Results



-  Increase turbidity
-  Decrease turbidity (“clearer”)
-  Inconclusive results



### November Mean Salinity and Turbidity over time



# Conclusions

- MD DNR Secchi Disk results revealed that Oct. 2015 was not clearer than 30 year historical record. However, Oct. 2015 was clearer when compared to the most recent 5-10 years.
- NOAA Satellite data showed the majority of the Bay in Oct. and Nov. 2015 were both clearer than the average of the previous 5 years of each month, respectively.
- NOAA CBIBS Nov. 2015 turbidity was statistically lower than the majority of prior Novembers at 5 of the 10 buoys.
- The entire Bay was not clearer in Oct. and Nov. 2015. Two buoys had statistically higher turbidity in Nov. 2015 and the satellite data also showed areas of increased turbidity in Oct. and Nov. 2015.
- DNR and CBIBS data showed the correlation between turbidity and salinity. In the majority of the buoys, the turbidity lowered with increased salinity, as expected.
- Further research could be done linking the USGS flow gage data, wind anomalies, salinity, turbidity and chlorophyll to get a better understanding of the causes of the Nov. and Oct. 2015 water quality results.