K_d and Secchi trends and patterns over time:

using GAM approach

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UMCES at CBP

STAC meeting 5-2-2017

Outline

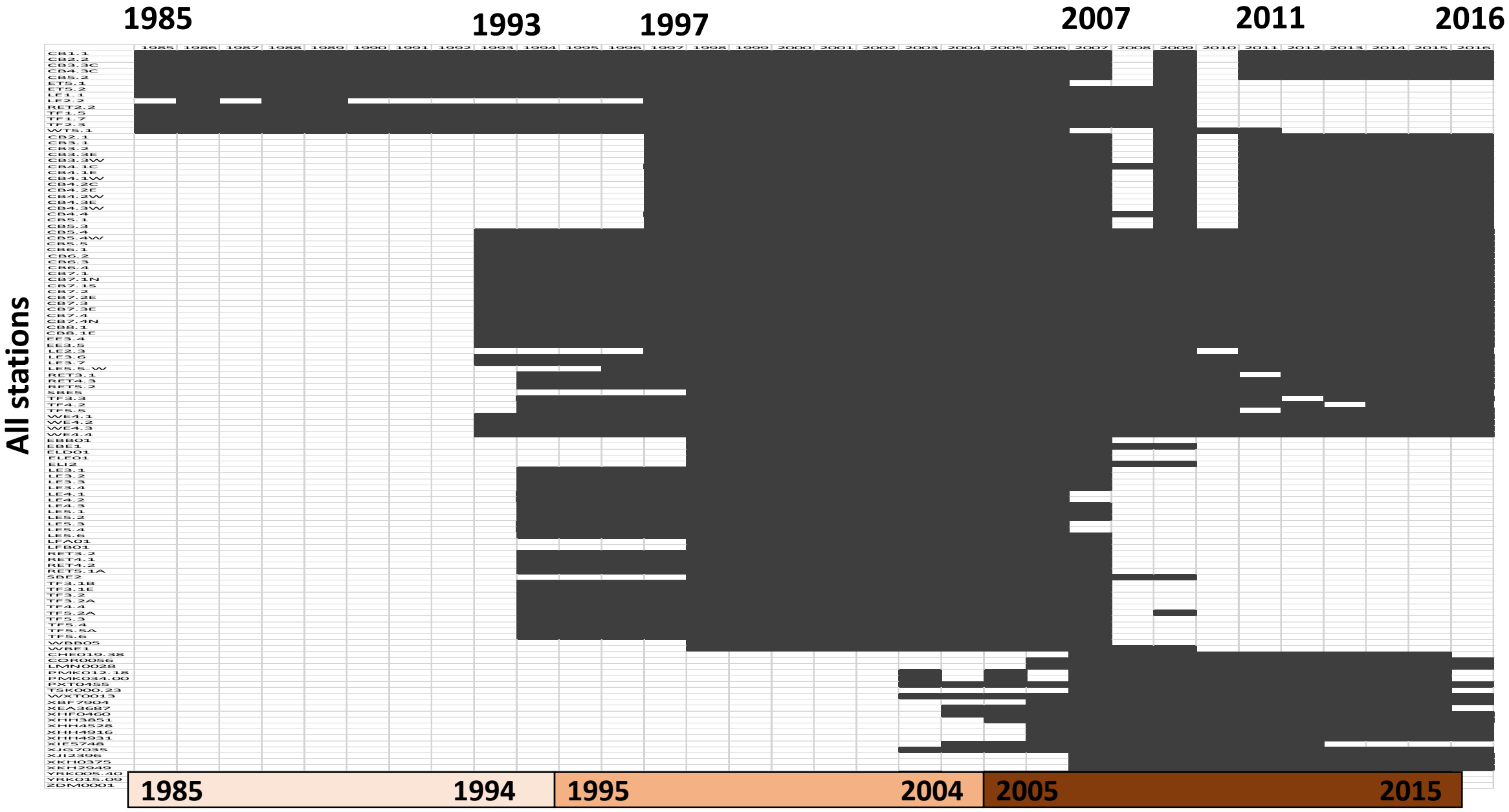
- Availability of Kd data
- GAM method
- kd trends over time: Maps and examples from different periods
- Secchi trends over time : side-by-side with kd
- First-cut summary of kd and Secchi trends by salinity zone and sampling program
- → *lots of maps and graphs*

Kd data

- Long-term MD and VA
- CONMON and DATAFLOW calibration sites
- Limited to stations with >7 years of data
- Considered which seasons data is available.
  - All stations Apr-Oct coverage good
  - Only 76/128 had good enough annual coverage (VA stations only)
  - → maps here focus on change in Apr-Oct period only
- Selected different sets of years to analyze based on data available:

Kd data compiled by Mike Mallonee (ICPRB at CBP)

Kd distribution through time



Generalized Additive Model Approach

Table: GAM Analysis of Variance.

Type	Source	edf	F-stat	p-value
parametric terms	cyear	1.00	0.0008	0.9777
smoothed terms	s(cyear)	8.40	0.6247	0.1277
" "	s(doy)	7.06	3.5646	0.0002
" "	ti(cyear,doy)	4.59	0.8509	0.0231

Table: GAM Parameter Coefficients.

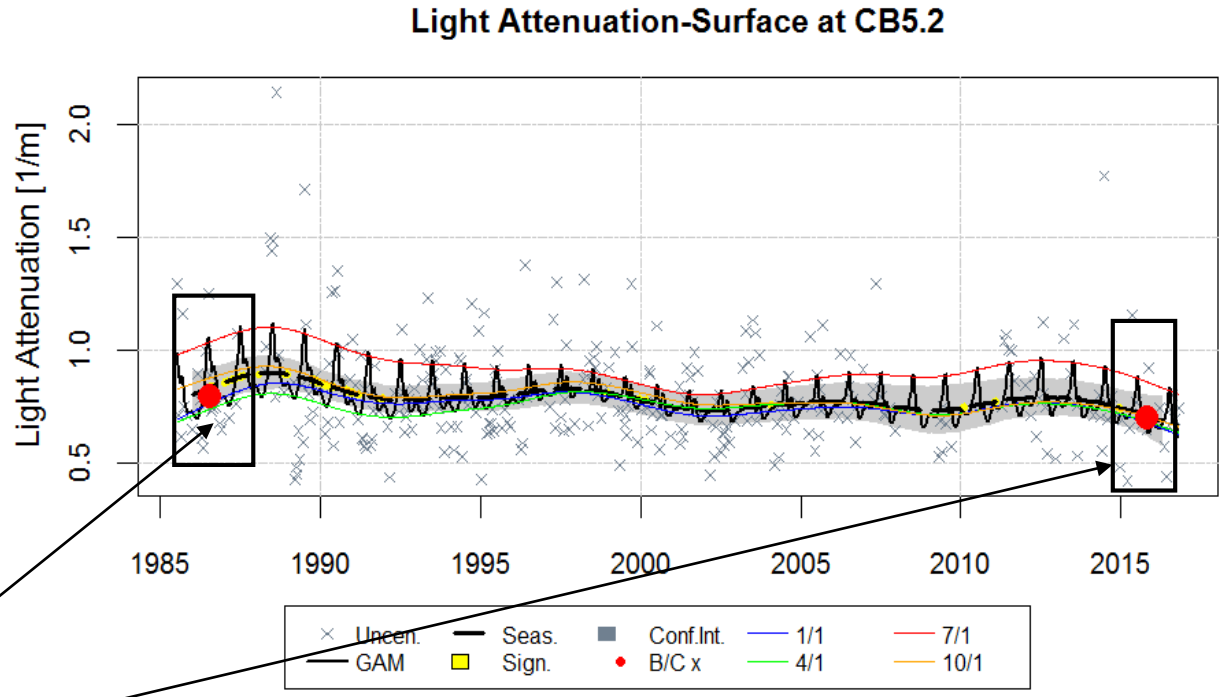
Parameter	Estimate	Std. Err.	t value	p-value
(Intercept)	0.807977	0.068152	11.8555	<0.0001
cyear	0.001033	0.036970	0.0279	0.9777

Table: GAM Diagnostics.

AIC	RMSE	Adj. R-squared
-77.95	0.2065	0.1324

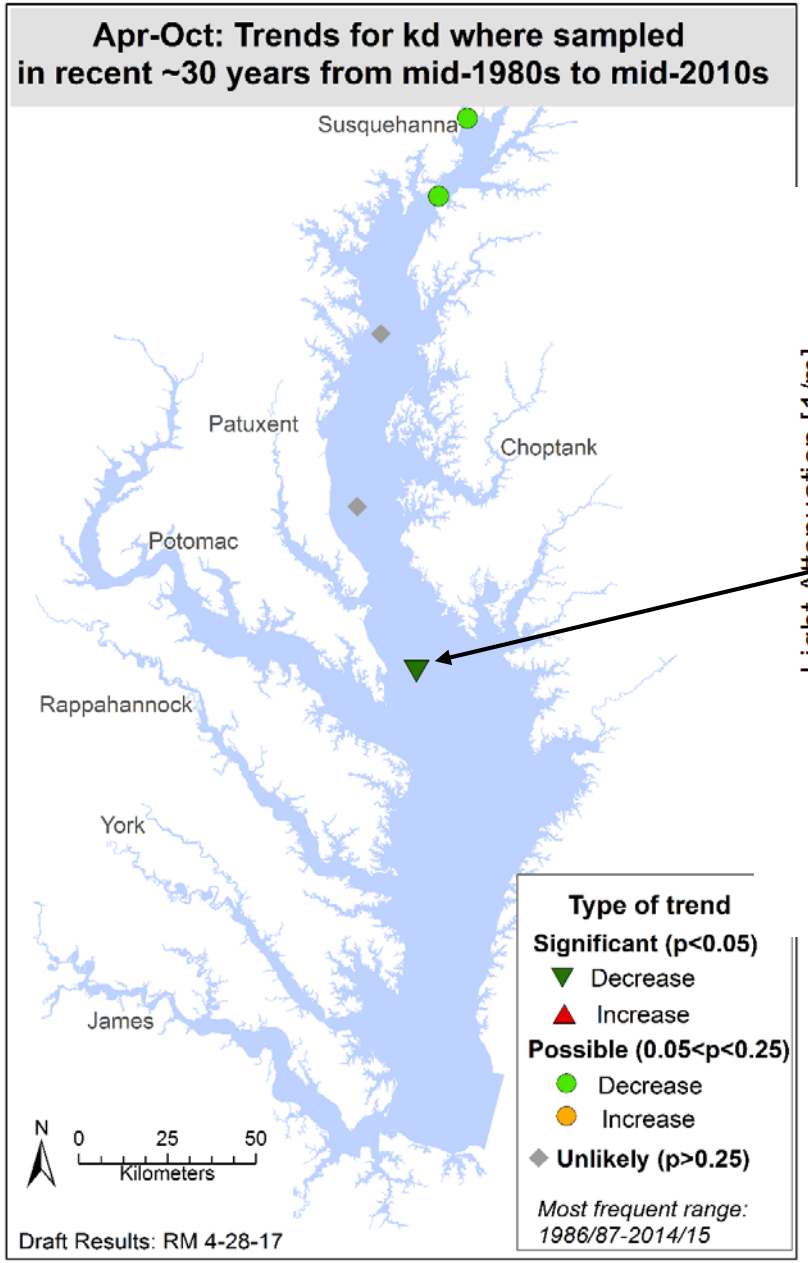
Table: Estimates of Change from 1985-2016.

Calculation	Estimate
Baseline mean	0.8012
Current mean	0.7024
Estimated difference	-0.0988
Std. Err. difference	0.0712
95% Confidence interval for difference	(-0.2382 , 0.0407)
Difference p-value	0.1662
Period of Record Percent Change Estimate (%)	-12.33%



x= data
Black line = full model
Colored lines = estimates on different days of the year (red is 7/1)

GAM development team: Elgin Perry, Jon Harcum (Tetra Tech), Jeni Keisman (USGS), Mike Lane (ODU), Renee Karrh (MDDNR)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Most frequent range:
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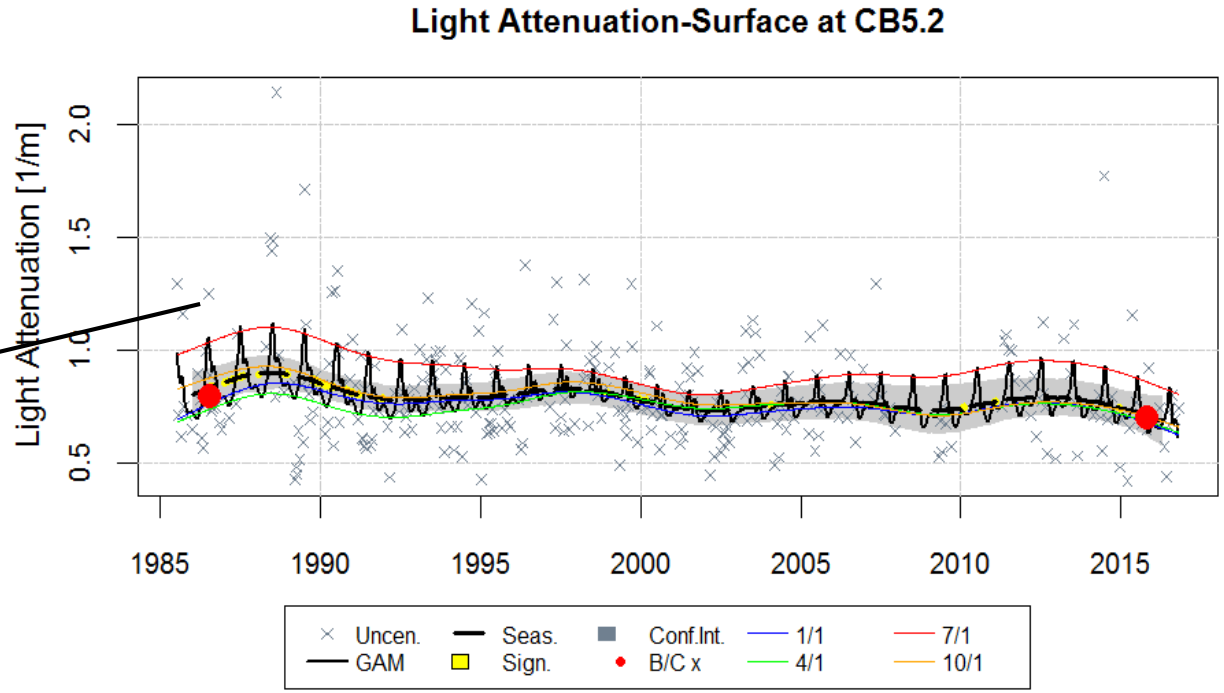
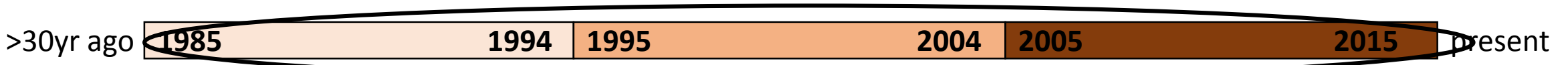
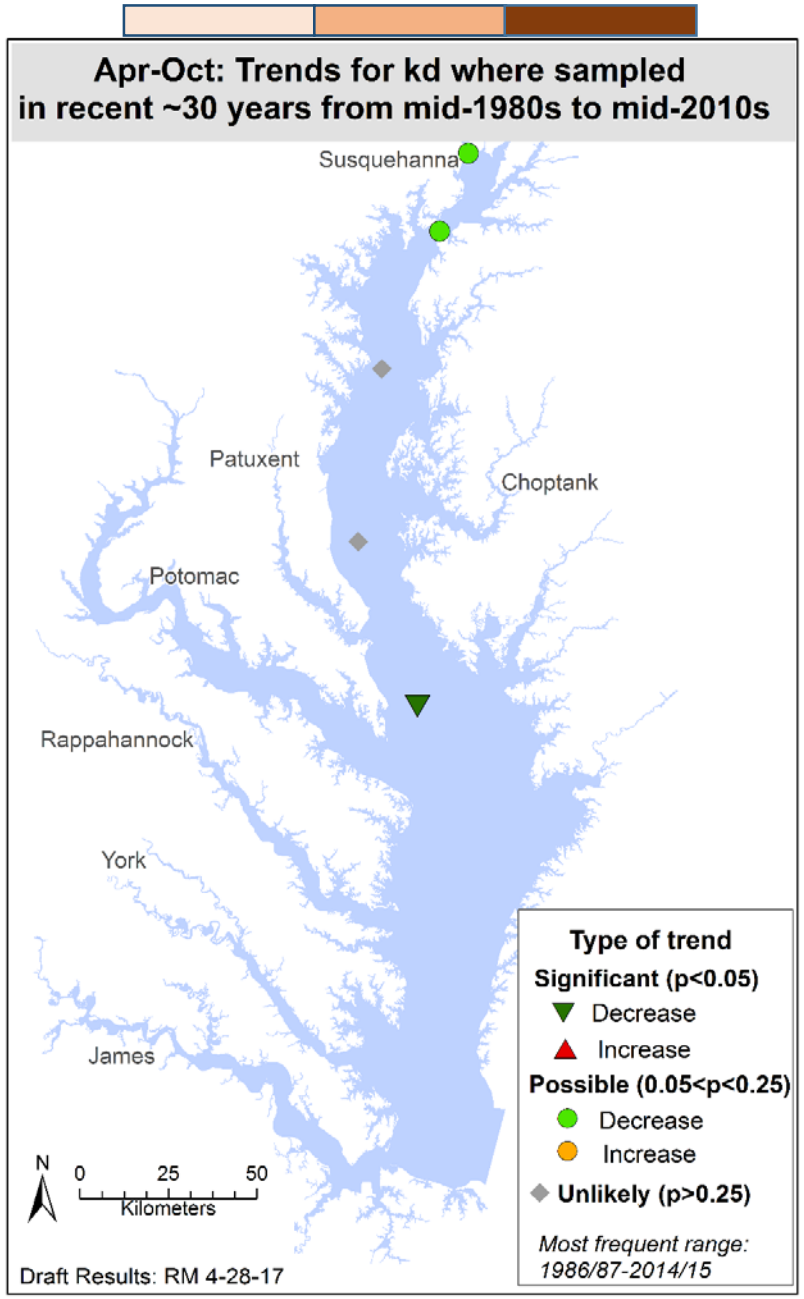
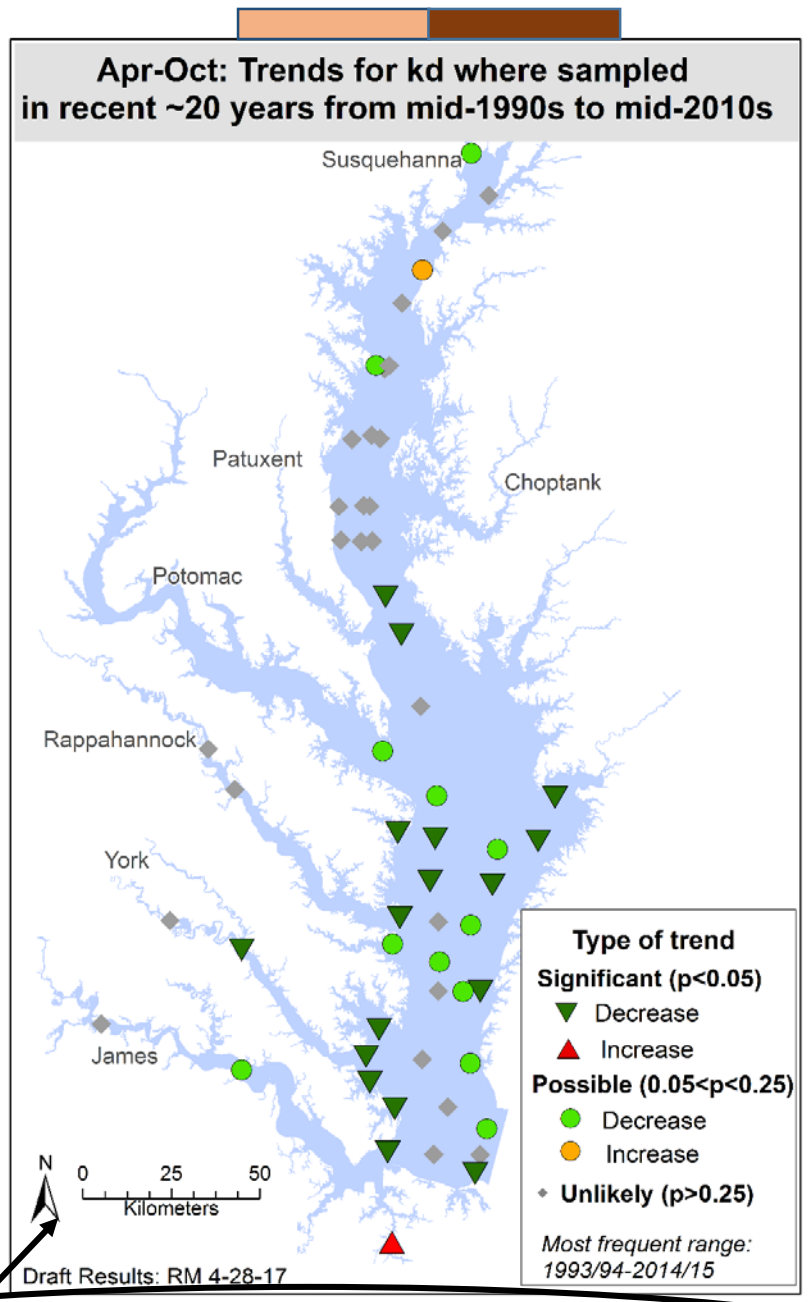
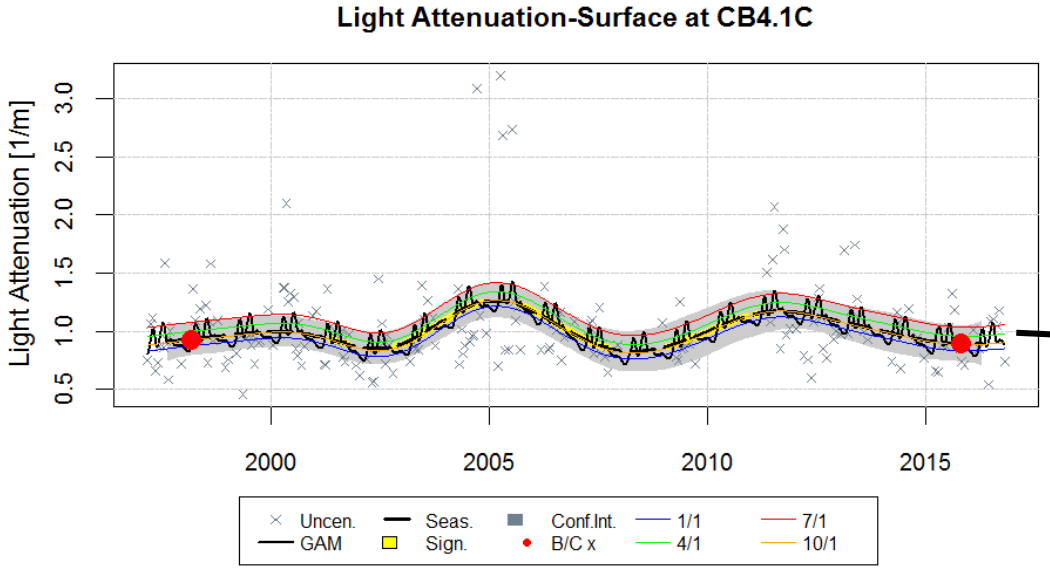

Light Attenuation-Surface at CB5.2
Light Attenuation [1/m]
0.5
1.0
1.5
2.0
1985
1990
1995
2000
2005
2010
2015
Uncen.
GAM
Seas.
Sign.
Conf.Int.
B/C x
1/1
4/1
7/1
10/1

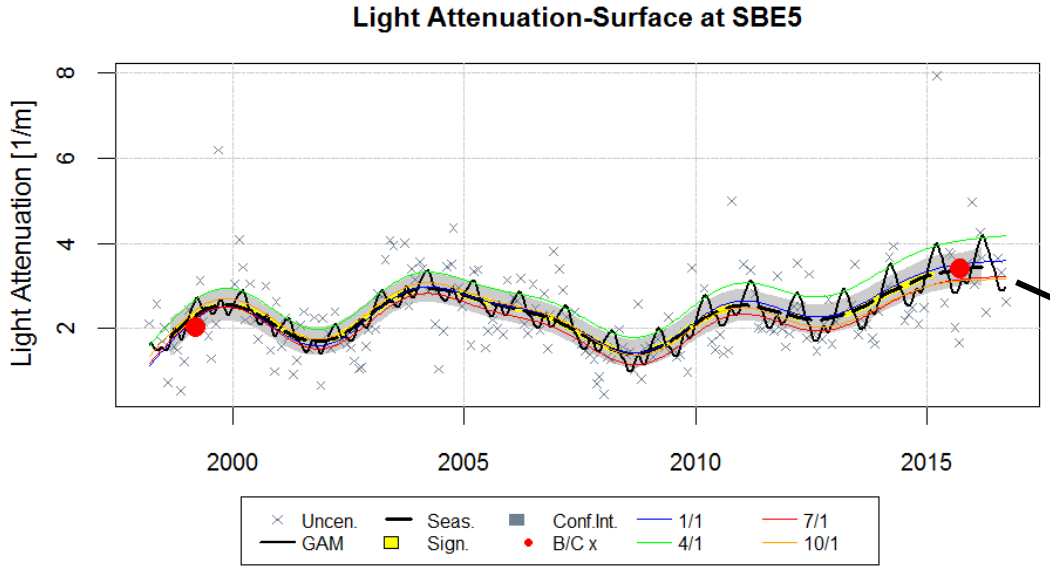

>30yr ago
1985
1994
1995
2004
2005
2015
present

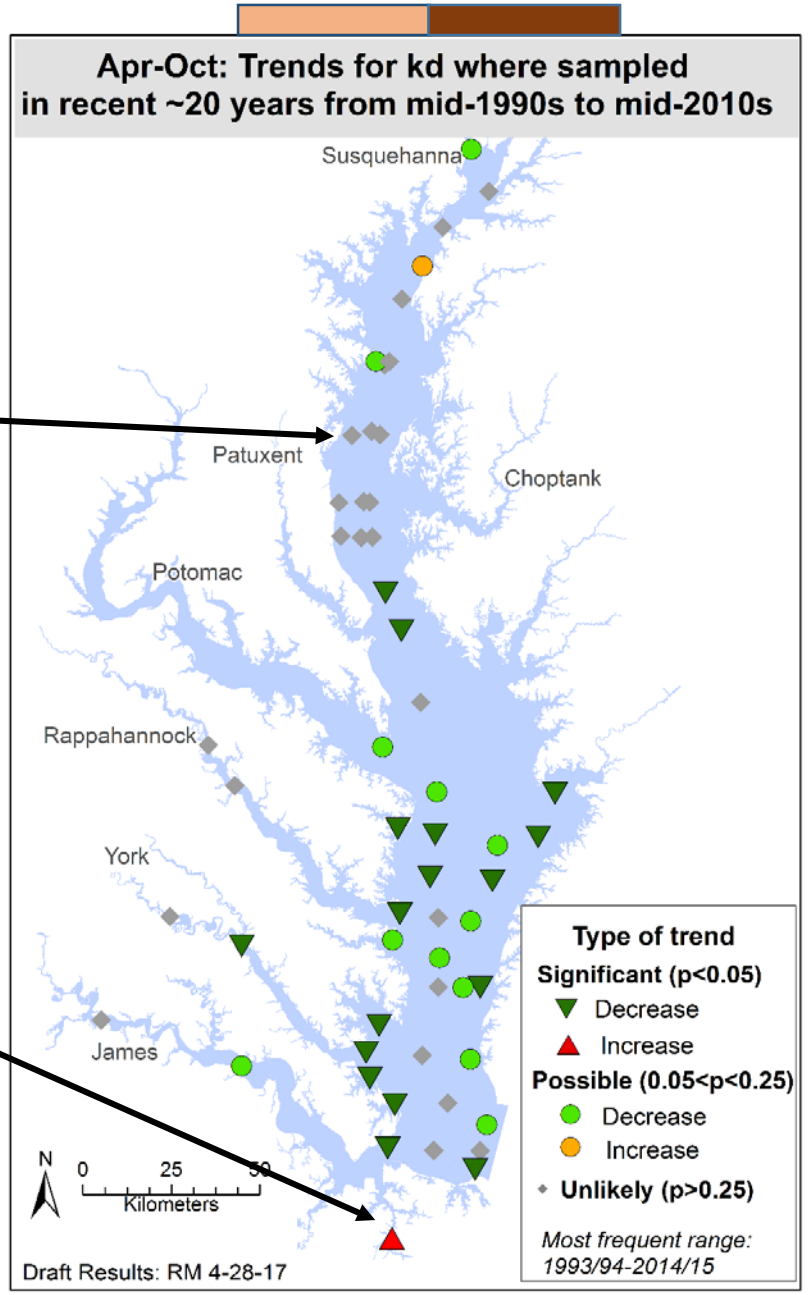




>30yr ago | 1985 | 1994 | 1995 | 2004 | 2005 | 2015 | present

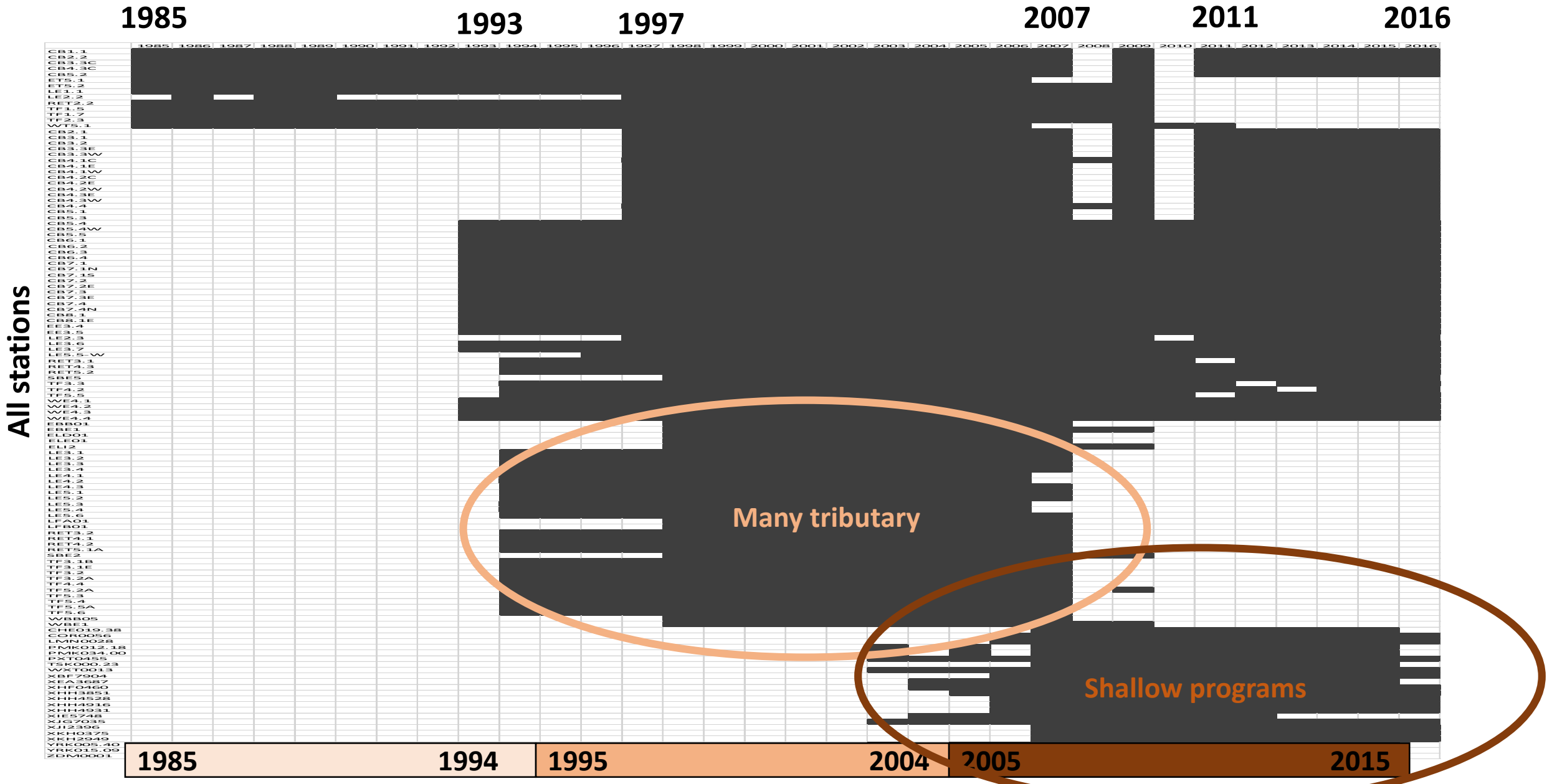




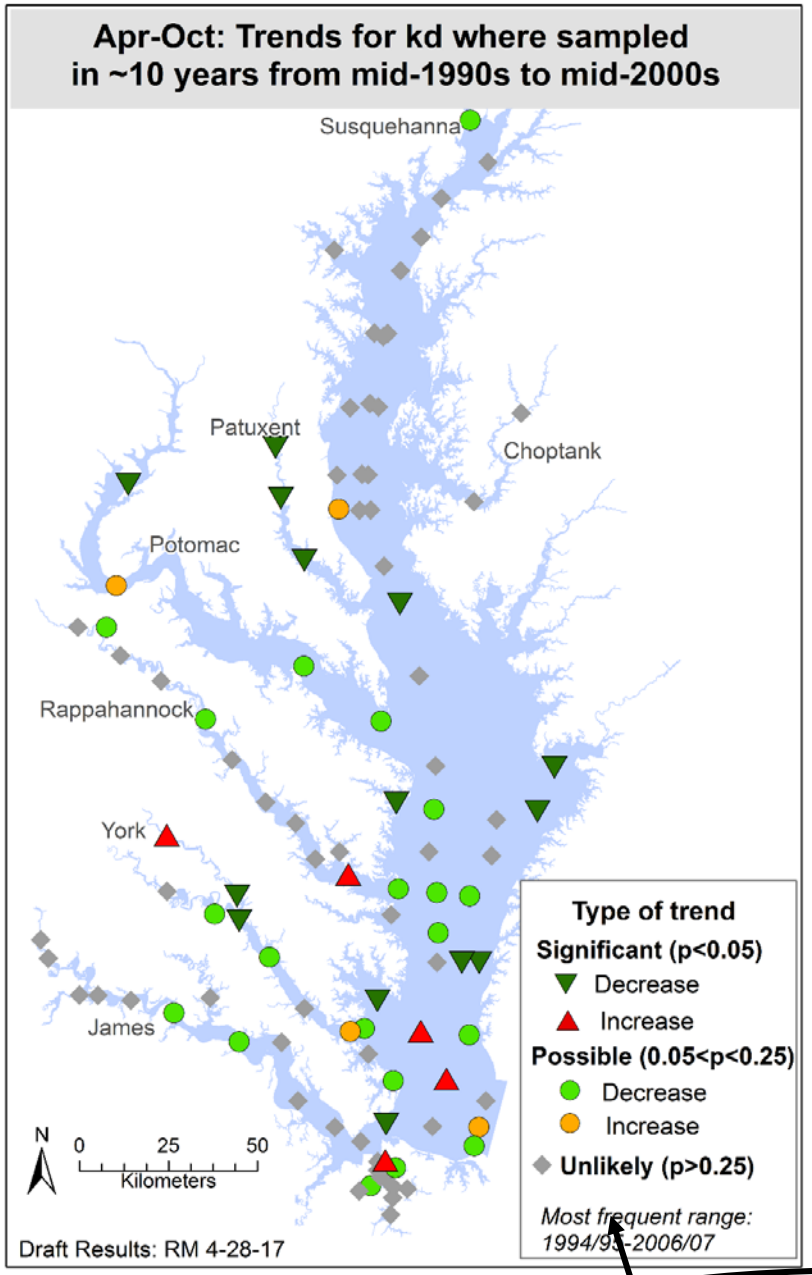


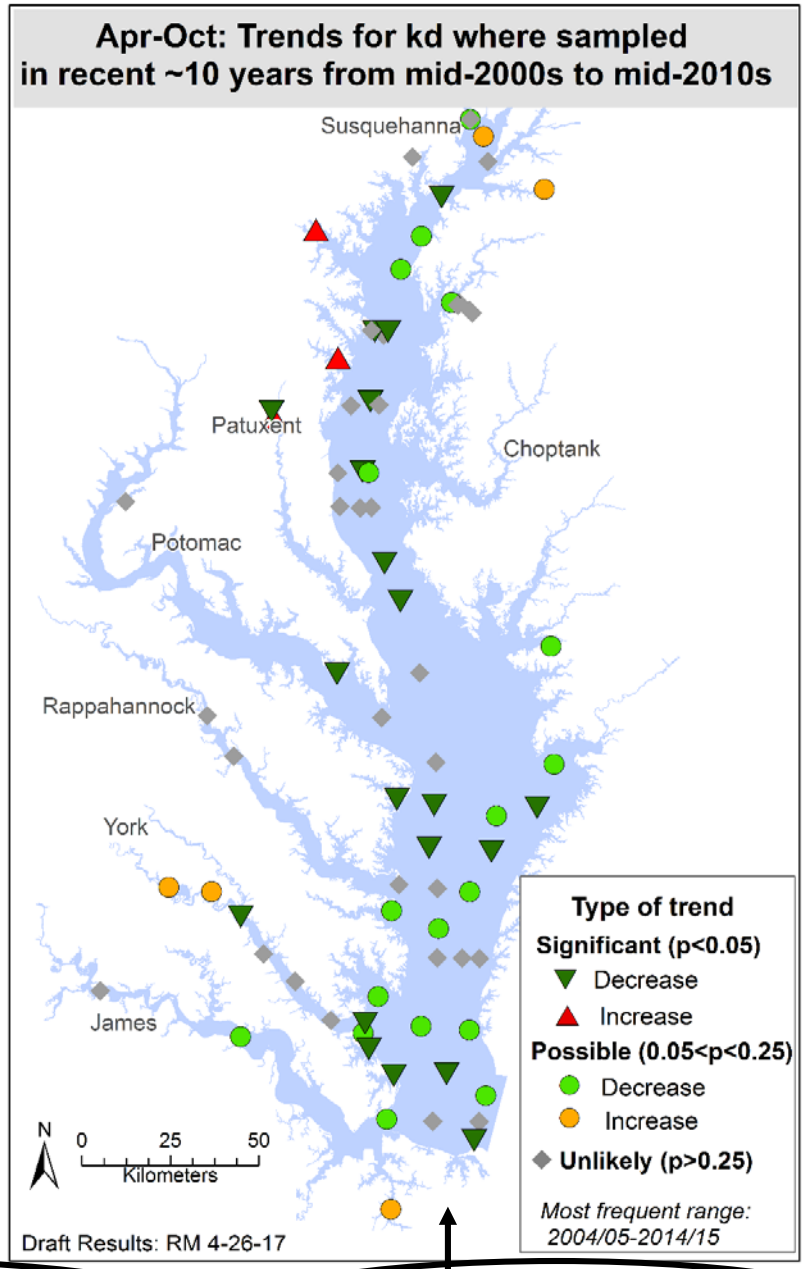
>30yr ago | 1985 | 1994 | 1995 | 2004 | 2005 | 2015 | present

Many stations sampled in ~10 year periods

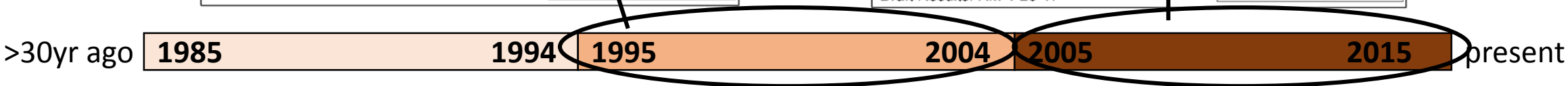


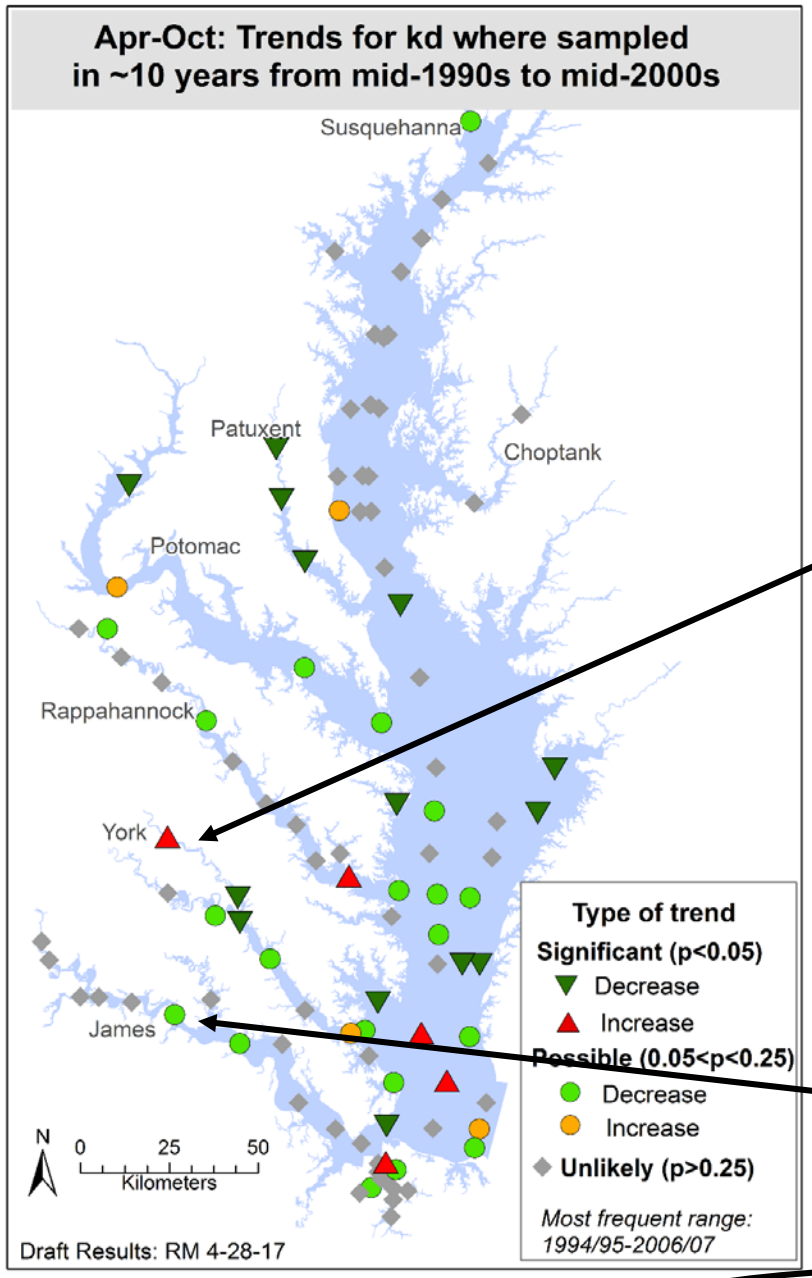
36 stations only sampled in this period (many tributary stations)

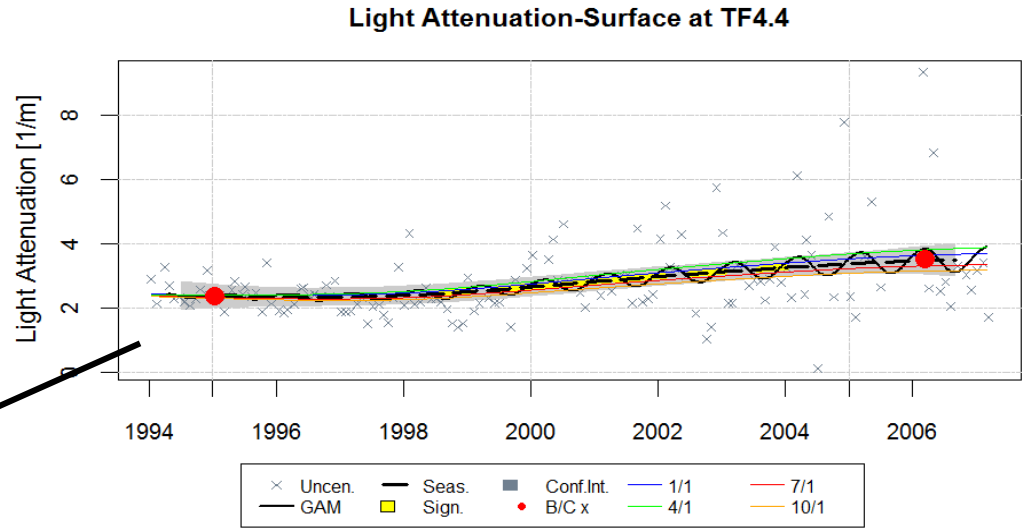


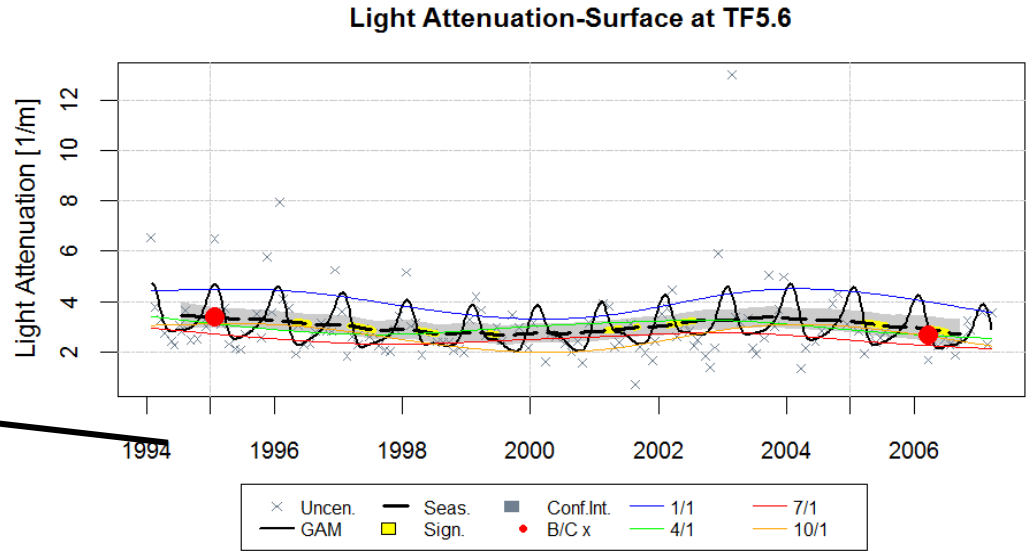


Recent period is the one with some CONMON and DATATFLOW calibration locations

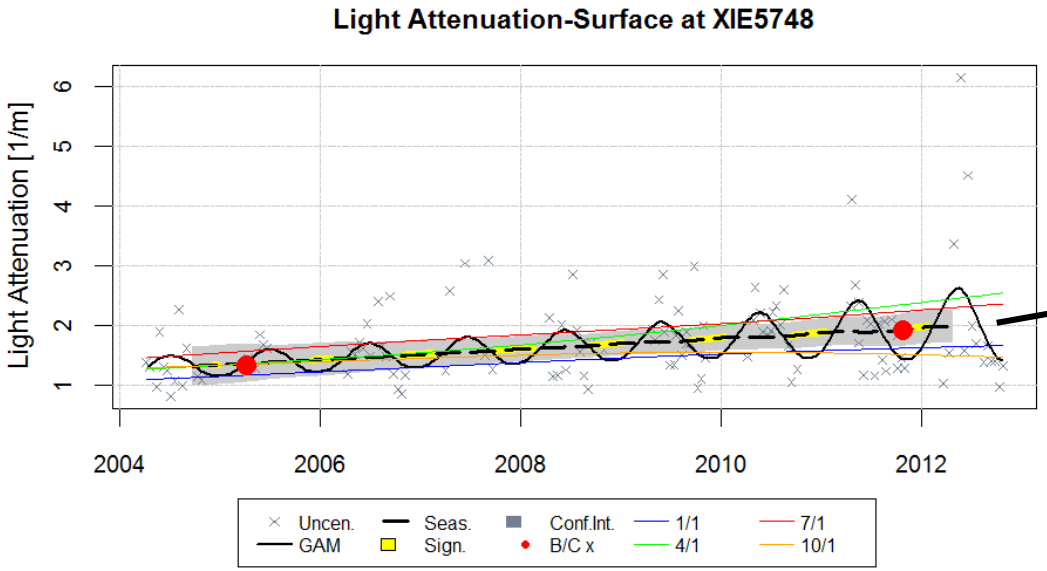


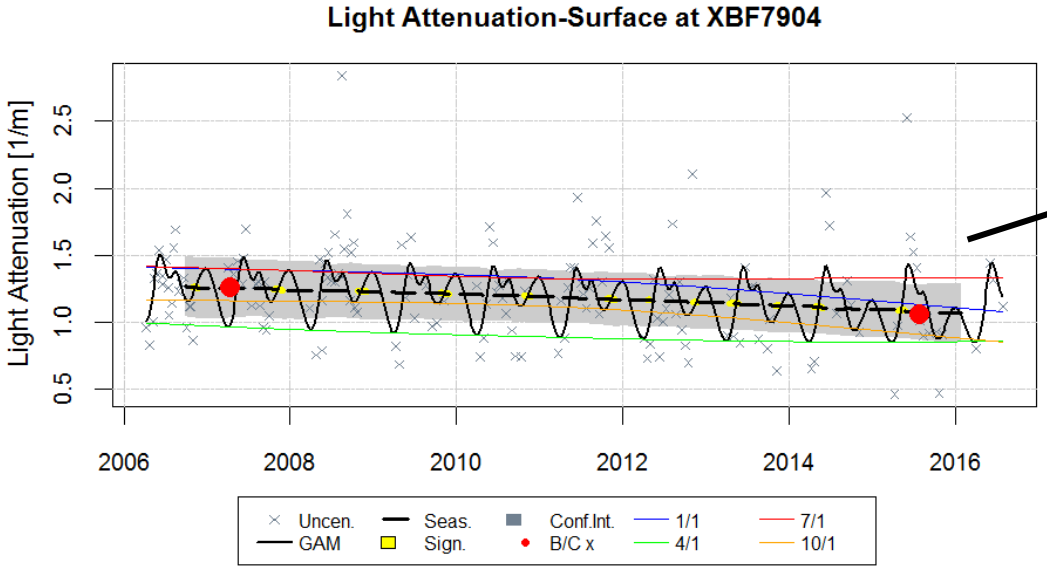


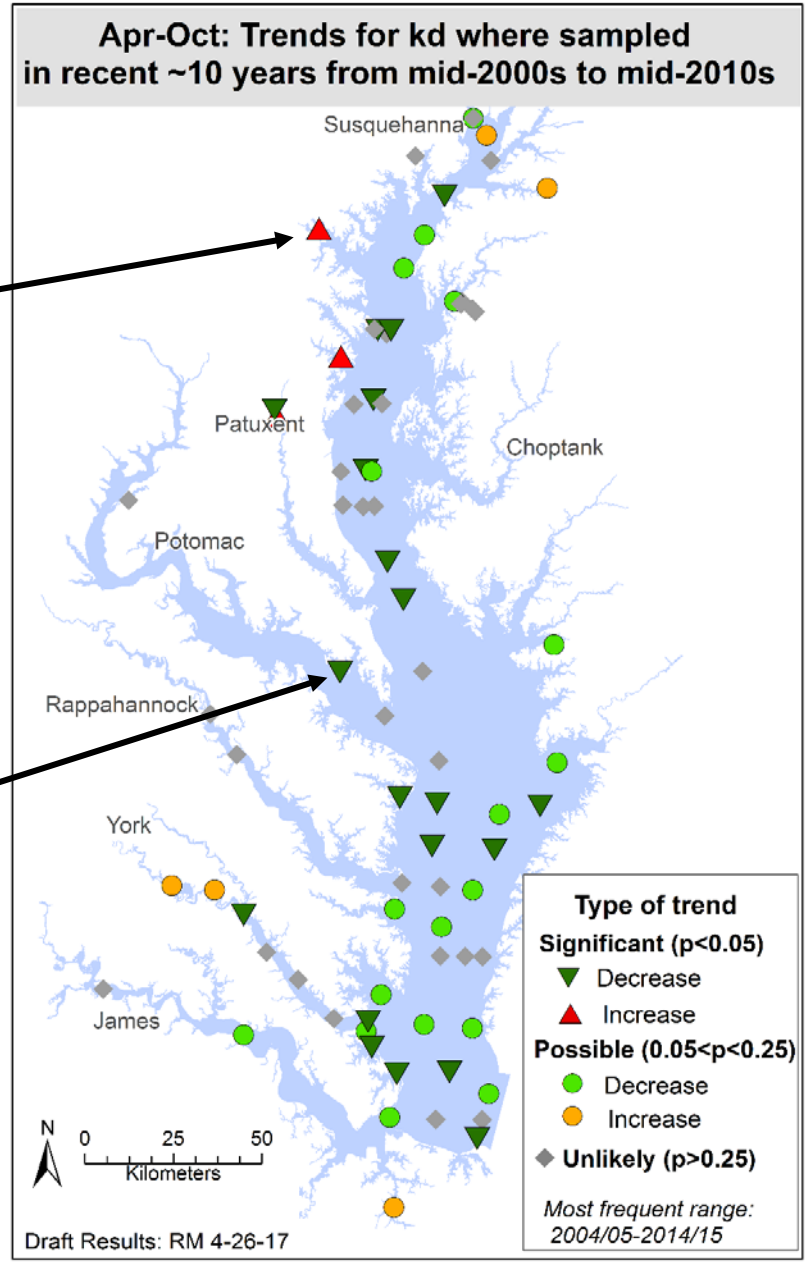




>30yr ago | **1985** | **1994** | **1995** | **2004** | **2005** | **2015** | present


Light Attenuation-Surface at XIE5748
Light Attenuation [1/m]
1
2
3
4
5
6
2004
2006
2008
2010
2012
Uncen.
GAM
Seas.
Sign.
Conf.Int.
B/C x
1/1
4/1
7/1
10/1


Light Attenuation-Surface at XBF7904
Light Attenuation [1/m]
0.5
1.0
1.5
2.0
2.5
2006
2008
2010
2012
2014
2016
Uncen.
GAM
Seas.
Sign.
Conf.Int.
B/C x
1/1
4/1
7/1
10/1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Susquehanna
Patuxent
Choptank
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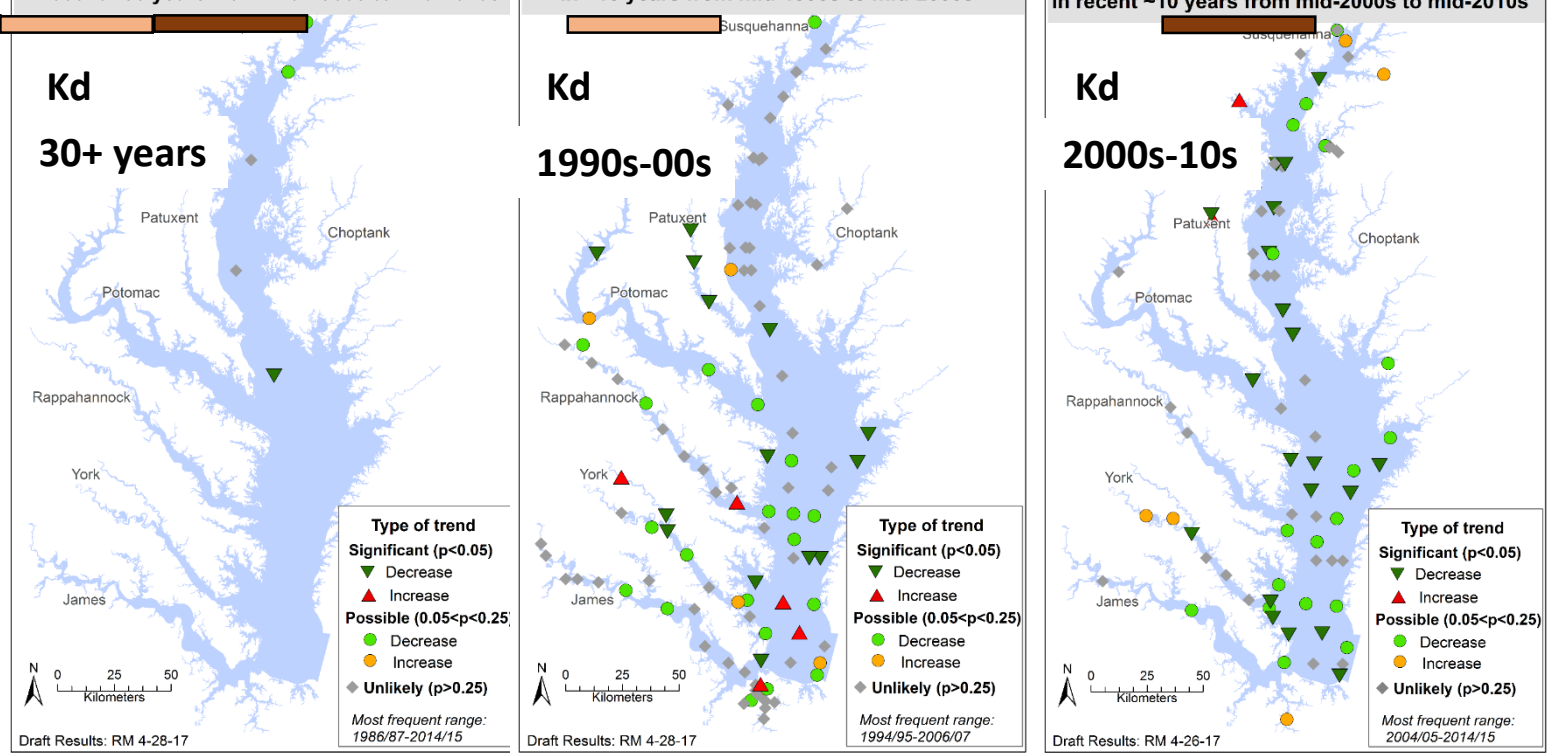
Rappahannock
York
James
N
0
25
50
Kilometers
Type of trend
Significant (p<0.05)
Decrease
Increase
Possible (0.05<p<0.25)
Decrease
Increase
Unlikely (p>0.25)
Most frequent range:
2004/05-2014/15
Draft Results: RM 4-26-17


>30yr ago
1985
1994
1995
2004
2005
2015
present

Secchi

- Pulled all long-term and CONMON/DATAFLOW stations with >7 years of secchi data
- Made maps for same periods (Apr-Oct and annual)
- Can compare graphs side-by-side
- Did some summary statistics of trends compared to kd for periods with most data

Overview


Kd
30+ years
Patuxent
Choptank
Potomac
Rappahannock
York
James
Type of trend
Significant (p<0.05)
Decrease
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30+ years
Secchi
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Secchi
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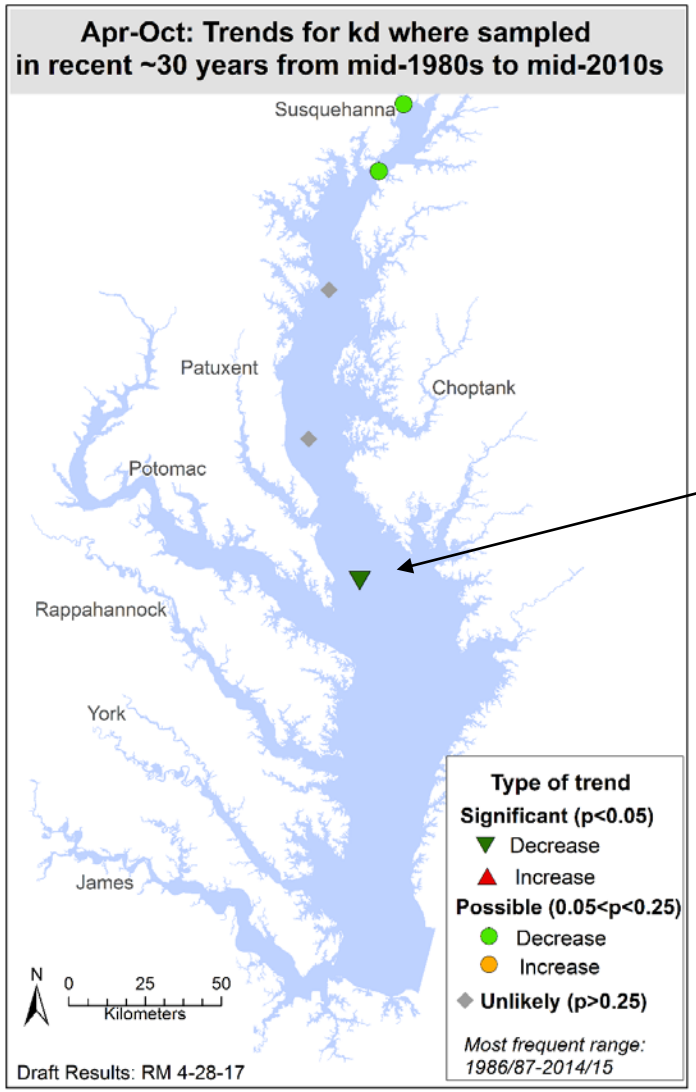
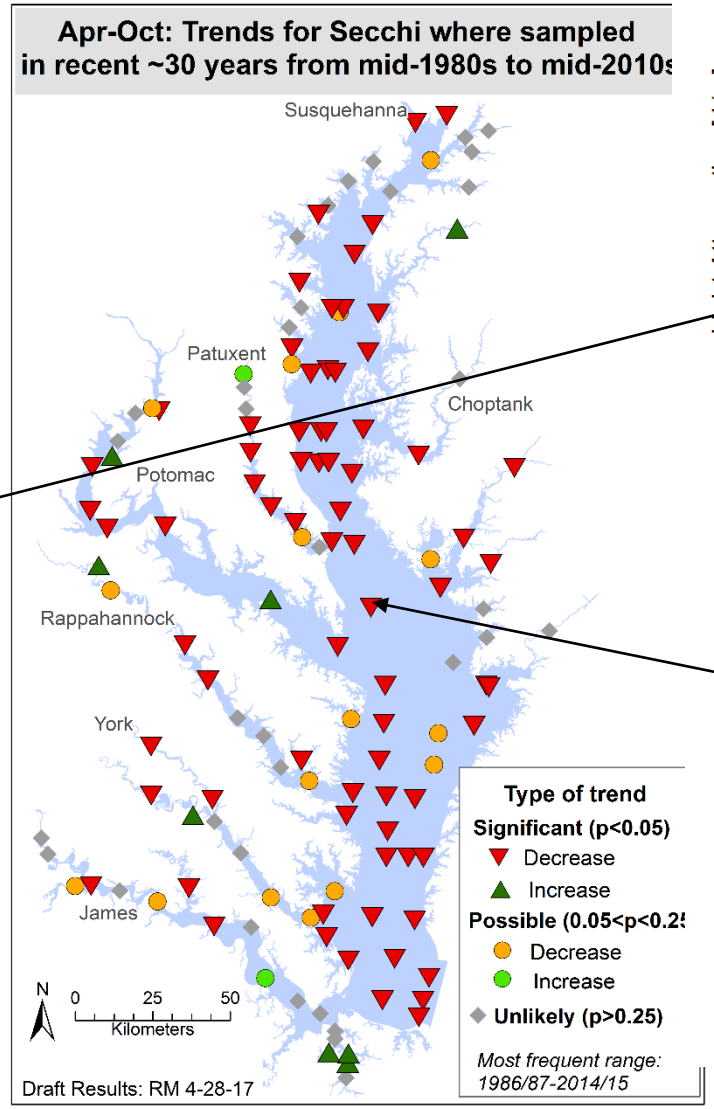
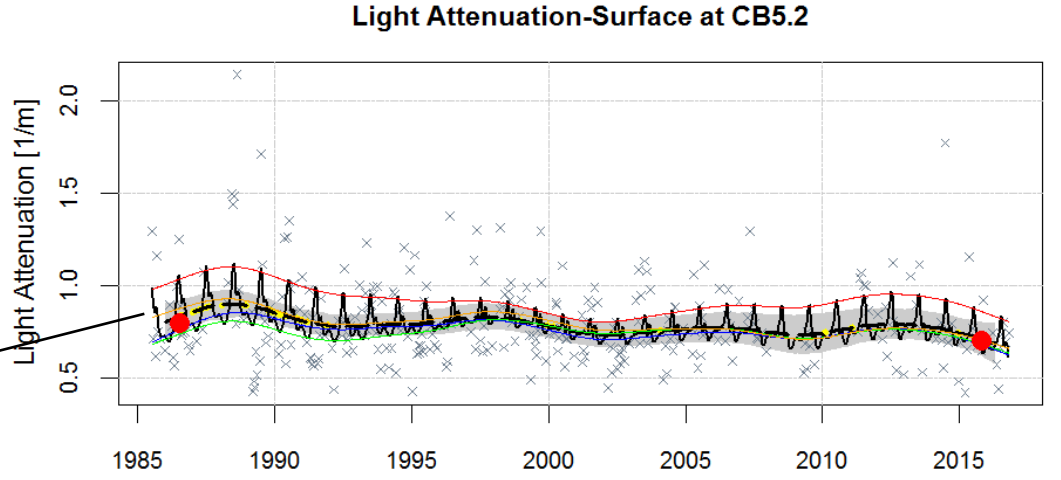
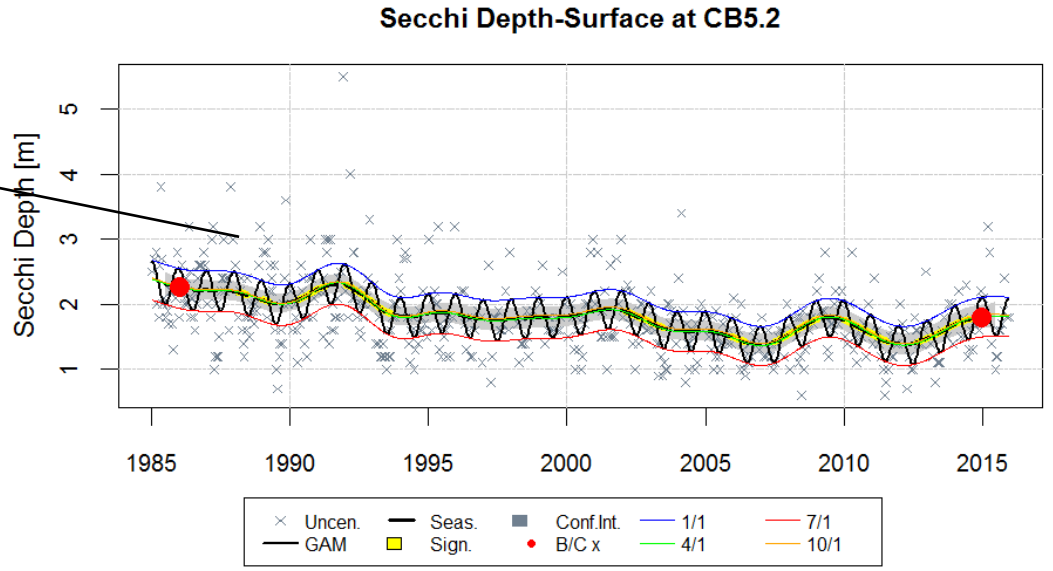
N
0
25
50
Kilometers

Full Period: 1980s to present



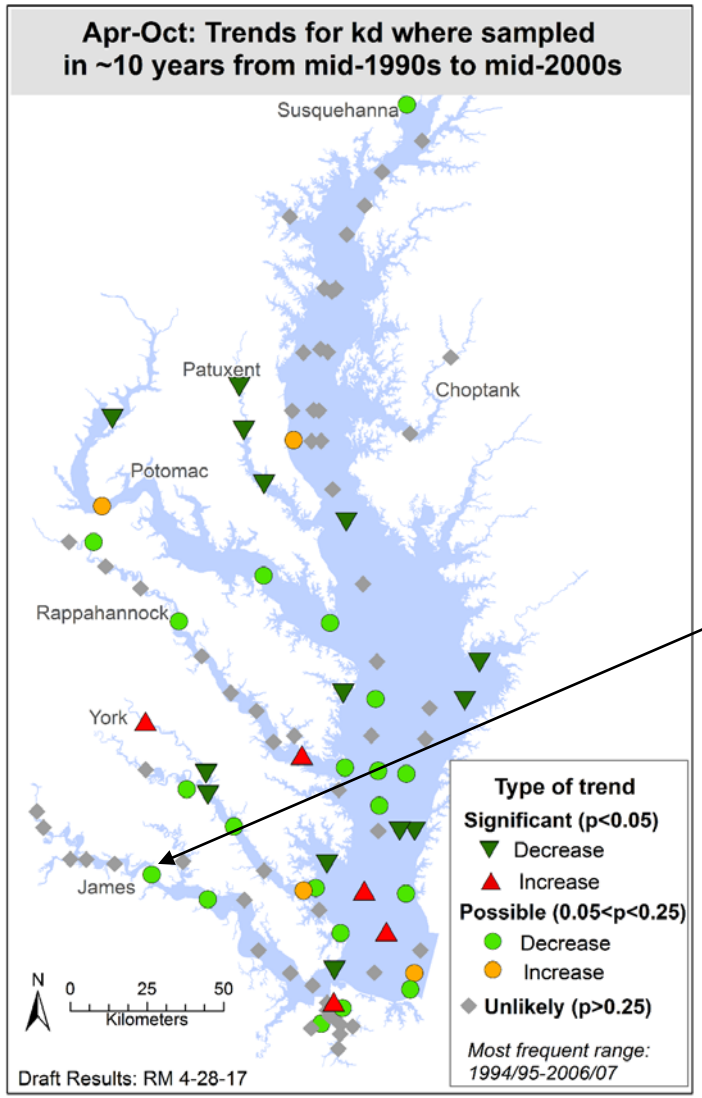


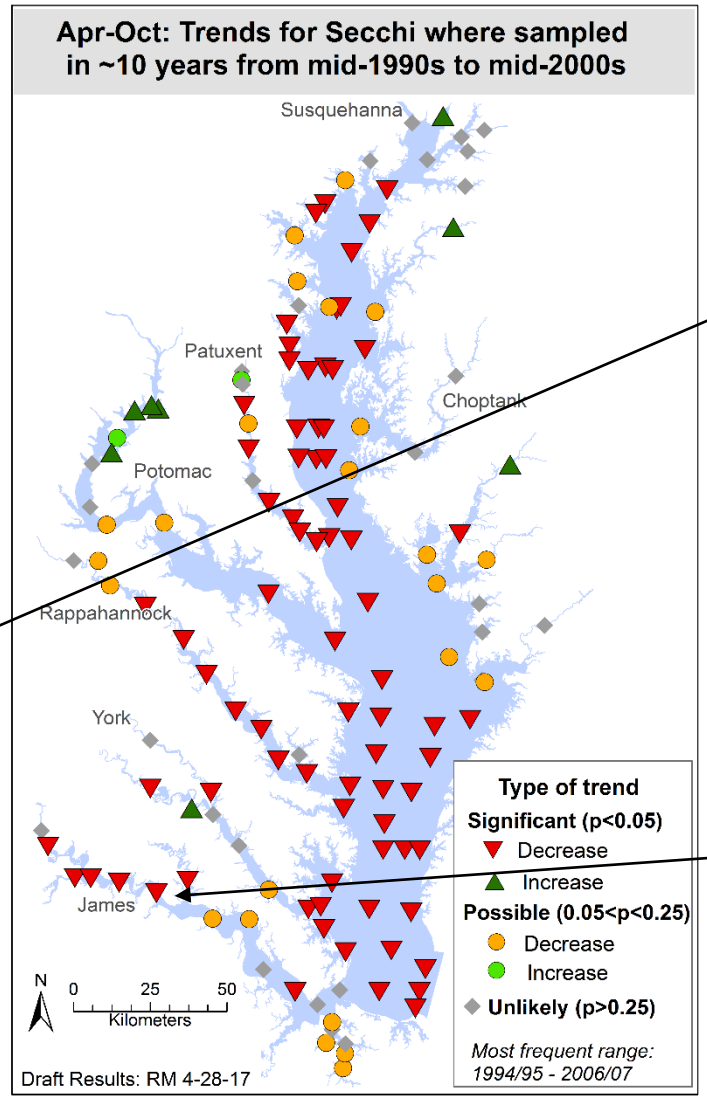


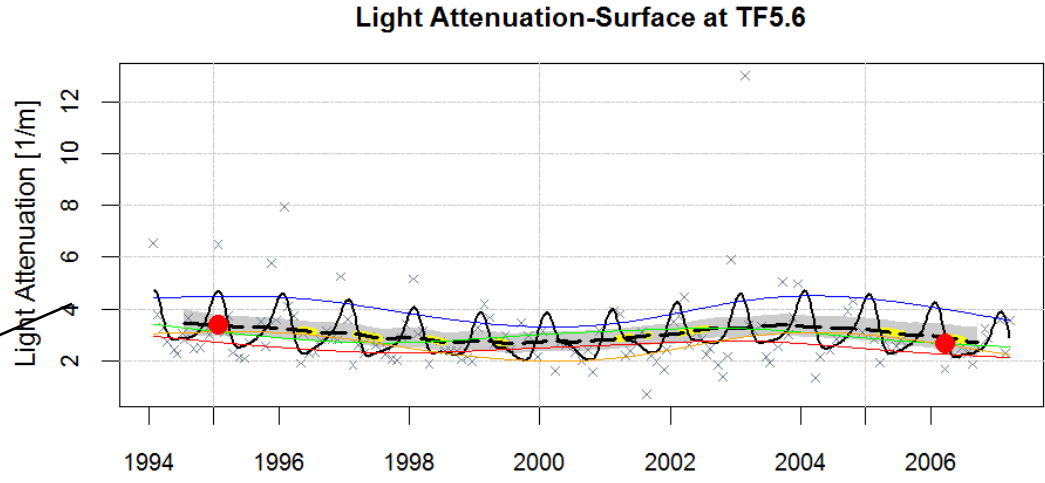


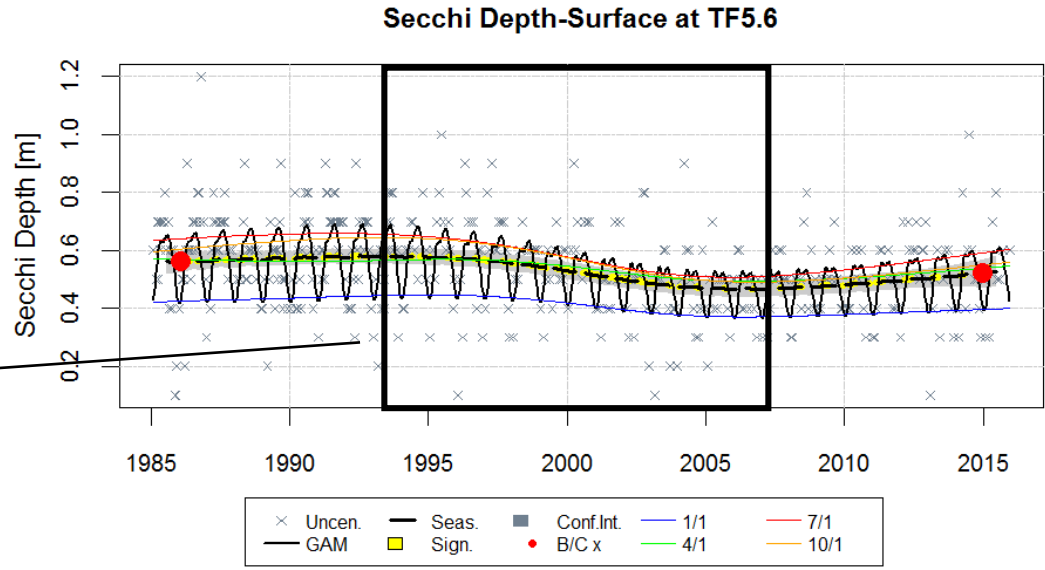
>30yr ago | 1985 – 1994 | 1995 – 2004 | 2005 – 2015 | present

Middle: 1990s to 2000s (approx. 10 years)









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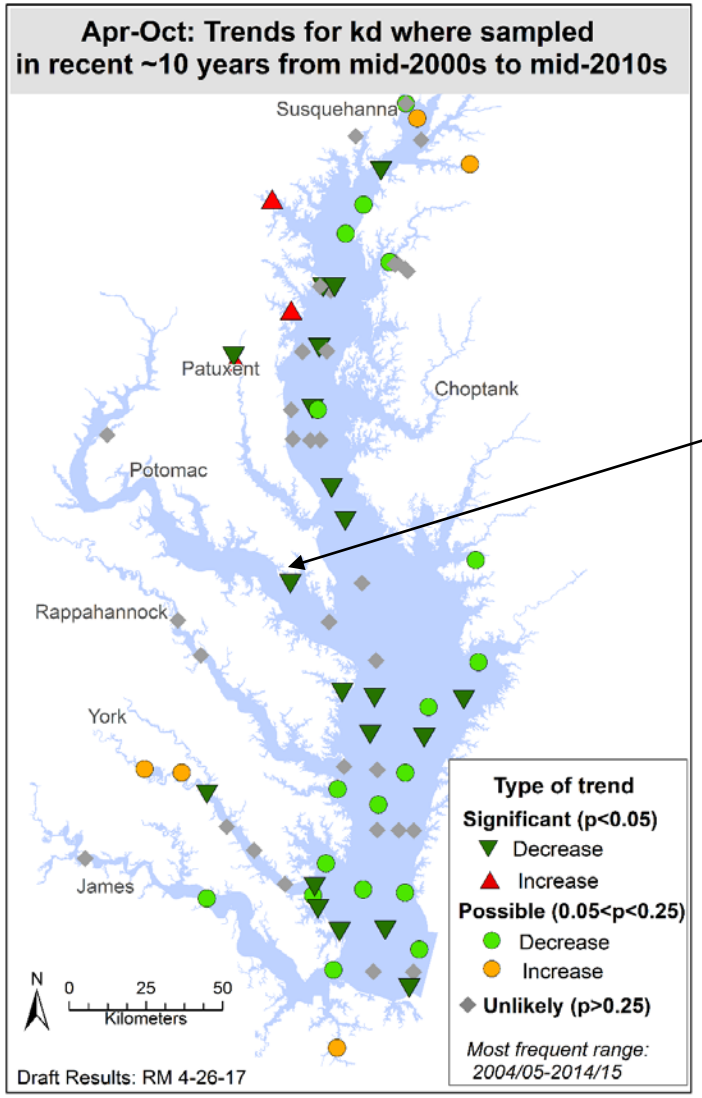
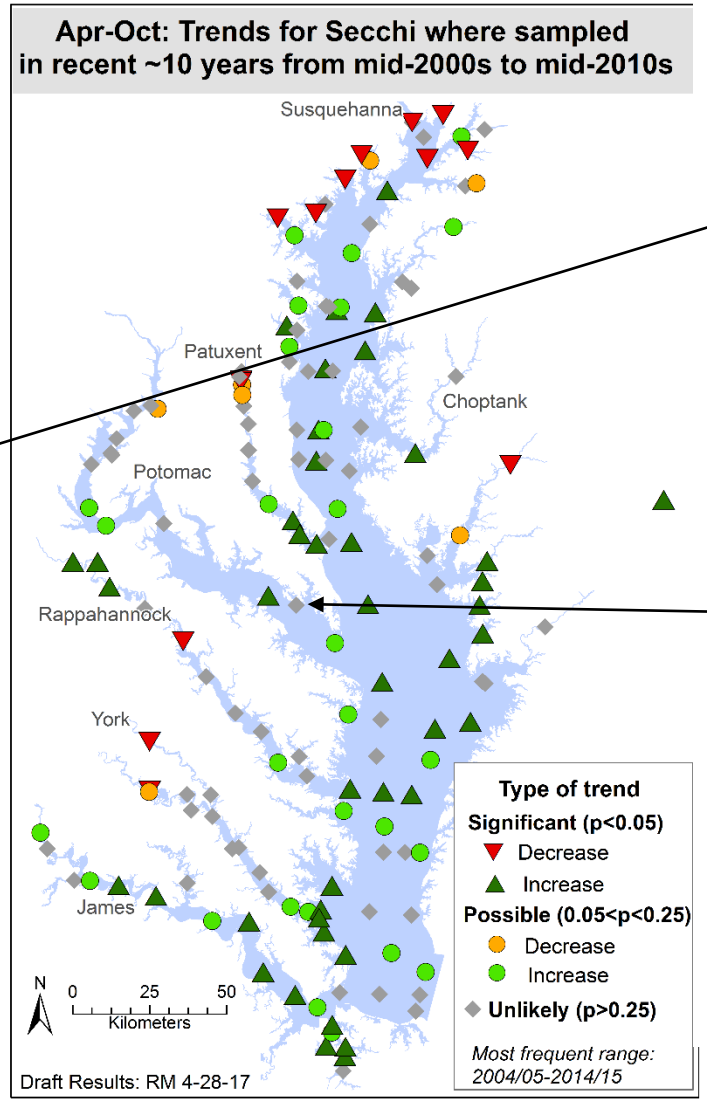
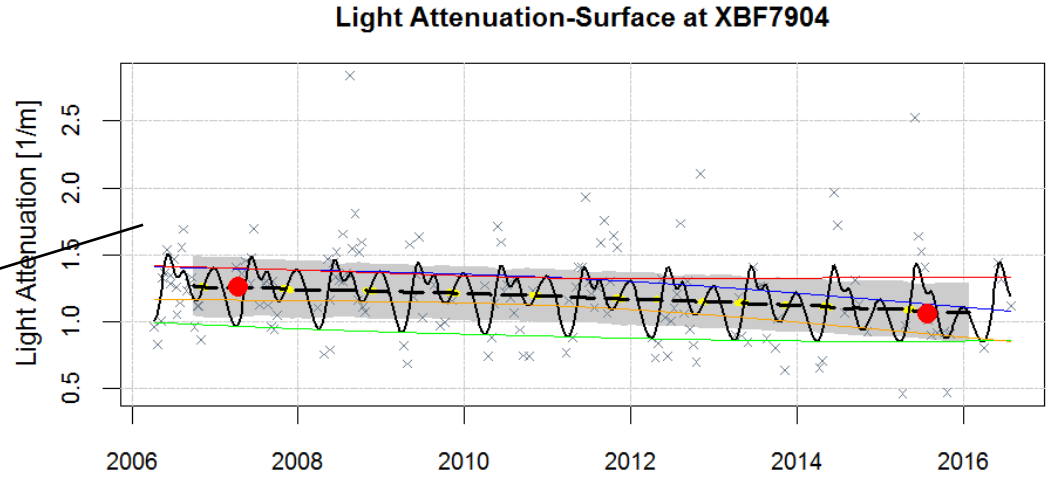
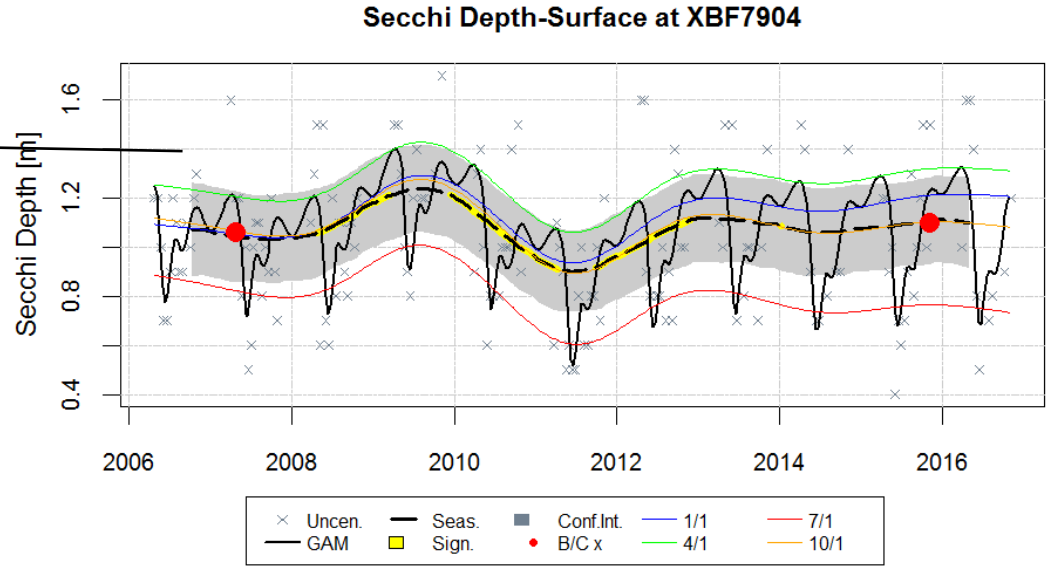
Recent: 2000s to present (approx. 10 years)









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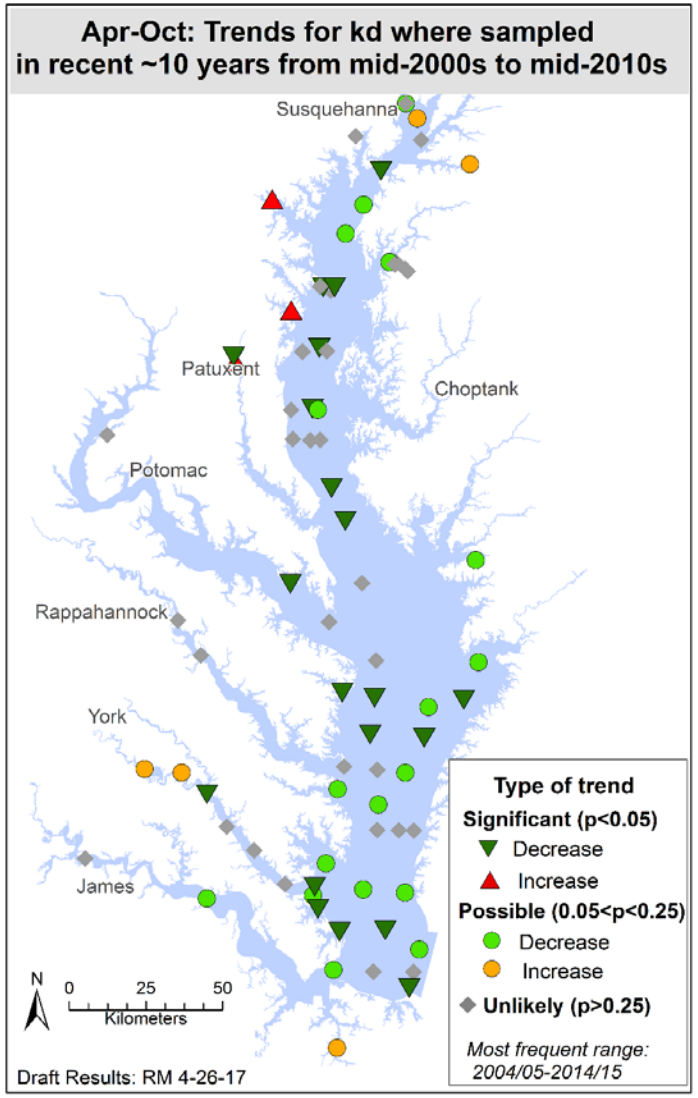
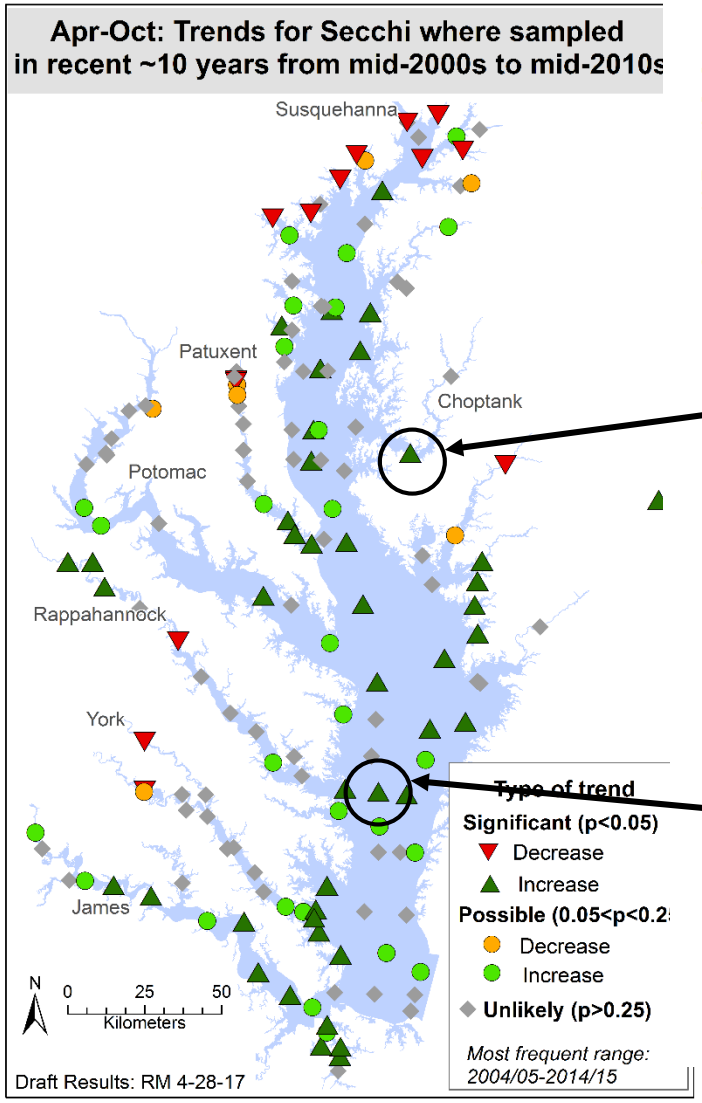
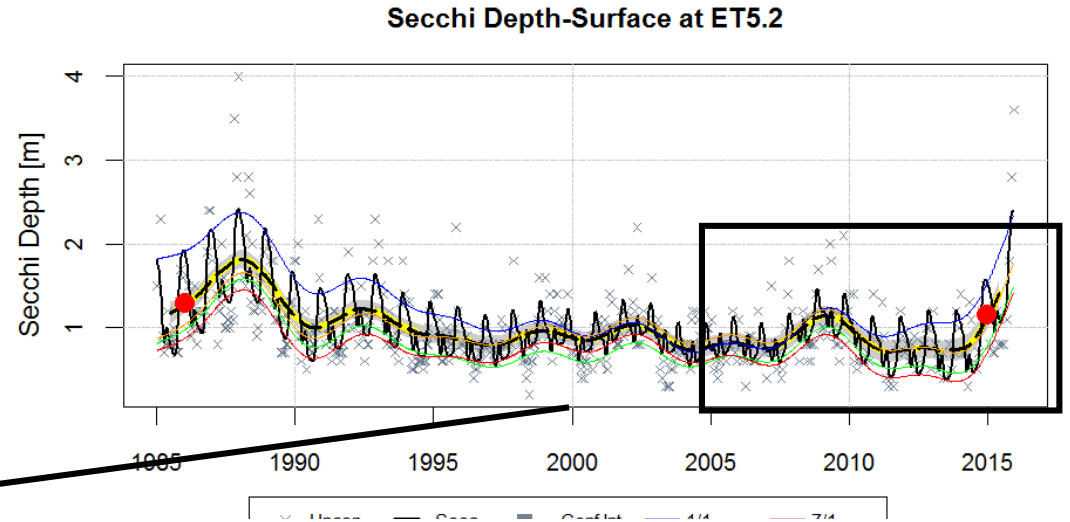
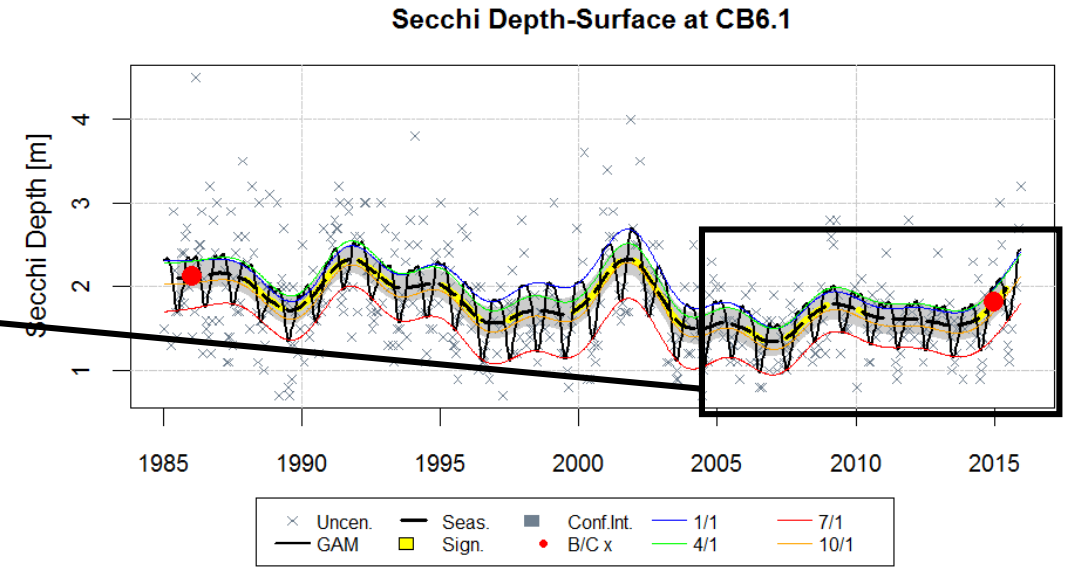




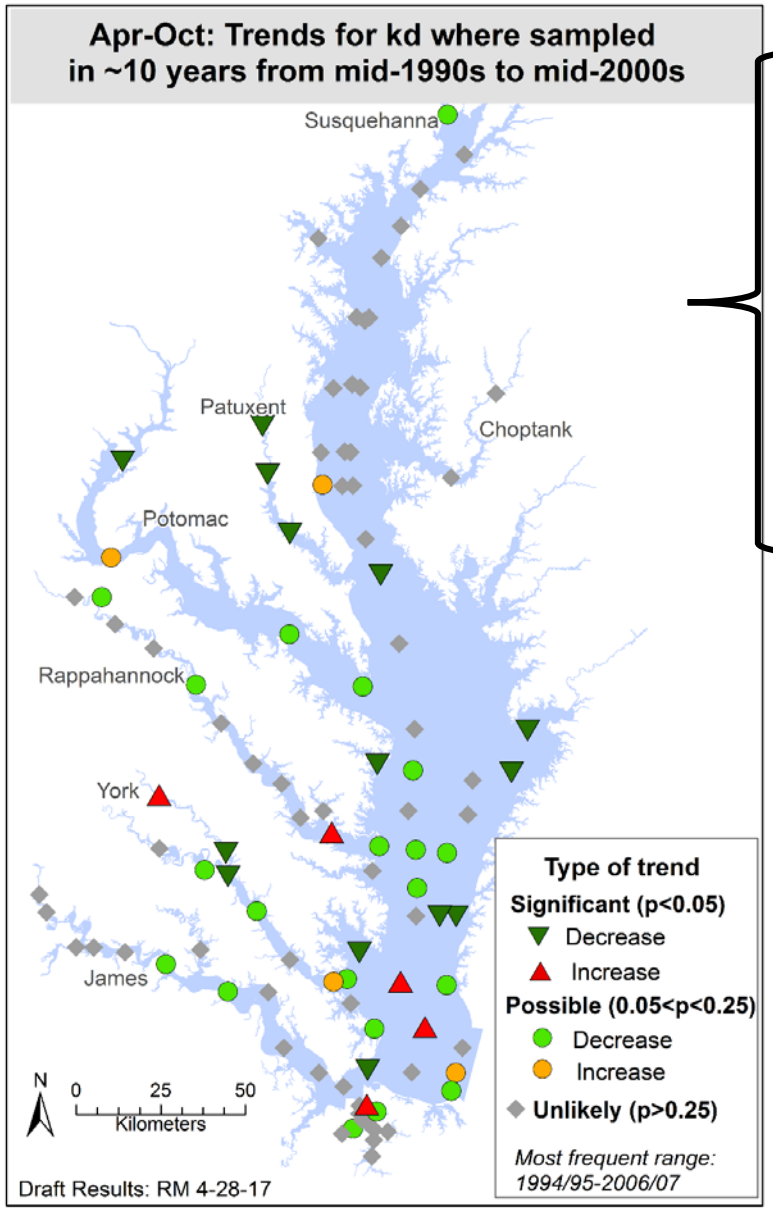




Are we going to sustain this recent increase? Need to be careful about it.

>30yr ago | **1985** | **1994** | **1995** | **2004** | **2005** | **2015** | present

Some overall summary comparisons



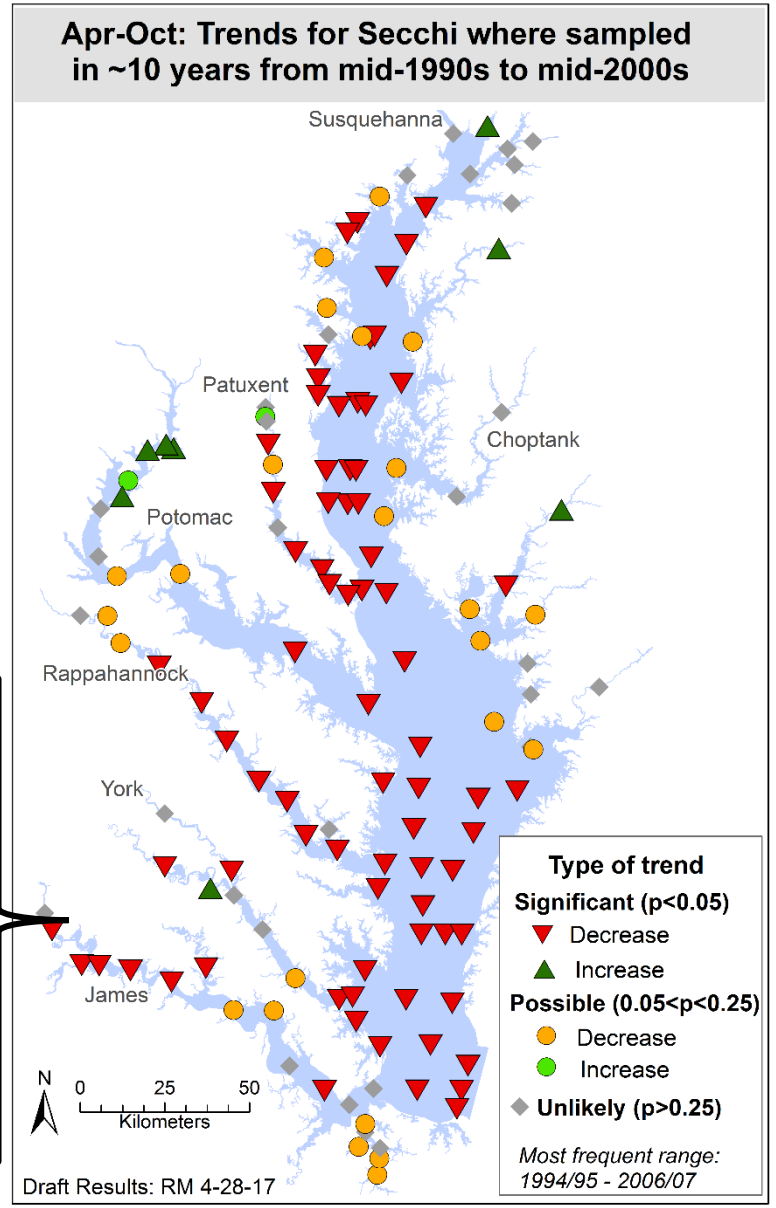
Kd: Percent of likely* trends from 90s to 00s

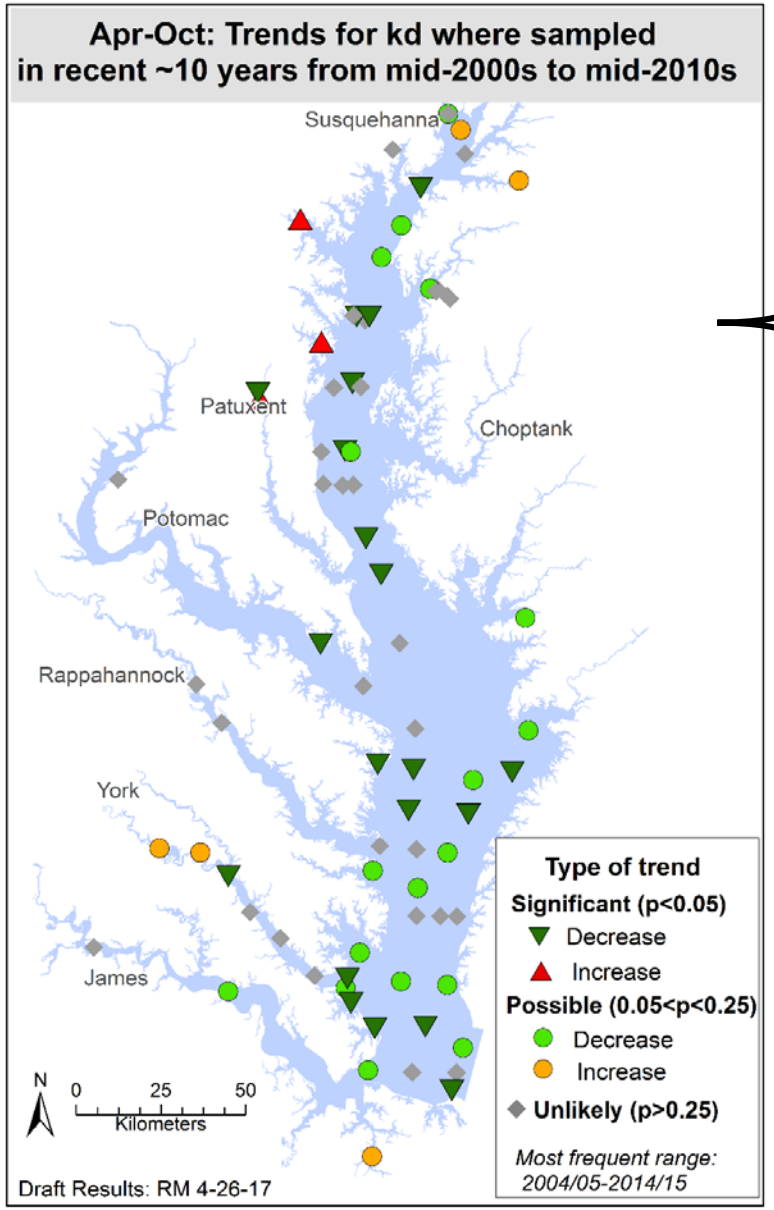
Zone	Improving	No trend	Degrading
TF	31%	**63%**	6%
OH	**45%**	**45%**	9%
MH	26%	**67%**	7%
PH	**43%**	**43%**	14%

Secchi: Percent of likely* trends from 90s to 00s

Zone	Improving	No trend	Degrading
TF	32%	32%	**36%**
OH	5%	33%	**62%**
MH	0%	17%	**83%**
PH	0%	12%	**88%**

*note, these are using “significant” and “possible” trends





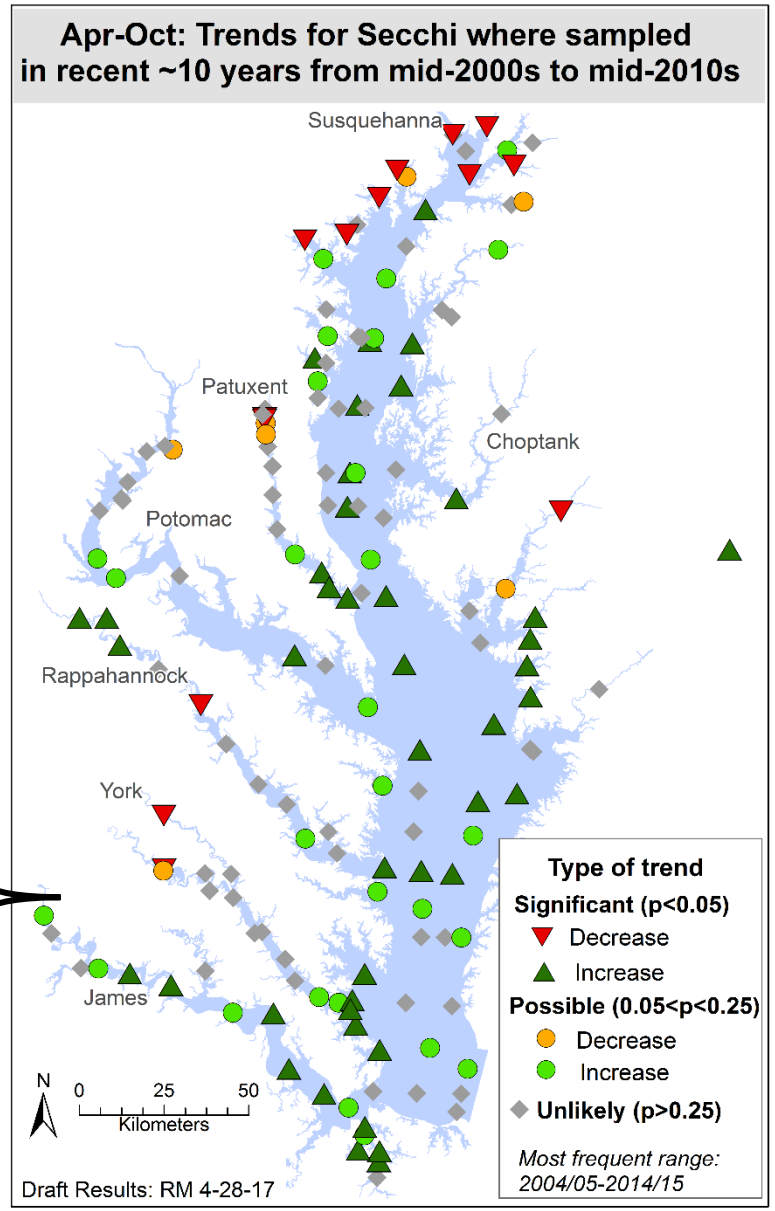
Kd: Percent of likely* trends from 00s to 10s

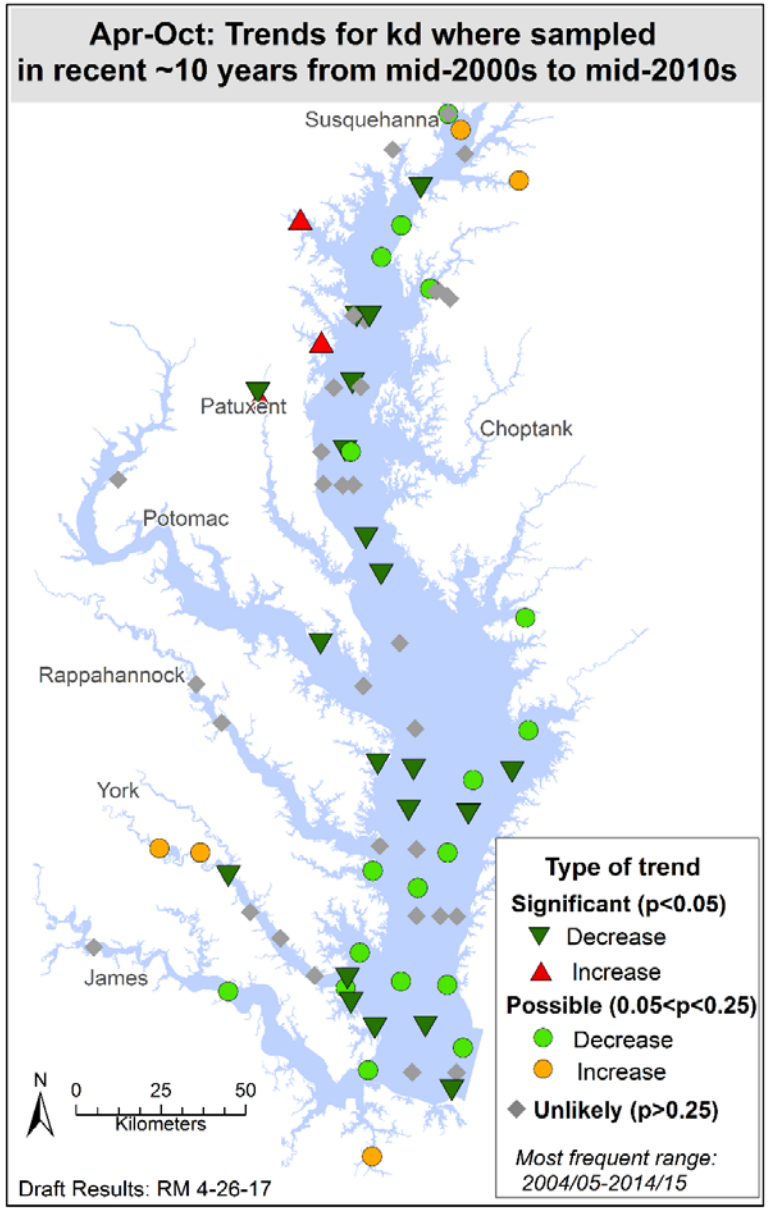
Zone	Improving	No trend	Degrading
TF	20%	**50%**	30%
OH	**43%**	29%	29%
MH	44%	**49%**	8%
PH	**70%**	30%	0%

Secchi: Percent of likely* trends from 00s to 10s

Zone	Improving	No trend	Degrading
TF	23%	**46%**	31%
OH	24%	**48%**	28%
MH	**49%**	47%	4%
PH	**66%**	34%	0%

*note, these are using “significant” and “possible” trends





Kd: Percent of likely* trends from 00s to 10s

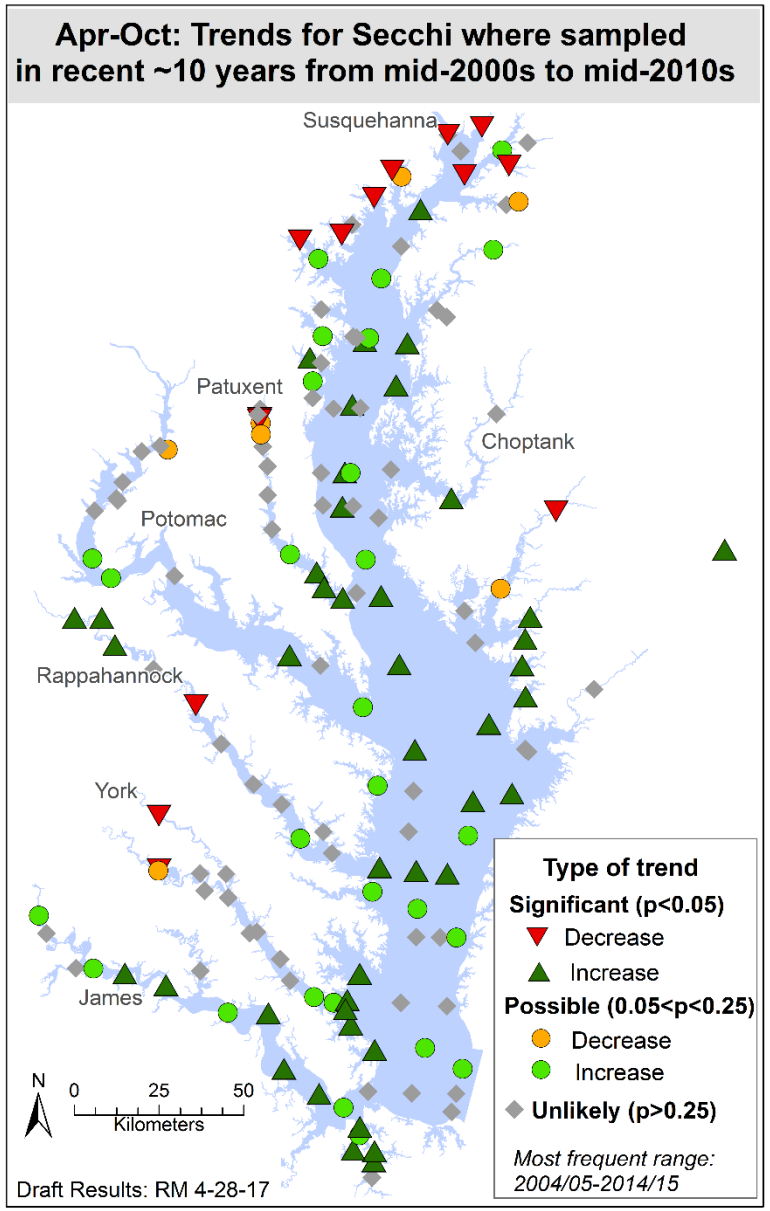
Program	Improving	No trend	Degrading
long-term	**59%**	38%	4%
shallow[a]	22%	**52%**	26%

Secchi: Percent of likely* trends from 00s to 10s

Program	Improving	No trend	Degrading
long-term	**49%**	41%	10%
shallow	12%	**62%**	27%

[a] "shallow" refers to either CONMON or DATAFLOW calibration observations

*note, these are using "significant" and "possible" trends



Summary

- Until recent years, trends for any period bay-wide for kd and secchi seem to be in opposite directions
  - Exception: Tidal fresh kd and secchi appear to be more similar in trend than anywhere else
- However, in recent 10 years, the kd and secchi are following generally the same improving pattern

- More generally:
  - Kd and secchi data are co-located at many stations in time
  - Many more graphs and ways to look at the data