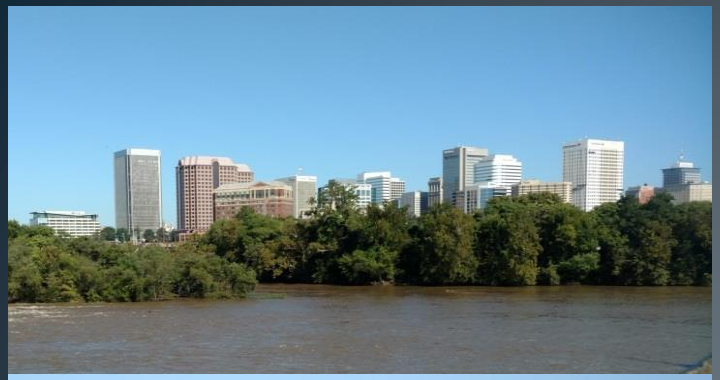
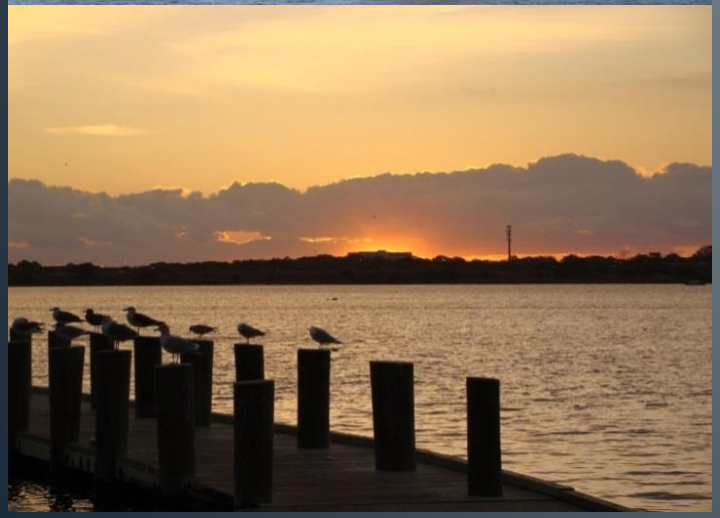




James River Chlorophyll-a Criteria Revisions

Tish Robertson
VirginiaA DEQ
TTAT May Meeting
May 22, 2018

In the late 1990s…

- EPA added a lot of VA's waters to the Impaired Waters list
- The tidal James was one such waterbody, along with most of the Chesapeake Bay.
- "Nutrients" were identified as the impairment cause for the James.
- EPA urged VA to adopt chlorophyll-a criteria for the James as a means to control nutrients

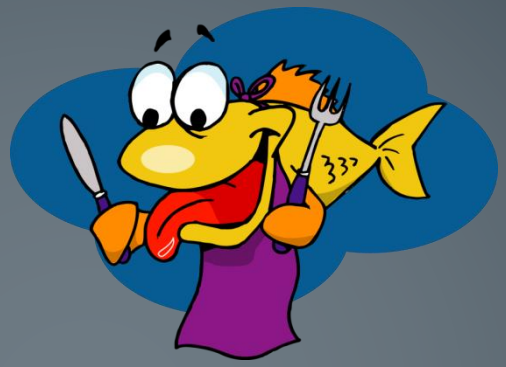
In 2005…

- DEQ adopted chl-a criteria for the tidal James.
- VA was one of the first to promulgate estuarine chl-a criteria in the US.
- These criteria were developed with the assistance of the EPA-Chesapeake Bay Program.


Photo: Vogelbein/VIMS

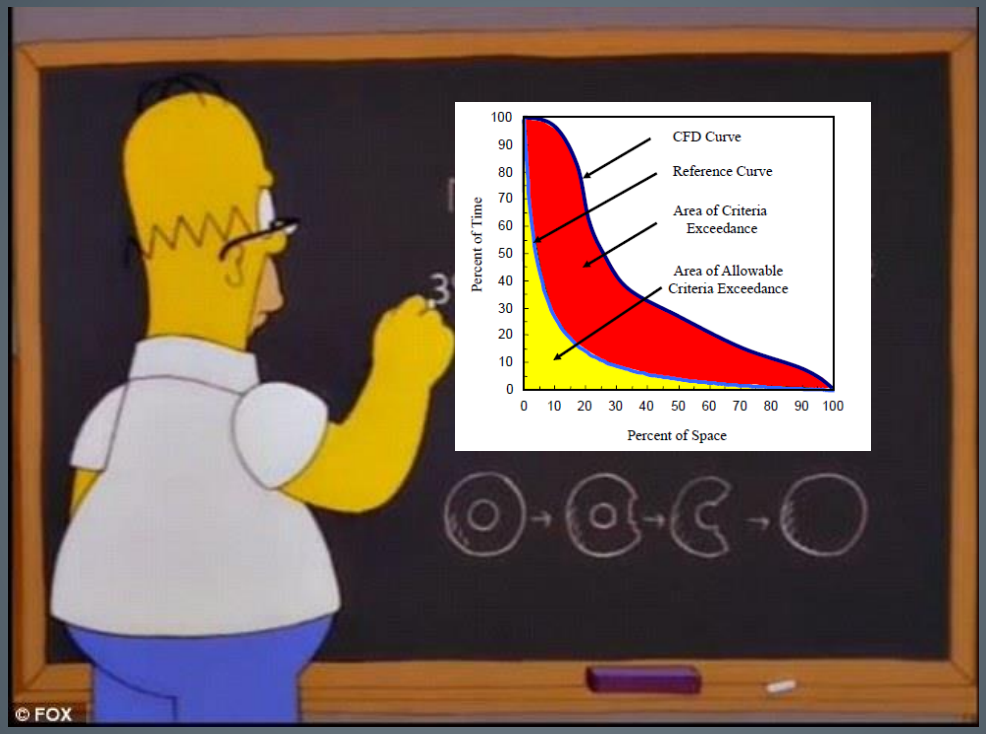
The basis of the current criteria is protection of "fish food"

Segment-Season	Original
JMSTFU-spring	10
JMSTFU-summer	15
JMSTFL-spring	15
JMSTFL-summer	23
JMSOH-spring	15
JMSOH-summer	22
JMSMH-spring	12
JMSMH-summer	10
JMSPH-spring	12
JMSPH-summer	10



Criteria expressed as seasonal (geometric) means

Shortly after DEQ adopted the JR chl-a criteria, we then adopted the Bay assessment protocols (by reference) into the WQS.



Five years after DEQ adopted the criteria…

@#$%!

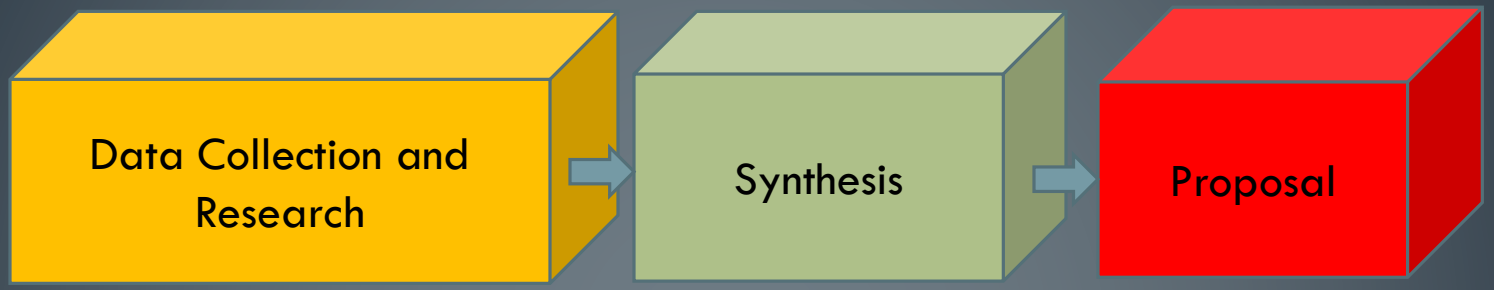
James River basin point sources weren't too happy about the Bay TMDL.

- An early version of the water quality model predicted that modest load reductions would be necessary for chlorophyll-a criteria attainment.
- But the updated model used for the TMDL predicted that much more drastic load reductions would be needed.
- The regulated community pushed back on the TMDL allocations for the James River basin and requested that DEQ re-evaluate the chlorophyll-a criteria.

DEQ initiated the James River Chlorophyll-a Study in 2011.

Goals of the study: 1) Re-establish the scientific basis of the criteria
2) Develop an improved water quality model for determining load reductions.

Study Timeline



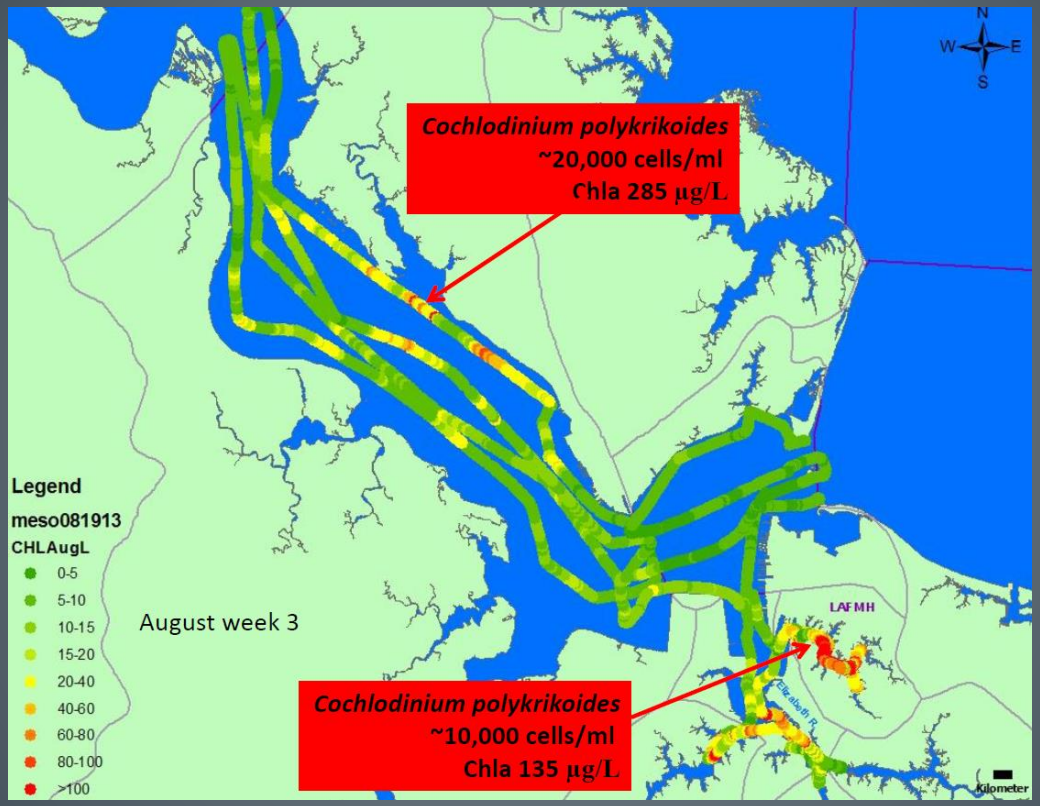
- Enhanced ambient monitoring
- Laboratory bioassays
- Literature review

alternative criteria &
alternative assessment method

- Development of an approach for testing the protectiveness of the current criteria (one that can also derive alternative criteria, if needed)

Phase 1. Data collection and Research

Performed by academic researchers under DEQ contract and HRSD



Weekly spatially-intensive monitoring in the lower estuary

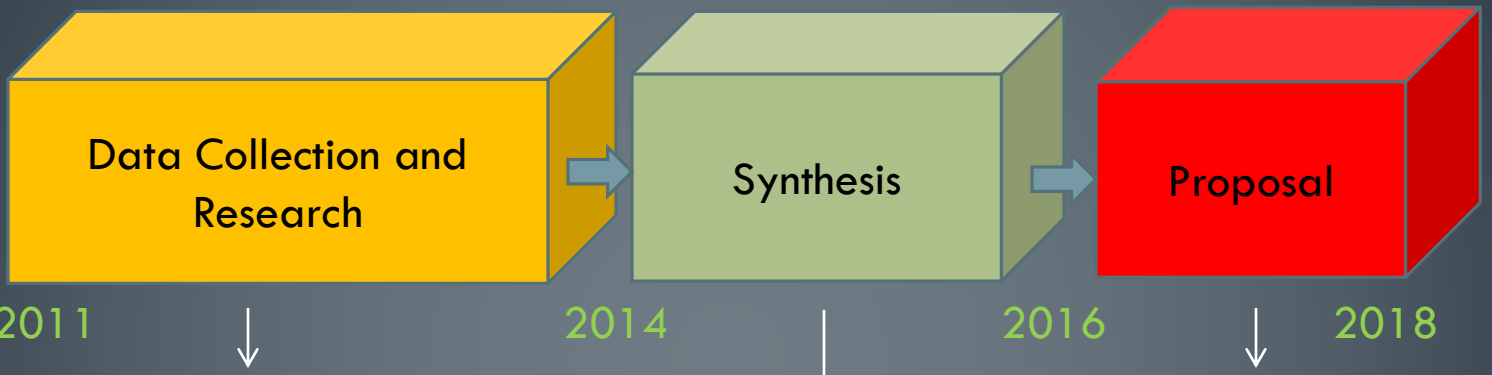
Physicochemical and phytoplankton samples

Phase 1. Data collection and Research

Performed by academic researchers under DEQ contract and HRSD

HAB bioassays on a variety of test organisms, evaluating a variety of endpoints.

Study Timeline



- Enhanced ambient monitoring
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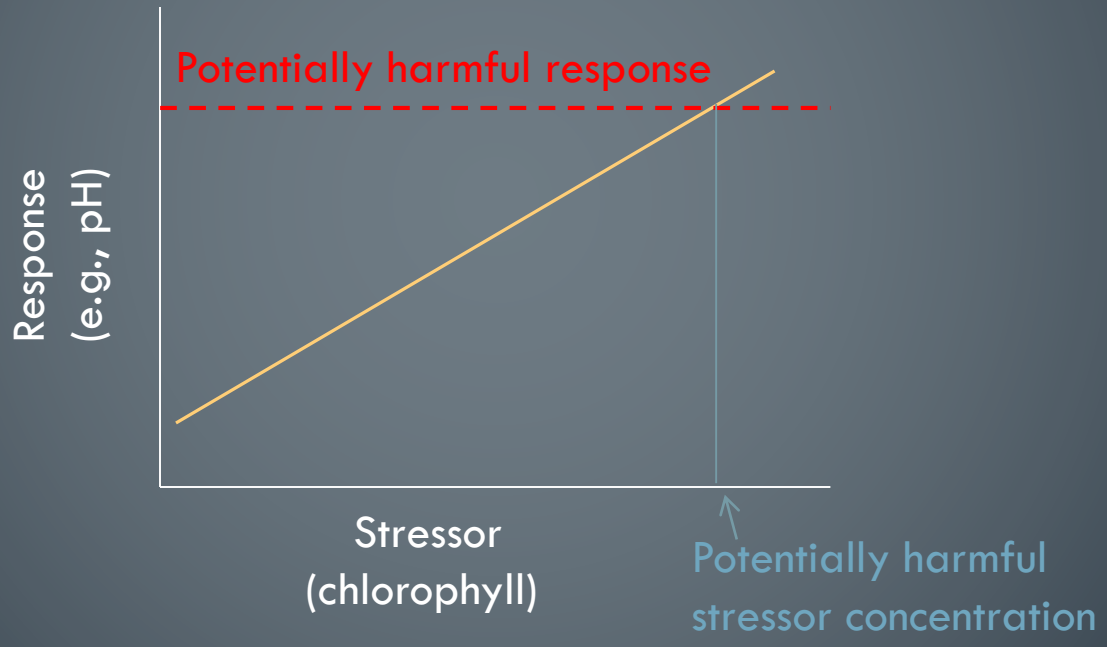
Phase 2. Synthesis

- We also used conventional statistical models to understand the relationship between chlorophyll and various response variables.



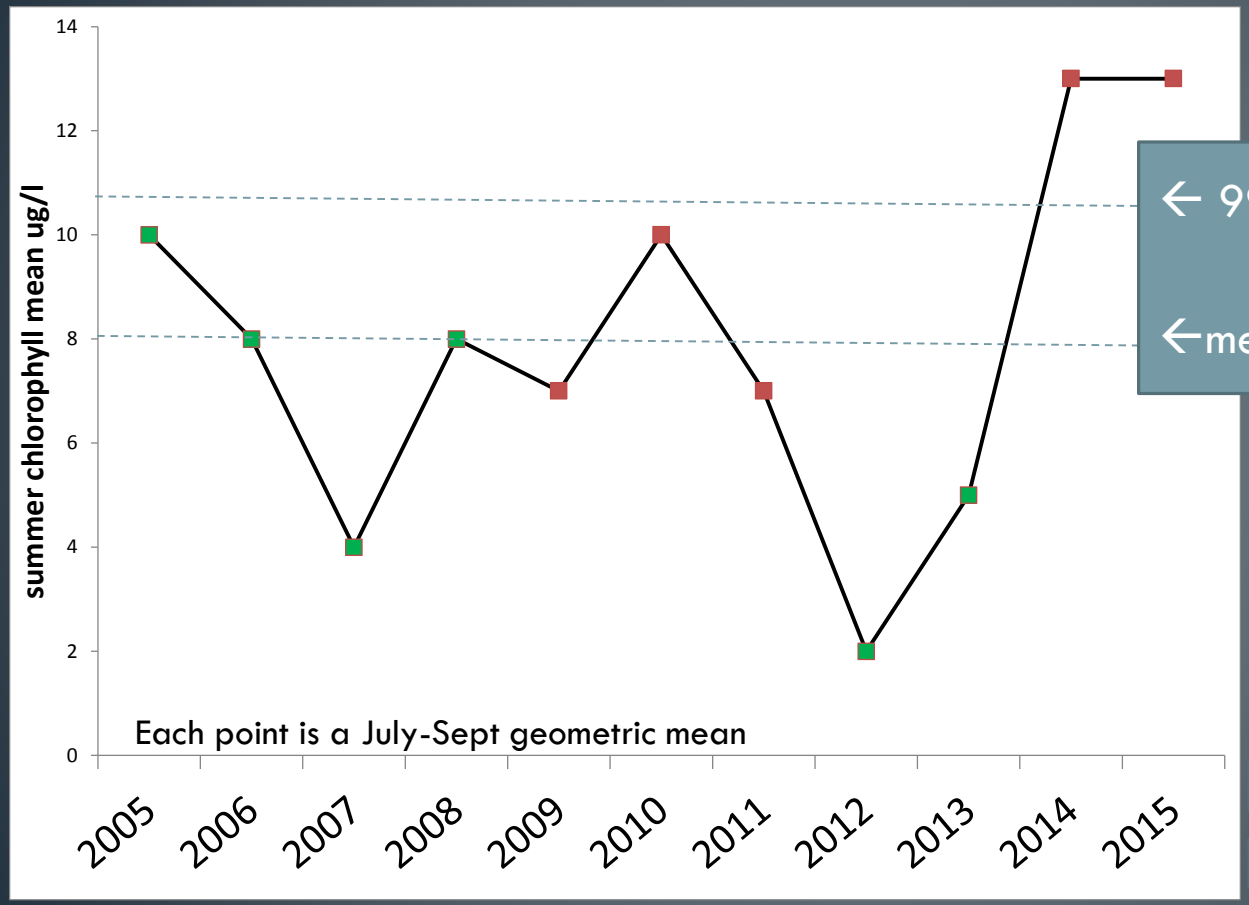
Response variables examined

- pH
- DO
- Water clarity
- Microcystin concentration
- Cochlodinium cell density

Phase 2. Synthesis

- We also used recent monitoring data to determine the baseline central tendency and spatial and temporal variability of chlorophyll in each segment-season.

Summer chlorophyll concentrations in JMSOH



← 99% UCL = 11 µg/l

←mean = 8 µg/l

VIMS Dataflow

DEQ Monitoring

The current criterion for JMSOH-summer is 22 µg/l

Baseline spatial variability (derived from Dataflow)

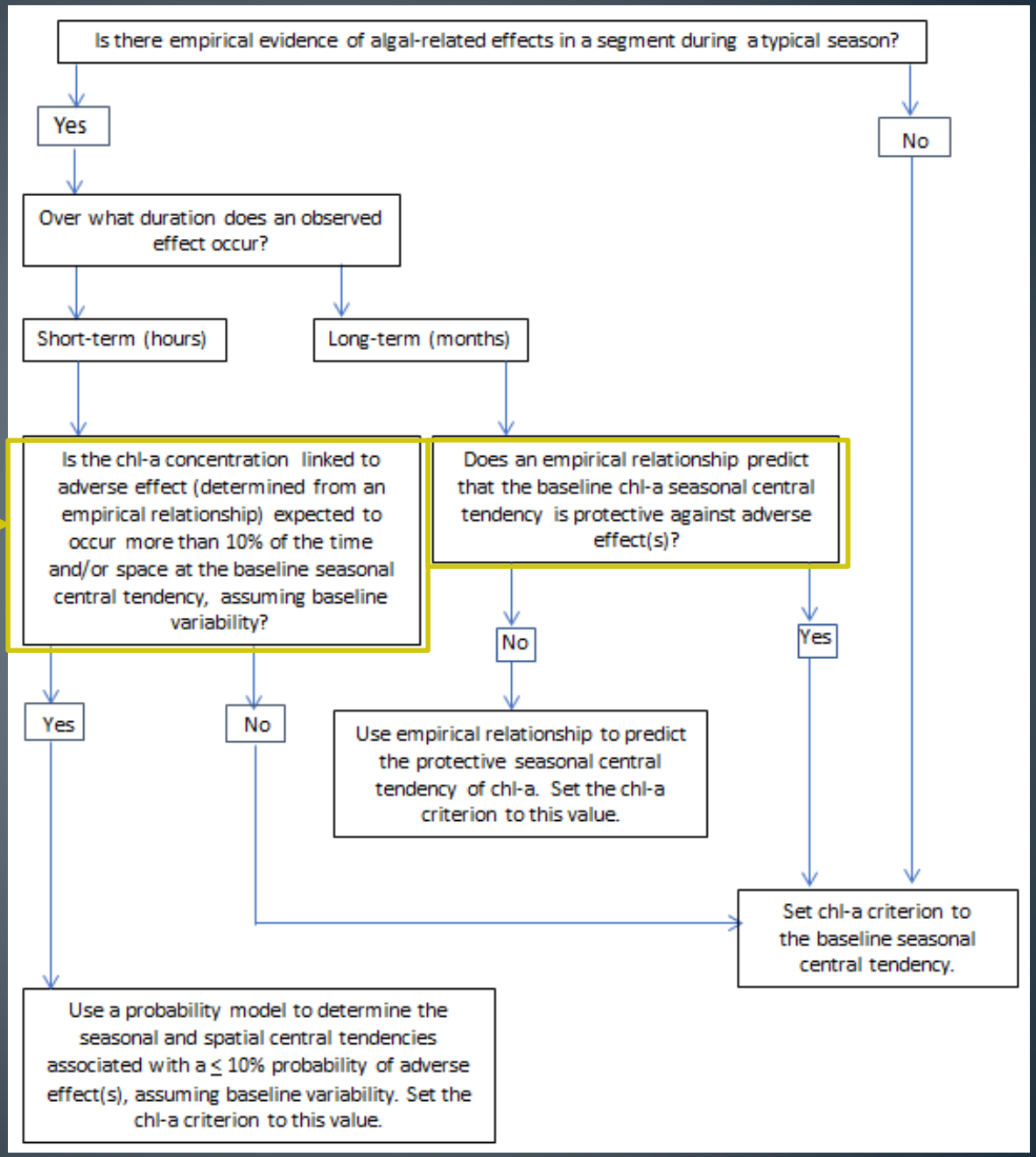
Segment-Season	n	Mean STDEV	U95CL STDEV
JMSTFU-upper Spring	7	0.777120126	0.907474087
JMSTFU-lower Spring	7	0.438874854	0.601119083
JMSTFU-upper Summer	12	0.664861671	0.862493318
JMSTFU-lower Summer	12	0.215986406	0.269303315
JMSTFL-upper Spring	8	0.202910226	0.256669097
JMSTFL-lower Spring	8	0.376454591	0.505667971
JMSTFL-upper Summer	12	0.204580228	0.240021506
JMSTFL-lower Summer	12	0.385486598	0.43109373
JMSOH Spring	25	0.382245794	0.466012756
JMSOH Summer	36	0.463815852	0.527822443
JMSMH Spring	137	0.727230915	0.785782579
JMSMH Summer	141	0.693756536	0.743328102
JMSPH Spring	135	0.355468822	0.385723059
JMSPH Summer	147	0.38086044	0.417056998

Baseline temporal variability (derived from ConMon or Dataflow)

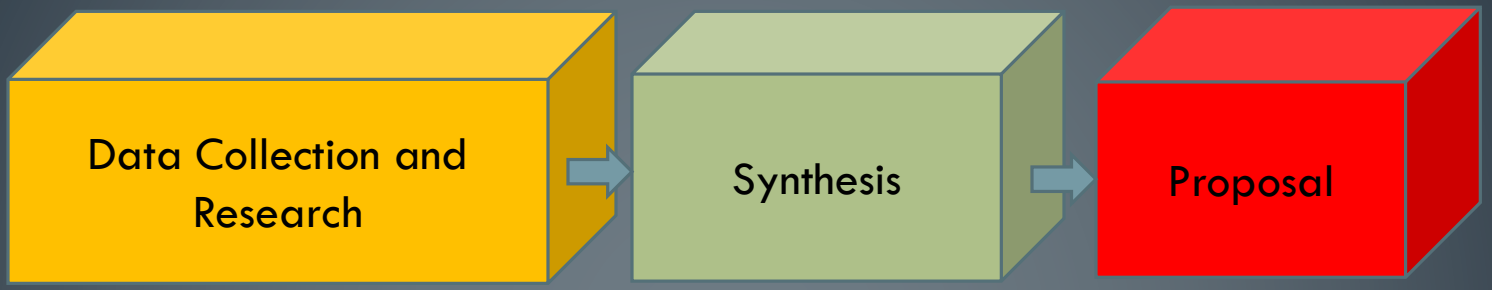
Segment-Season	n	Mean STDEV	U95CL
JMSTFU-upper Spring	3	0.69104397	0.903940312
JMSTFU-lower Spring	3	0.527053568	0.68267773
JMSTFU-upper Summer	3	0.512128202	0.71778251
JMSTFU-lower Summer	3	0.313900711	0.396182296
JMSTFL-upper Spring	3	0.527053568	0.68267773
JMSTFL-lower Spring	3	0.400438846	0.424532847
JMSTFL-upper Summer	3	0.313900711	0.396182296
JMSTFL-lower Summer	3	0.313371862	0.386876437
JMSOH Spring	3	0.400438846	0.424532847
JMSOH Summer	3	0.313371862	0.386876437
JMSMH Spring	11	0.888583538	0.938333876
JMSMH Summer	11	0.75198526	0.795695085
JMSPH Spring	11	0.576054936	0.713006181
JMSPH Summer	11	0.623283494	0.771890104

Decision tree used to re-derive JR chl criteria

Stressor-response model
+
Baseline chl parameters



Study Timeline



- Enhanced ambient monitoring
- Laboratory bioassays
- Literature review

- alternative criteria & alternative assessment method

- Development of an approach for testing the protectiveness of the current criteria (one that can also derive alternative criteria, if needed)

Phase 3. Proposal

Segment-Season	2005 Criteria	Recommended
JMSTFU-spring	10	8
JMSTFU-summer	15	21
JMSTFL-spring	15	10
JMSTFL-summer	23	24
JMSOH-spring	15	13
JMSOH-summer	22	11
JMSMH-spring	12	7
JMSMH-summer	10	7
JMSPH-spring	12	8
JMSPH-summer	10	7

DRAFT

Estimated using 2005-2015 monitoring datasets

Segment-Season	2005 Criteria	Recommended	Baseline
JMSTFU-spring	10	8	8
JMSTFU-summer	15	21	23
JMSTFL-spring	15	10	10
JMSTFL-summer	23	24	28
JMSOH-spring	15	13	13
JMSOH-summer	22	11	11
JMSMH-spring	12	7	7
JMSMH-summer	10	7	7
JMSPH-spring	12	8	8
JMSPH-summer	10	7	8

DRAFT

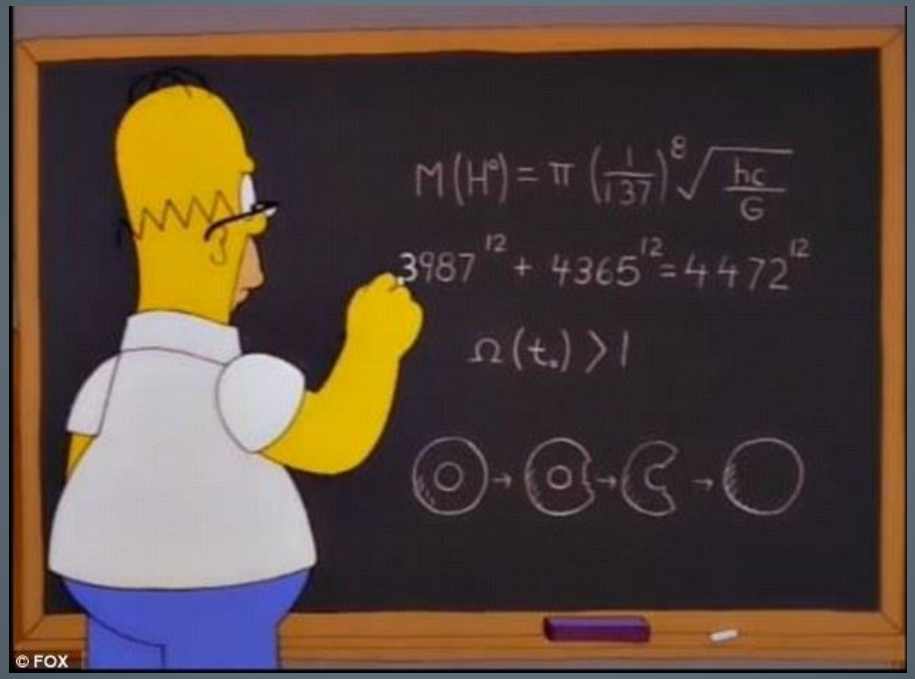
Segment-Season	2005 Criteria	Recommended	Basis for recommended criteria lower than baseline	Baseline
JMSTFU-spring	10	8		8
JMSTFU-summer	15	21	Enhanced protection from elevated pH	23
JMSTFL-spring	15	10		10
JMSTFL-summer	23	24	Enhanced protection from elevated pH and harmful algal blooms	28
JMSOH-spring	15	13		13
JMSOH-summer	22	11		11
JMSMH-spring	12	7		7
JMSMH-summer	10	7		7
JMSPH-spring	12	8		8
JMSPH-summer	10	7	Enhanced protection from harmful algal blooms	8

DRAFT

Unlike the 2005 criteria, the recommended criteria….

- are truly site-specific.
- protect against both HABs and physicochemical effects.
- protect current water quality.

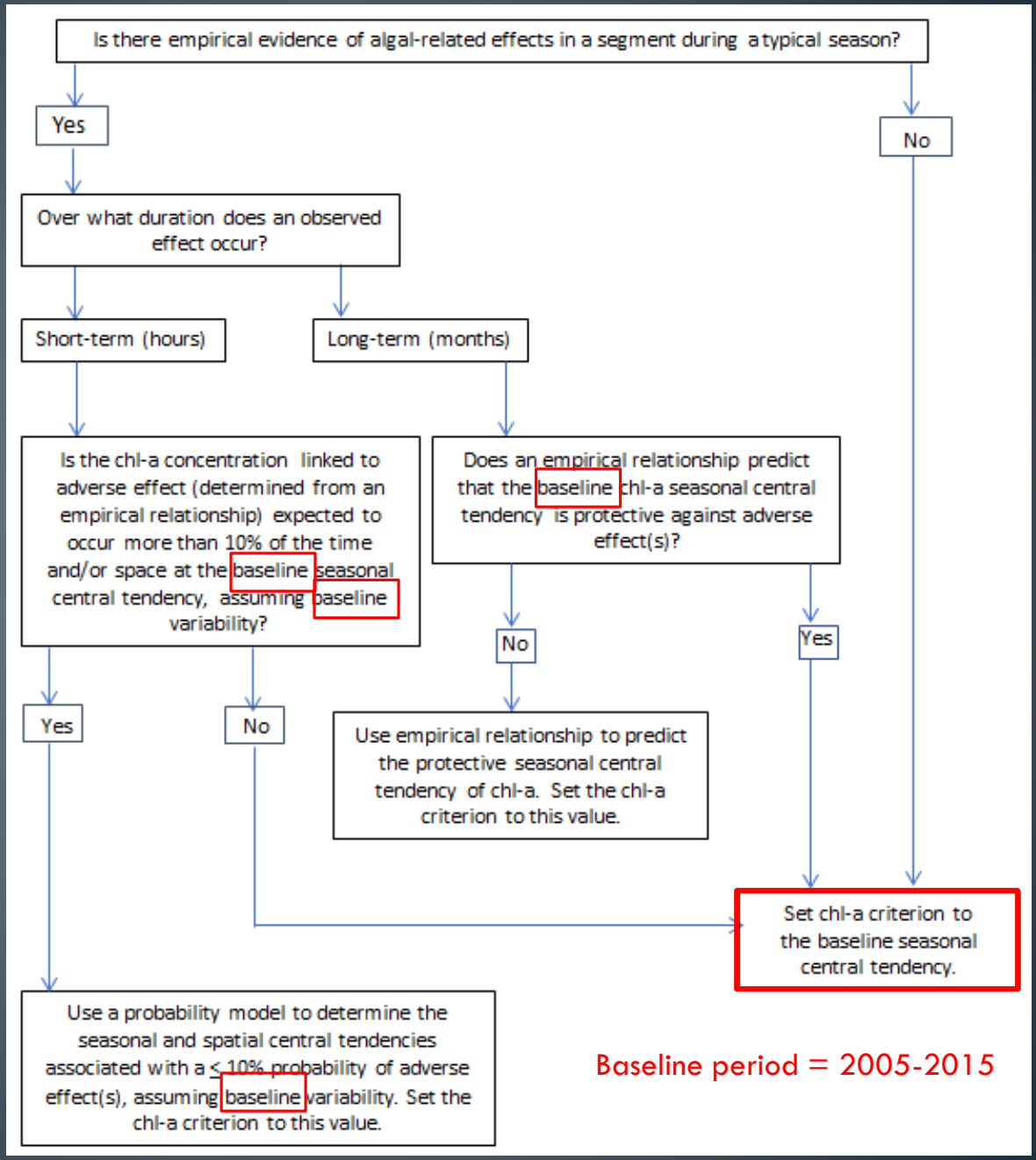
We are also proposing an alternative assessment procedure!



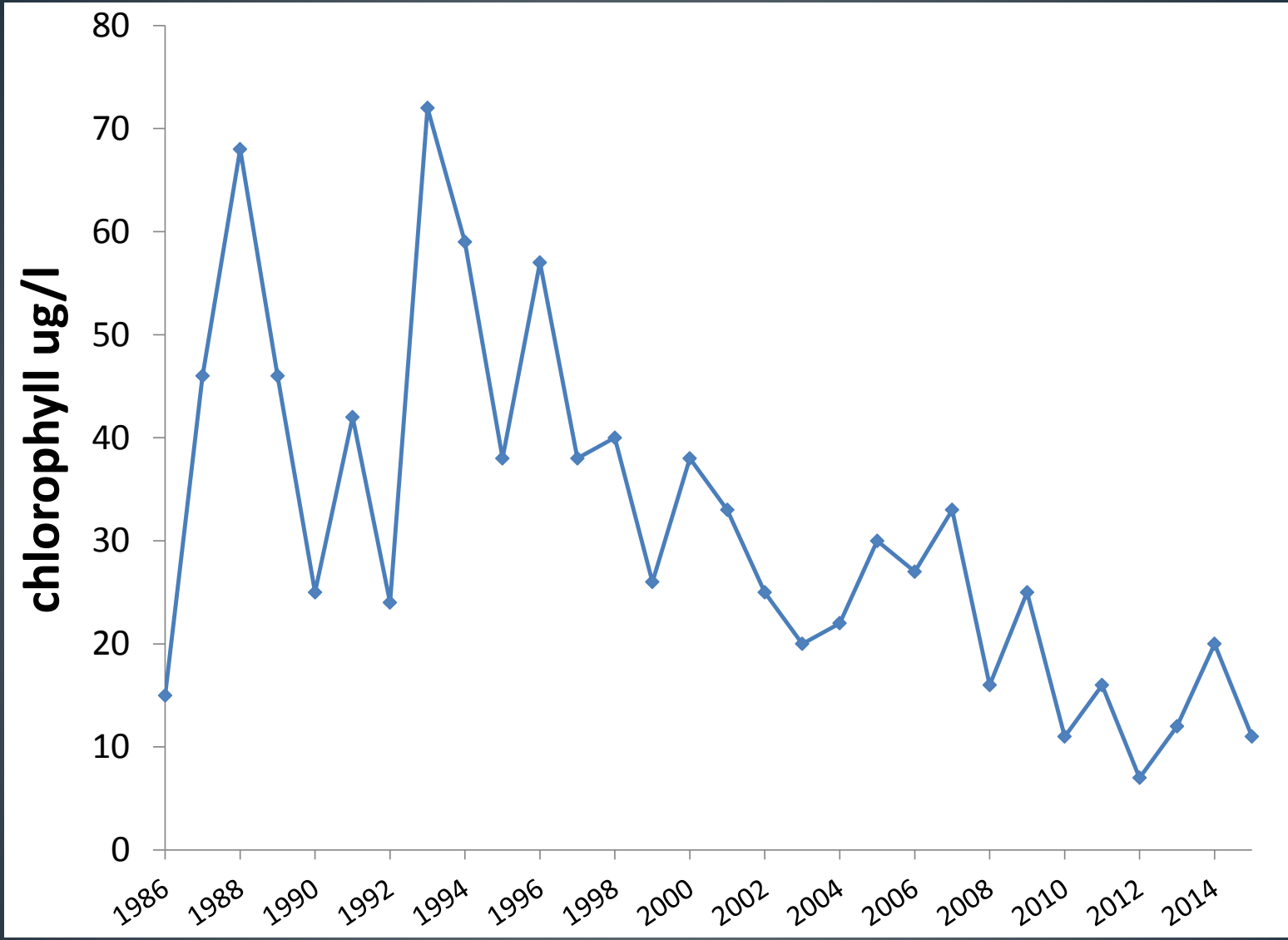
One last thing!

DEQ considered chlorophyll-a trends in the James as it developed its proposal.

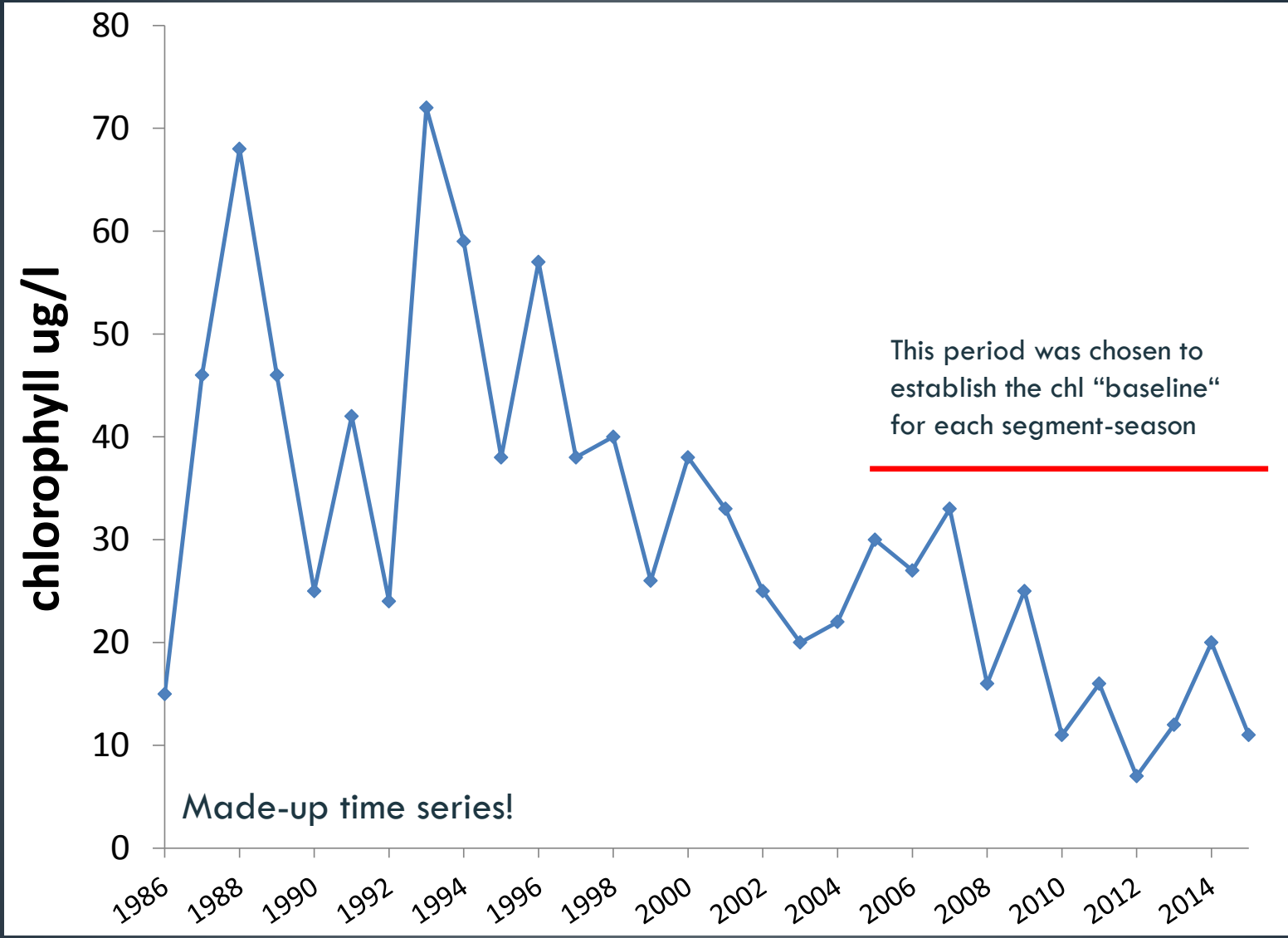
Decision tree used to re-derive JR chl criteria

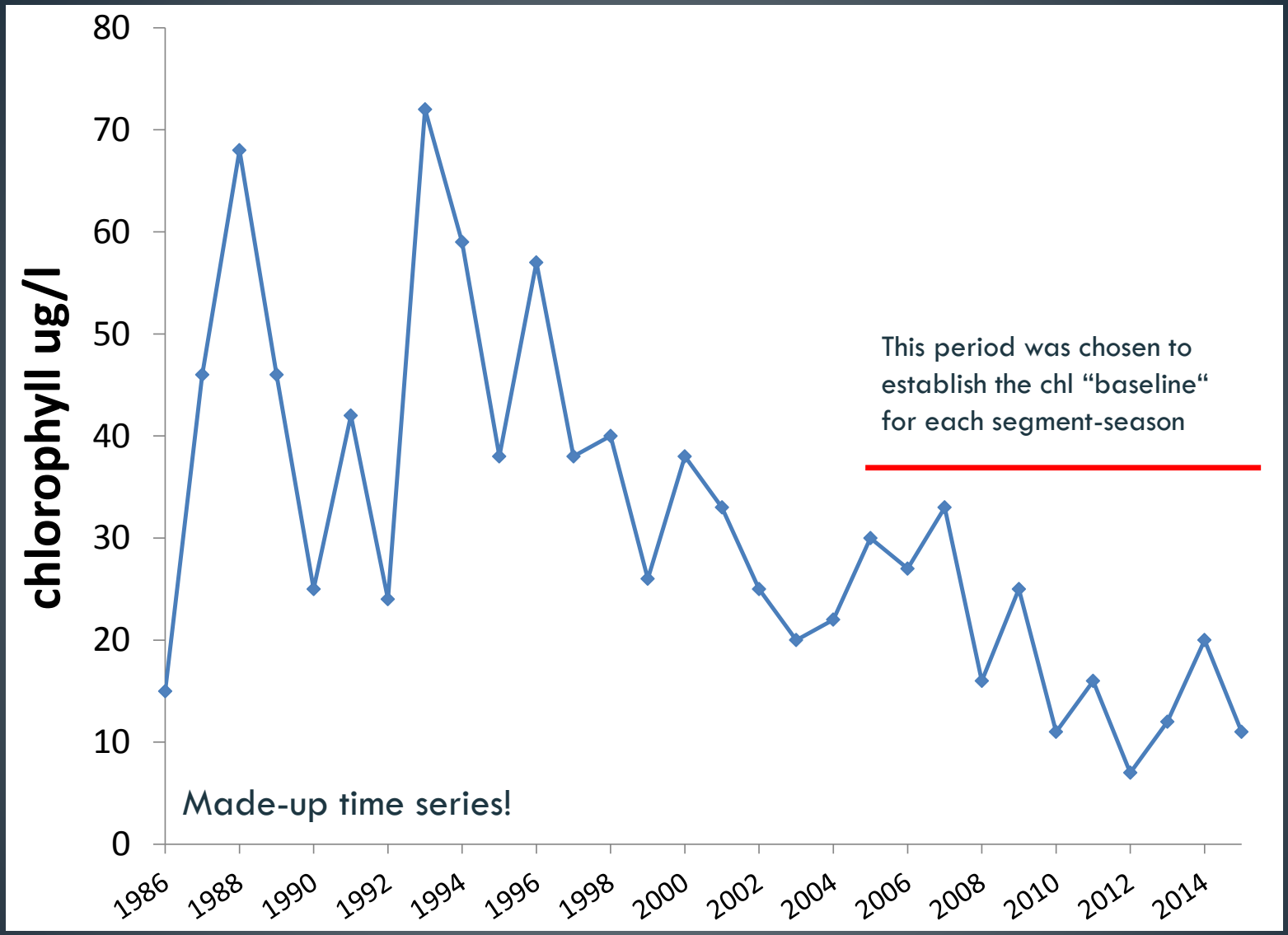


Baseline period = 2005-2015

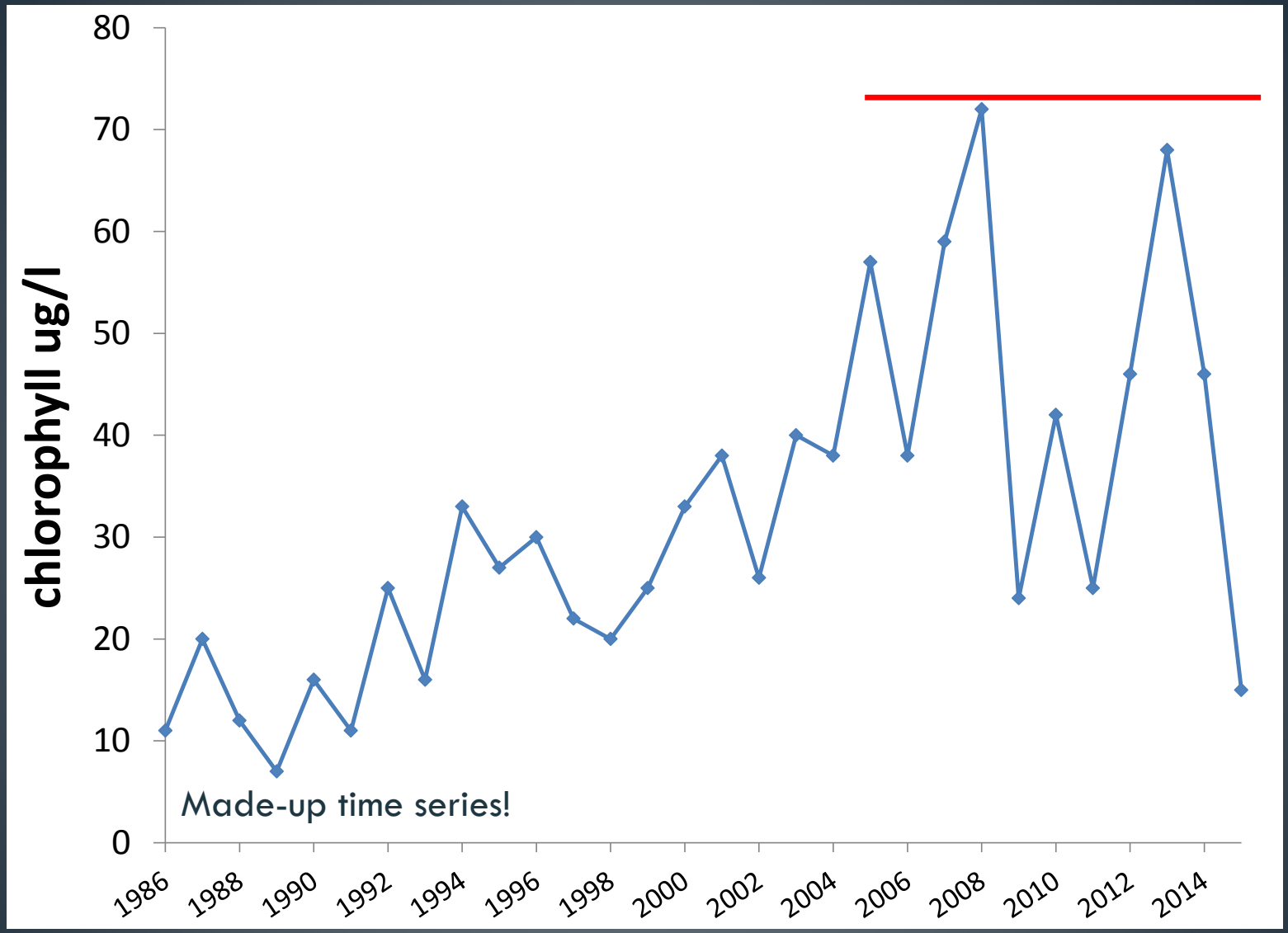


Made-up time series!


chlorophyll ug/l
80
70
60
50
40
30
20
10
0
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
This period was chosen to establish the chl "baseline" for each segment-season
Made-up time series!

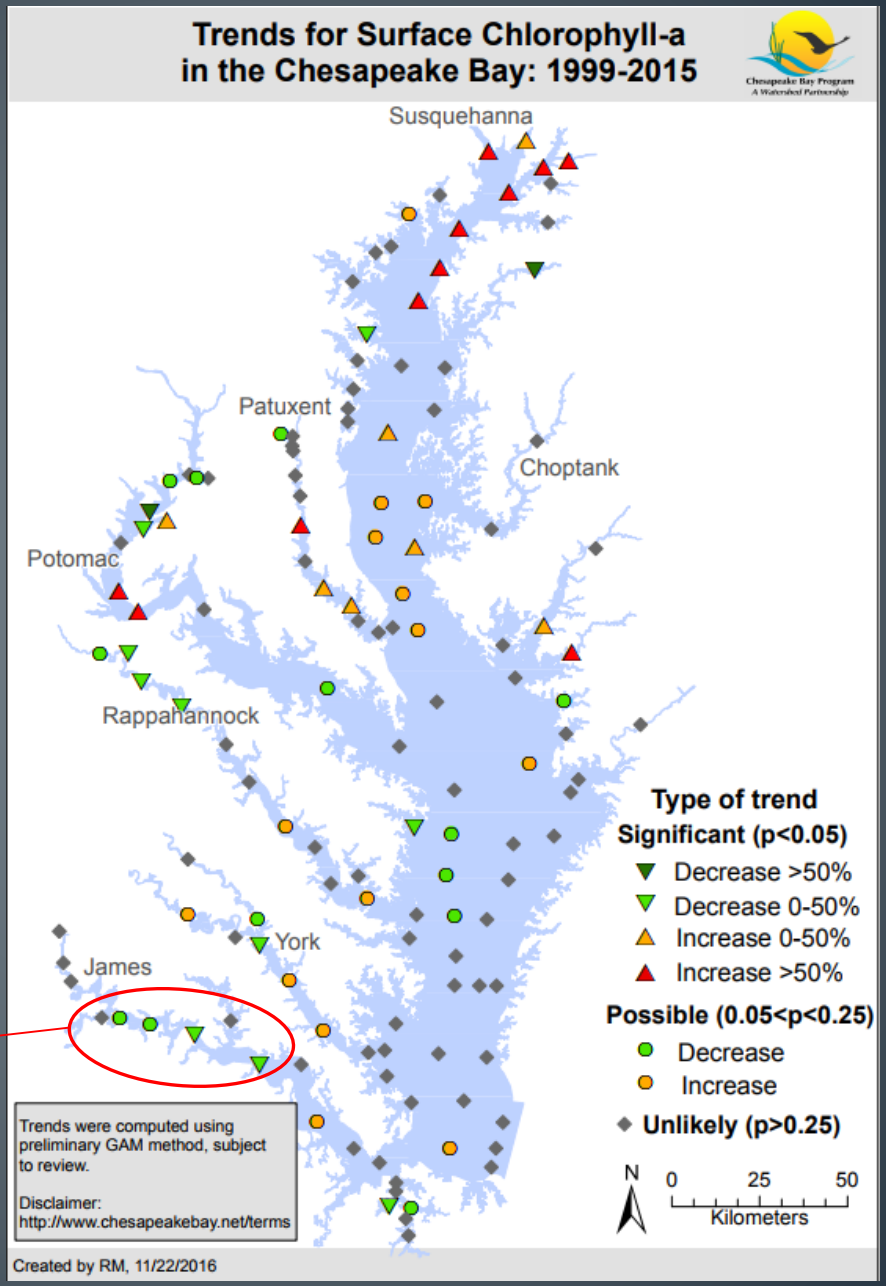


In this scenario, baseline criteria would represent "best observed condition" and would thus be ideal.



But in this scenario, baseline criteria would represent "worst observed condition" and thus would not be ideal.

GAMs indicate improving annual trends in the upper and middle estuary ☺



Segment	Season	p-value	Sen Slope	% change over 1985-2017	Trend direction
JMSTFU	spring	0.0040	-0.07	-33.23	Improving
JMSTFU	summer	0.3062	-0.04	-26.71	No significant trend
JMSTFL	spring	0.0057	-0.36	-51.94	Improving
JMSTFL	summer	0.7689	-0.10	-11.15	No significant trend
JMSOH	spring	0.4720	-0.04	-18.07	No significant trend
JMSOH	summer	0.3406	-0.04	-17.25	No significant trend
JMSMH	spring	0.6340	0.02	8.88	No significant trend
JMSMH	summer	0.0001	0.11	76.76	Degrading
JMSPH	spring	0.3028	0.04	14.17	No significant trend
JMSPH	summer	0.0000	0.18	147.40	Degrading

But seasonal Kendall indicates degrading trends in JMSMH and JMSPH .☹

HOWEVER…

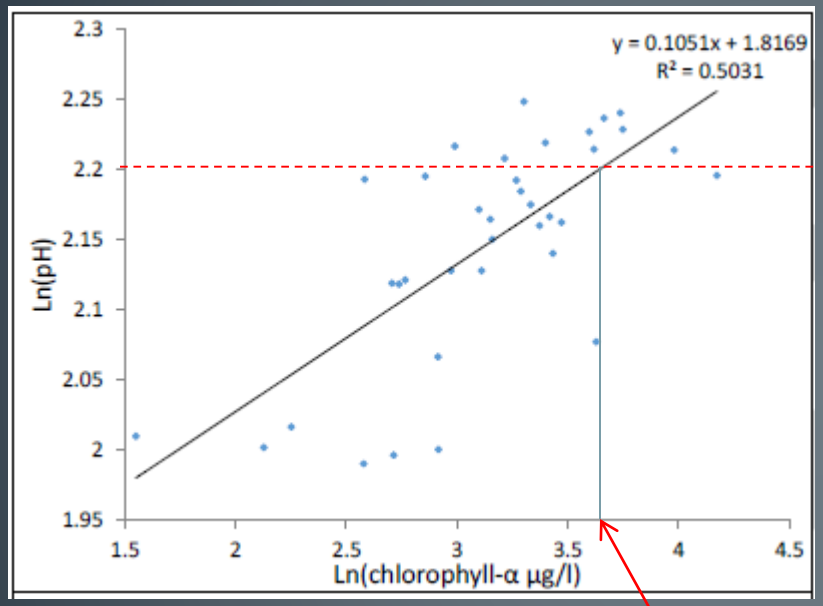
		2005-2015	Central tendency estimates over alternative baseline periods		
Segment	**Season**	**Recommended Criterion**	**1986-2015**	**1986-1999**	**2000-2015**
JMSTFU	spring	**8**	11	13	10
	summer	21	28	33	26
JMSTFL	spring	**10**	13	16	12
	summer	24	30	37	27
JMSOH	spring	**13**	14	16	15
	summer	**11**	11	13	10
JMSMH	spring	**7**	10	12	10
	summer	**7**	8	7	10
JMSPH	spring	**8**	12	14	11
	summer	7	10	8	12

Almost all the proposed baseline criteria (in bold) are lower than the mean estimates derived from older datasets.

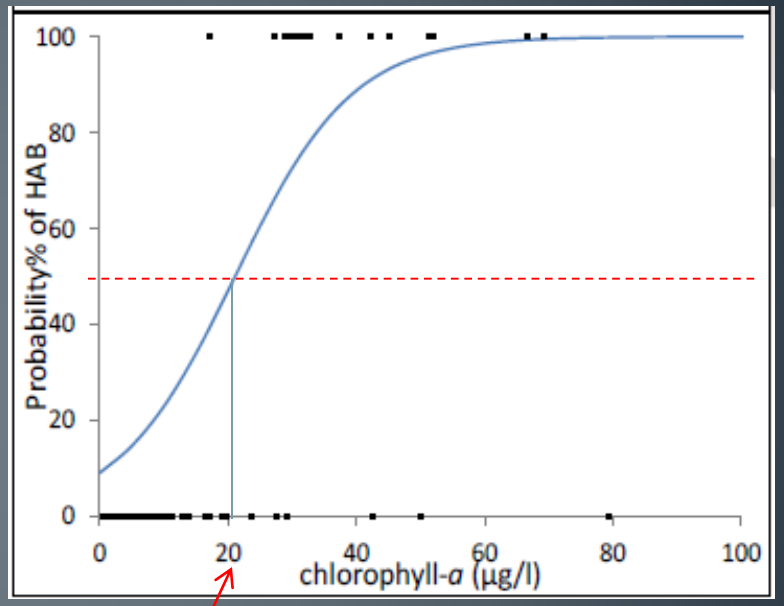
This is true even in the lower estuary.

Questions?

JMSTFL Spring



JMSPH Summer



Chlorophyll concentrations associated with potentially harmful effects