Assessing water clarity in the Chesapeake Bay for standards attainment

Ken Moore

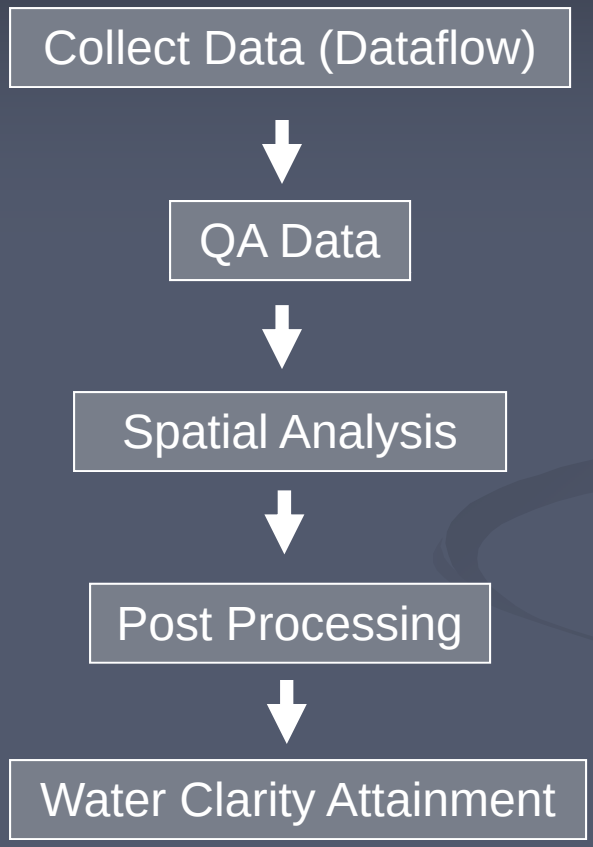
TMAW June 12, 2012

WILLIAM & MARY
VIMS
VIRGINIA INSTITUTE OF MARINE SCIENCE
SCHOOL OF MARINE SCIENCE

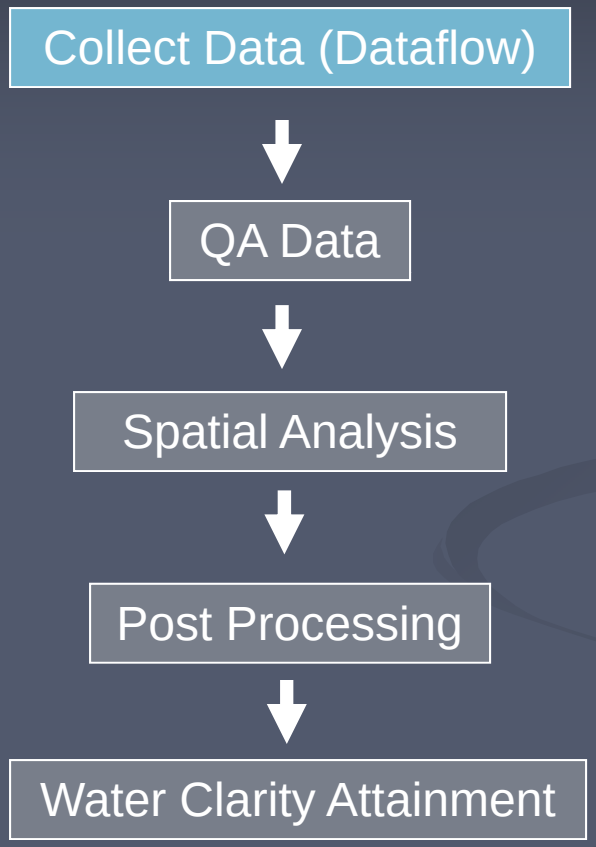
Dataflow and Water Clarity

- Strong link b/w water clarity & SAV persistence
- 2003: EPA establishes water clarity criteria for shallow water areas (< 2m) of Chesapeake Bay
  - Polyhaline – Mesohaline: 22% PLL
  - Oligohaline - Tidal Fresh: 13% PLL
- VA and MD use DATAFLOW to monitor compliance

Workflow


Collect Data (Dataflow)
QA Data
Spatial Analysis
Post Processing
Water Clarity Attainment

Workflow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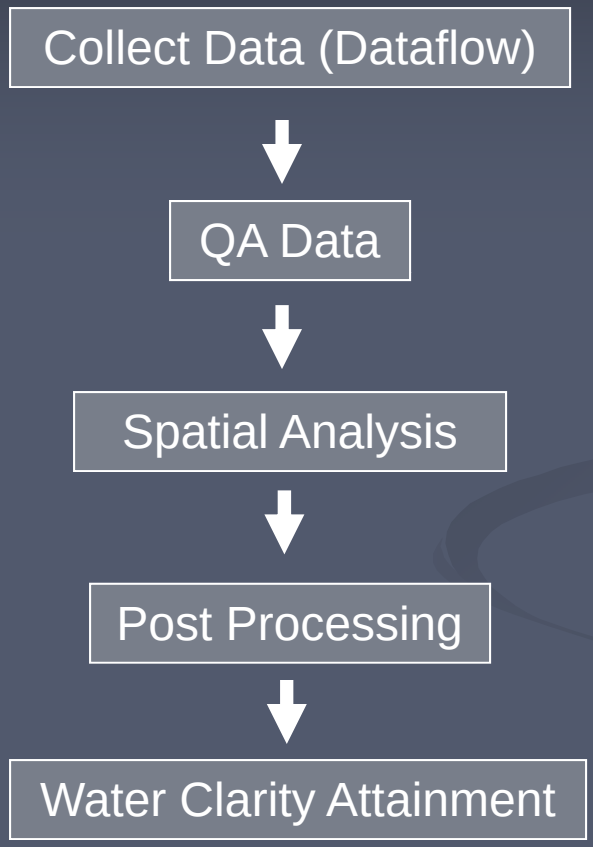
Collect Data (DATAFLOW)

- Pumps water through array of sensors - YSI 6600
- Chl, Salinity, Turb, DO, pH, & Temp, collected every 3-4 s
- Cruises take place one a month
- Bay segments sampled for 3 consecutive years
  - 5 verification stations per segment
  - Calibration data enables flourescence - ext chl regressions

Workflow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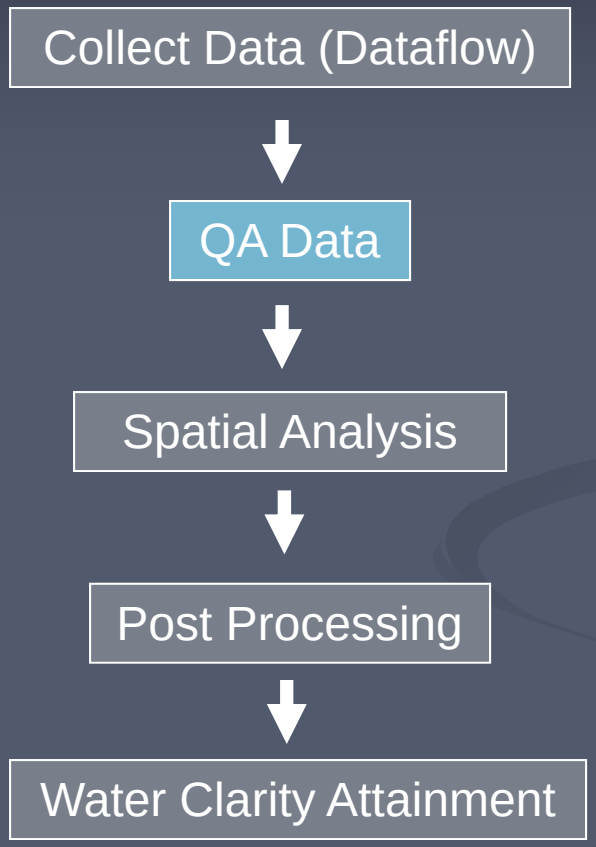
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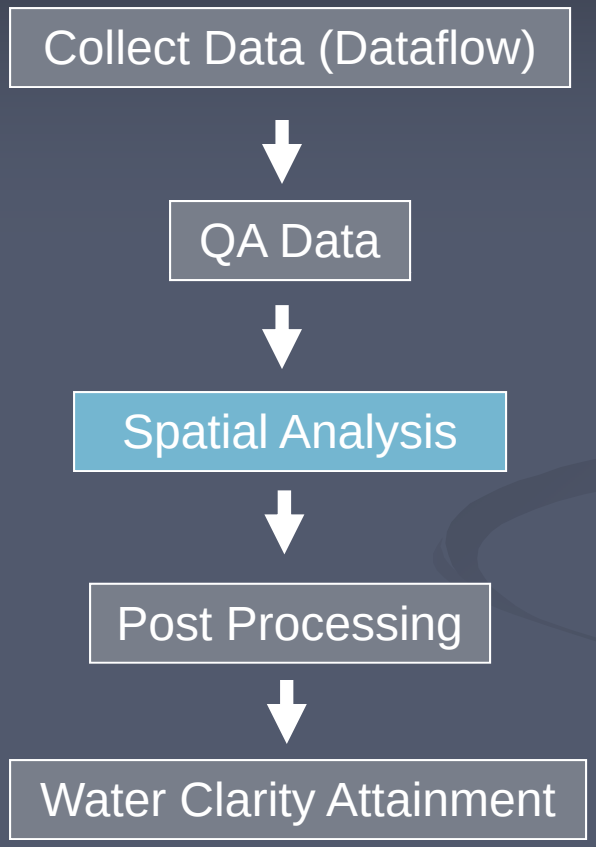
Dataflow QA

- Utilize macro to format comma delimited data
- Use field notes to identify questionable data
- Parameters are graphed over time to identify outliers or abnormal trends
- Examine YSI post-calibration data

Workflow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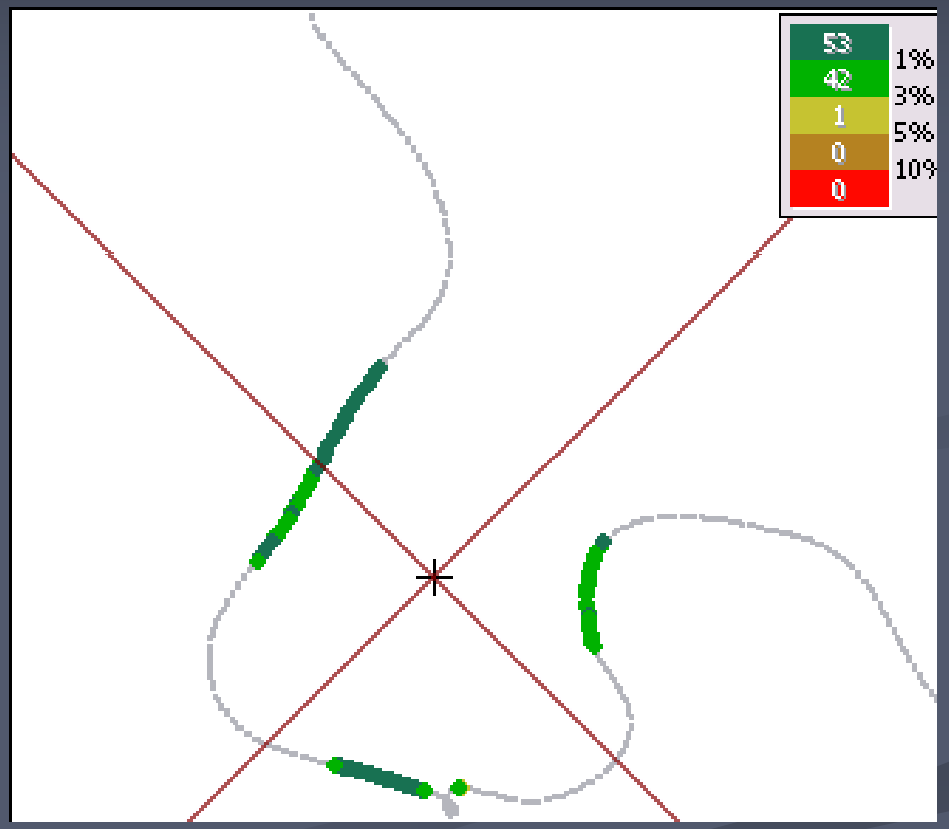
Kriging Process

- Performed in ArcMap Geostatistical Wizard
- Use spherical model
- Where available, 100 dataflow points used to interpolate value for each cell
- Data is stored in a grid format

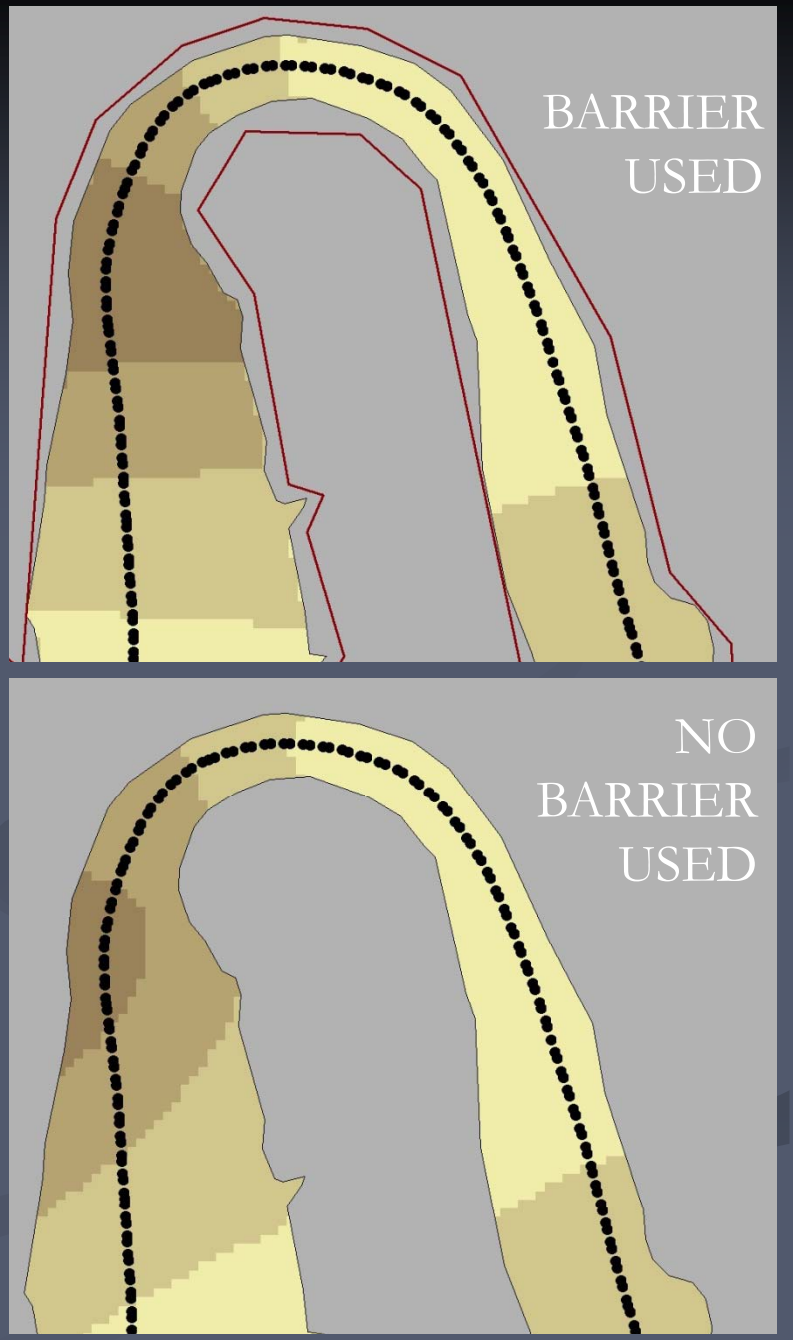


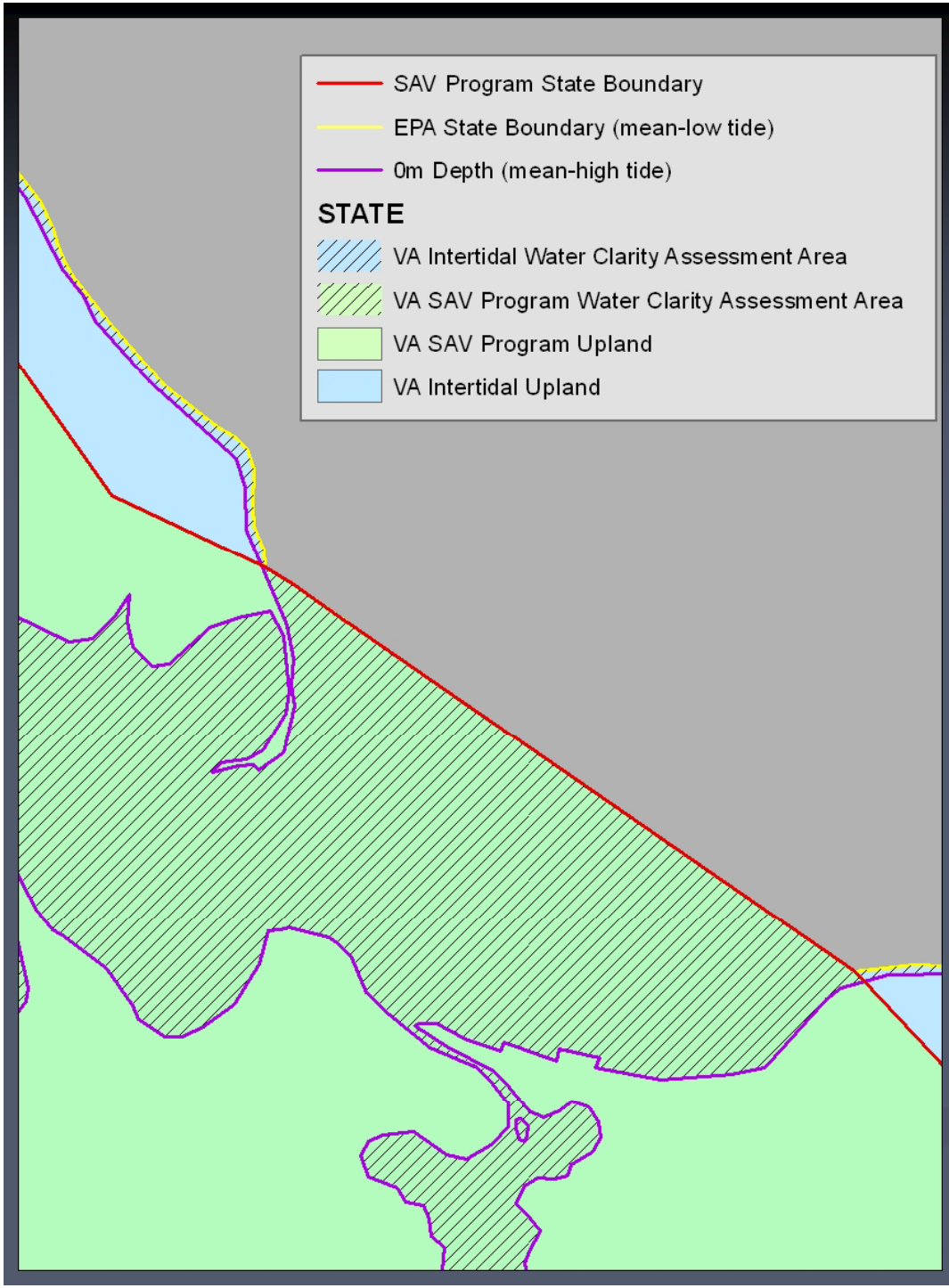
Barriers

- Barrier used for interpolations in some segments

- Simplified shoreline used as barrier

- Decreases influence of samples from other areas of river





State Boundary

- VA State Bounday is set to mean low water
- 0m contour is mean high tide
- Creates an intertidal sliver that must be assessed
- SAV program did not initially assign SAV in this region to VA
- State boundary will shift whenever remapped

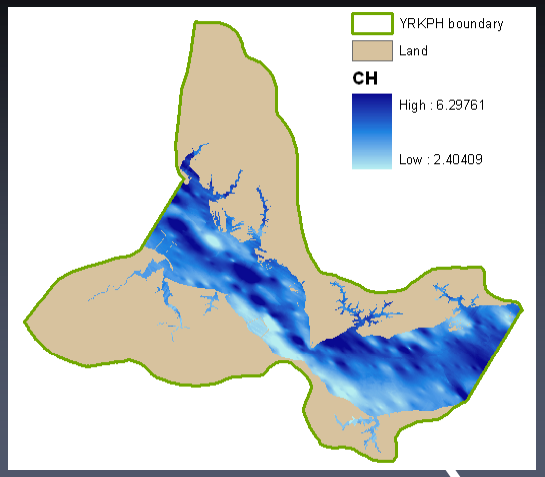
Kd Conversion

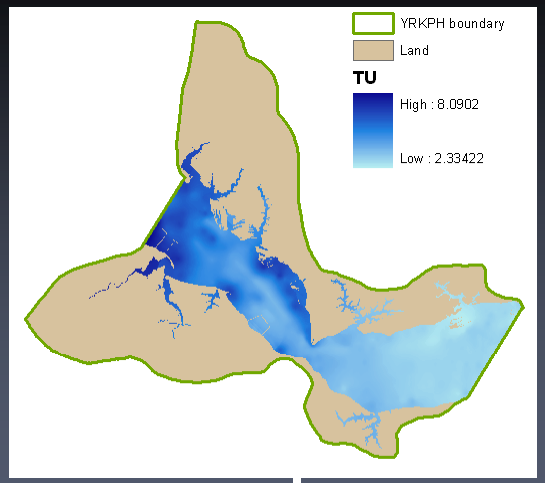
- For Segments MPNOH, MPNTF, CHKOH, JMSPH, JMSOH, JMSMH, JMSTF1, JMSTF2, APPTF:

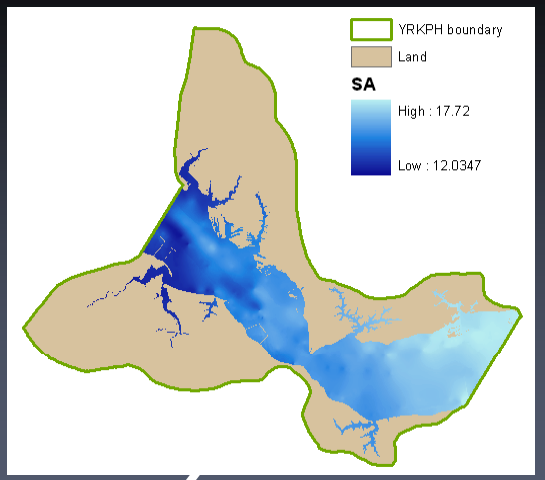
$$Kd = 1.192674757 + 0.29562072\ 2 \times \sqrt[1.5]{TU} - .056160407 \times SA + .000274598 \times CH$$

- For Segments LYNPH, PMKOH, PMKTF, YRKPH, YRKMH, PIAMH:

$$Kd = 0.5275793536 + 0.3193475331 \times \sqrt[1.5]{TU} + 0.0176700982 \times SA + 0.0271723238 \times CH$$







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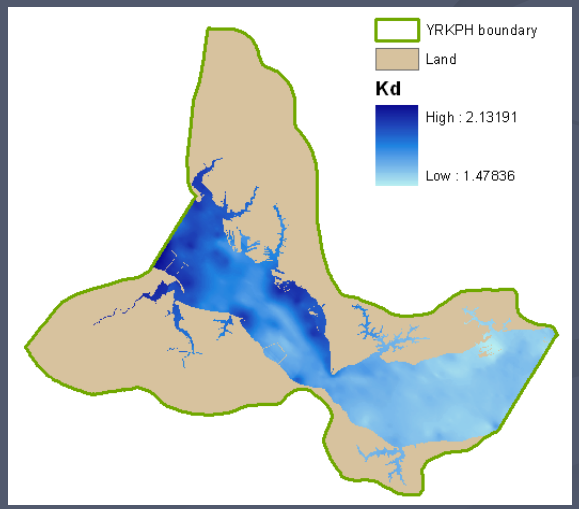
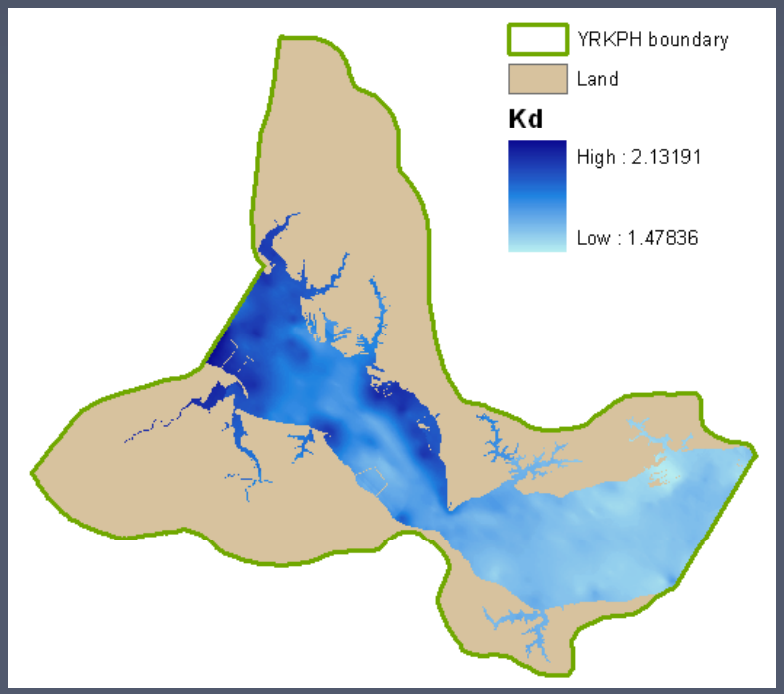


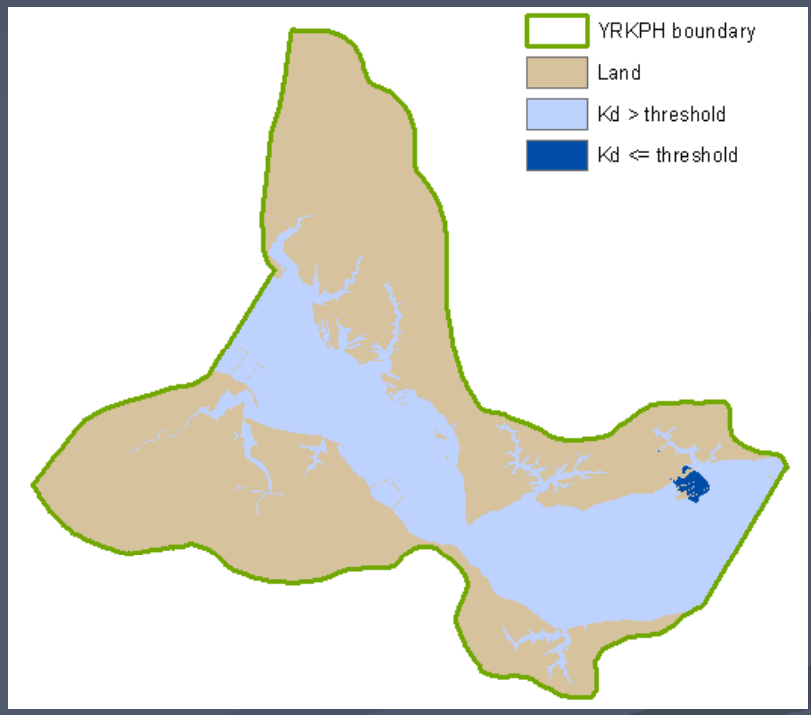
Kd Threshold

PLL	Zones	
	0-1m	1-2m
0.22	1.51	0.76
0.13	2.04	1.02

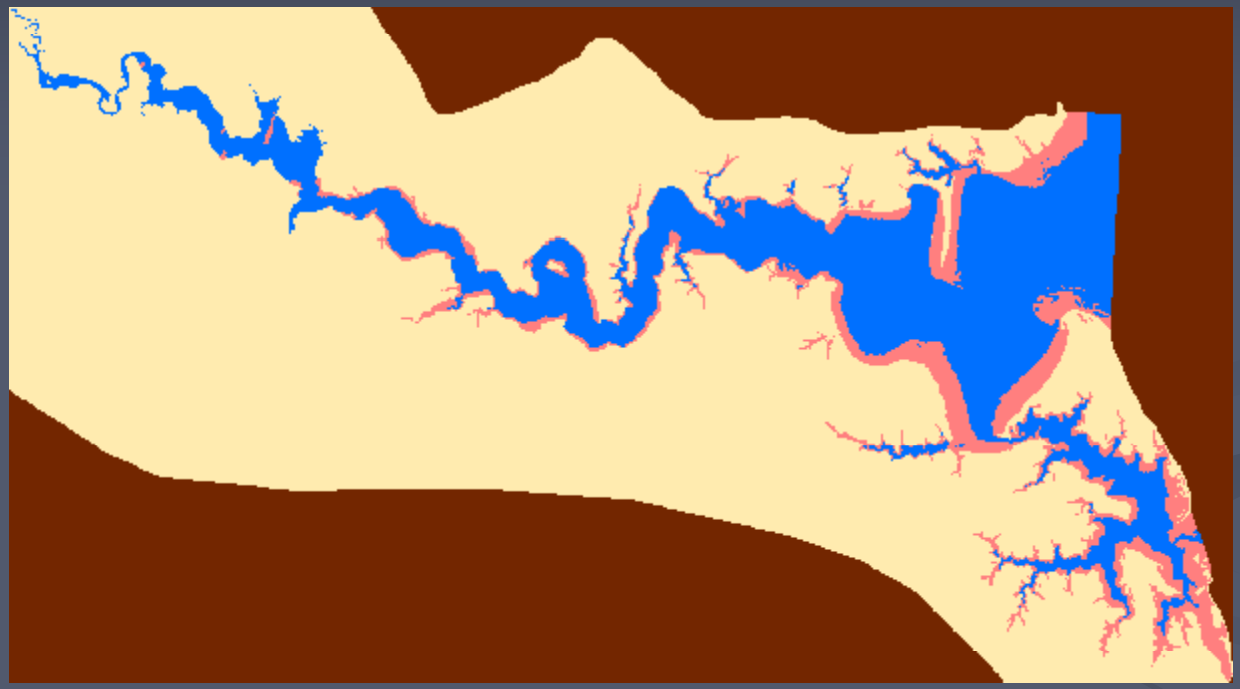
$$PLW = 100 \times e^{-Kz}$$

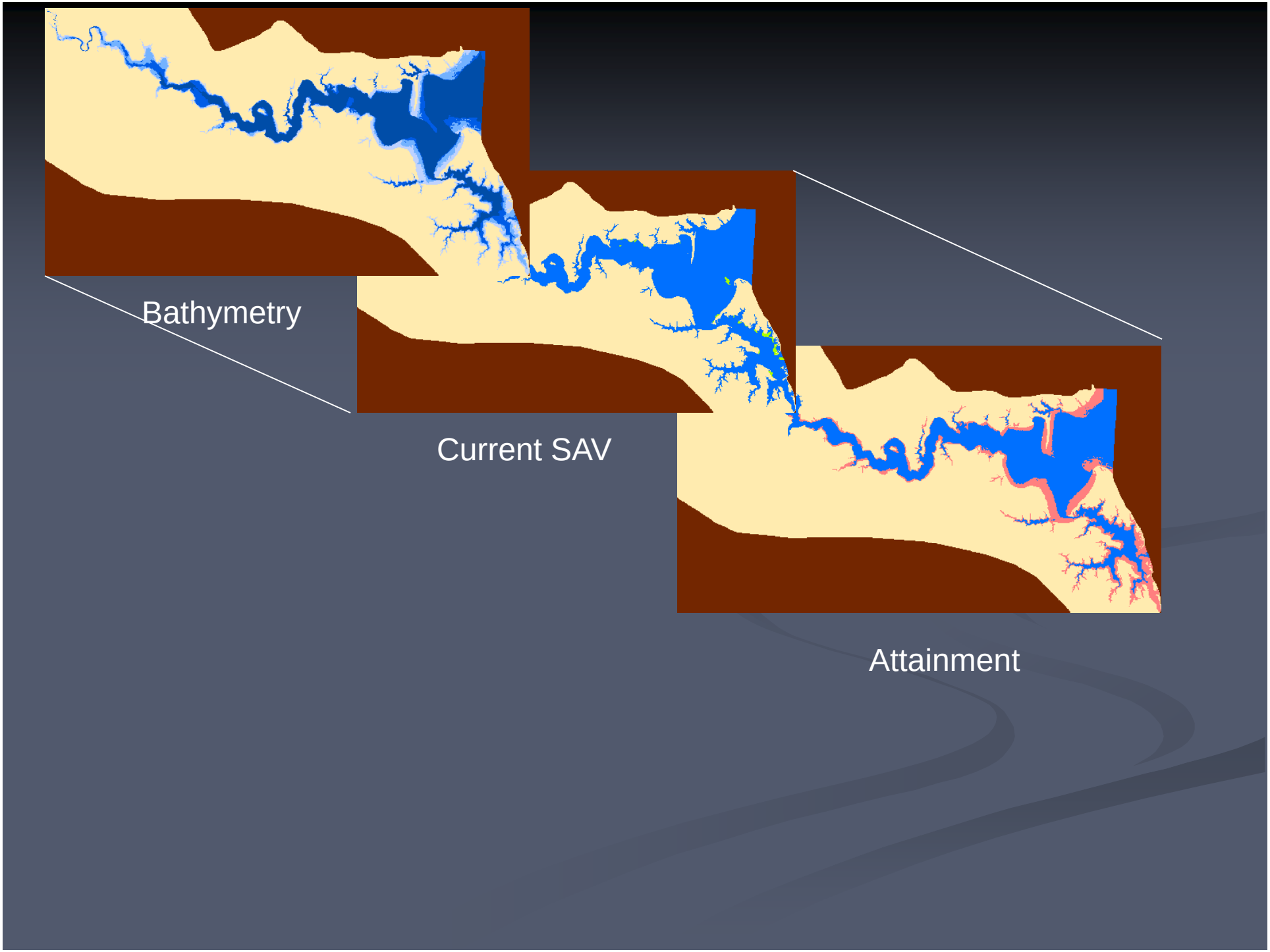
Kd compared to threshold = Attainment



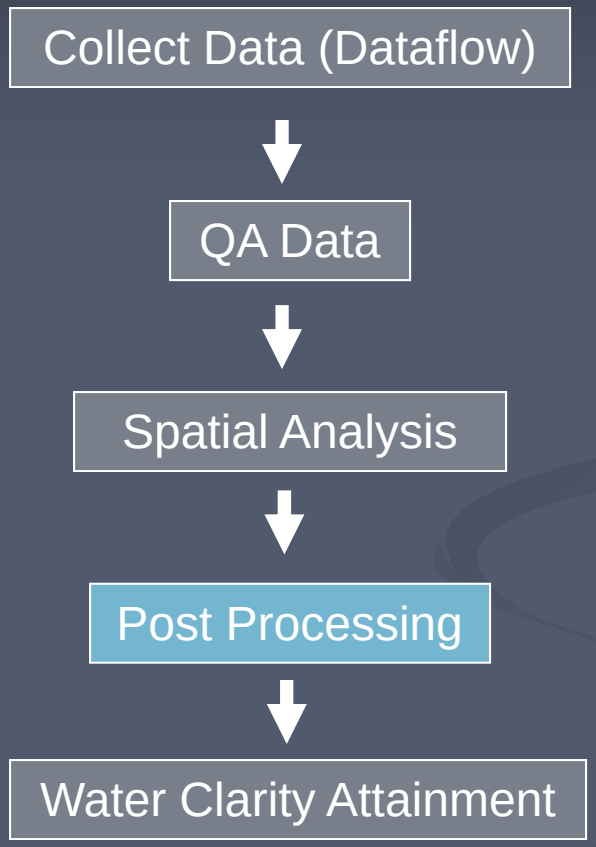


Attainment




Bathymetry
Current SAV
Attainment

Workflow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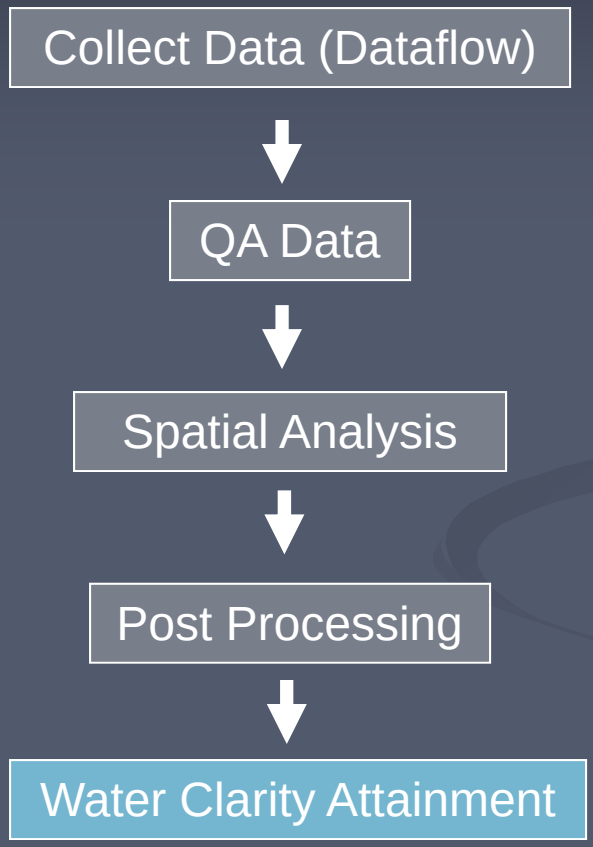
Water Clarity Attainment

Post Processing

CBSEG	DATE	COUNT	CU_SAV	BATHY	ATMNT
cb6ph	111610	215	0	3	0
cb6ph	111610	114	2	1	0
cb6ph	111610	224	2	3	1
cb6ph	111610	360	4	3	1
cb6ph	111610	27	4	1	0
cb6ph	111610	103	4	4	0

Workflow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CBPSEG	Year	WCAG	CUSAV	WCA	NSWCA	WC Met	WC + SAV Met
apptf	2008	948	0	0	0	no	no
cb6ph	2010	3168	531	3488	3113	yes	yes
chkoh	2006	1338	706	916	820	no	yes

WCAG = Water Clarity Acreage Goal (0-2m)

CUSAVa = Total SAV acreage as reported by Orth et al.

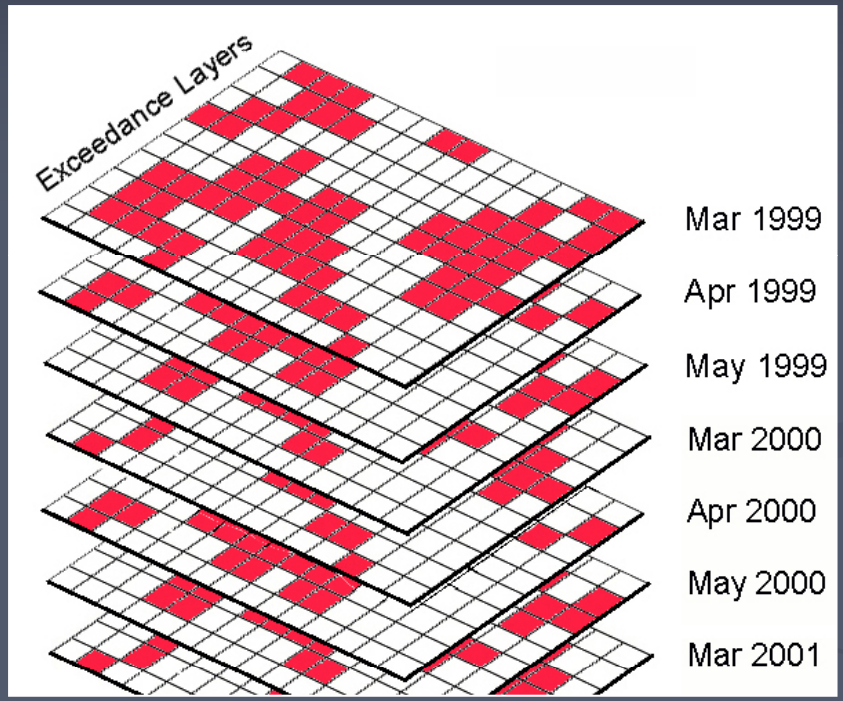
M_WCA = Mean Annual Acreage Meeting Water Clarity Goal

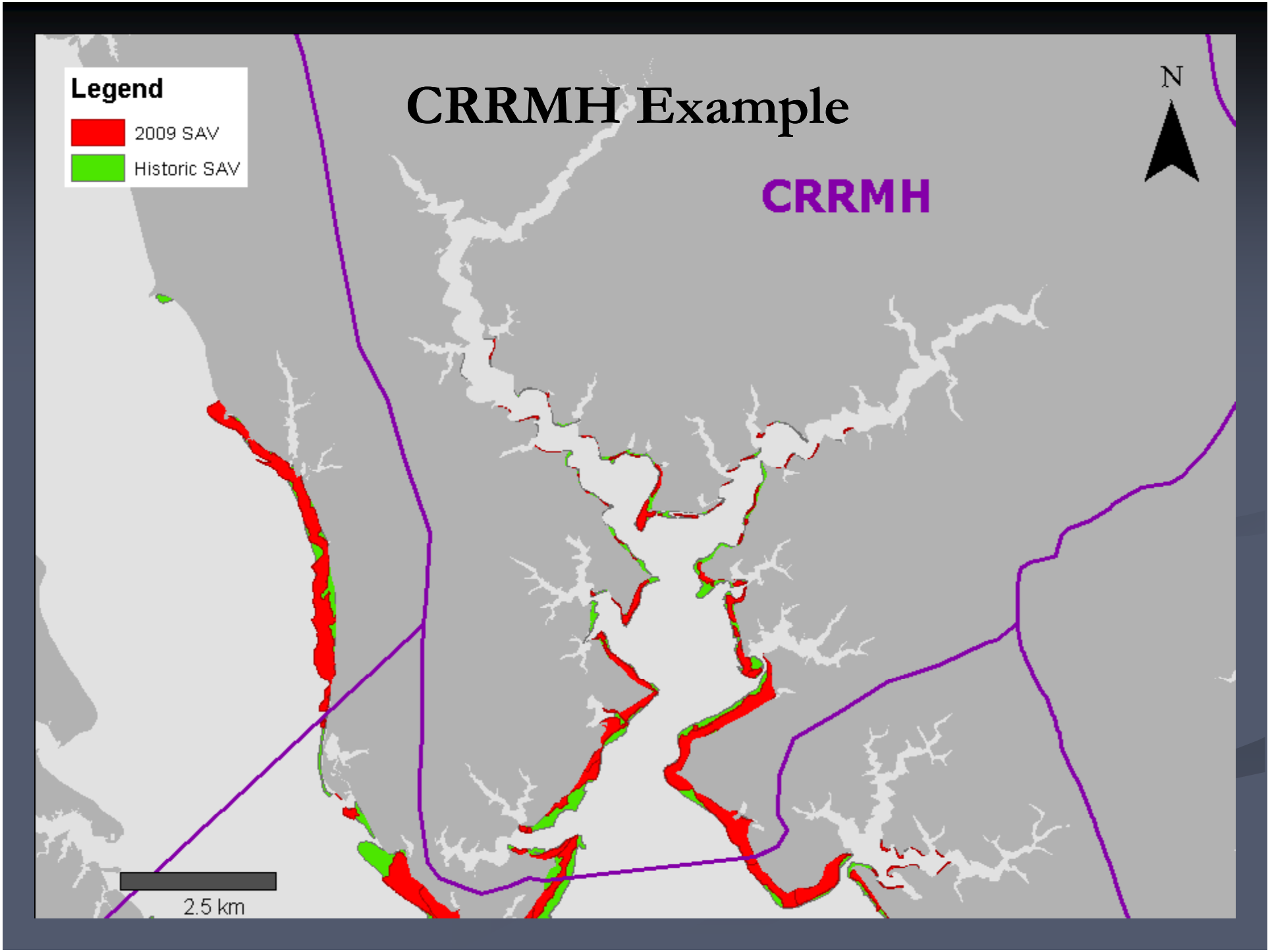
M_NSWCA = Mean Annual Non-SAV Acreage Meeting Water Clarity Goal

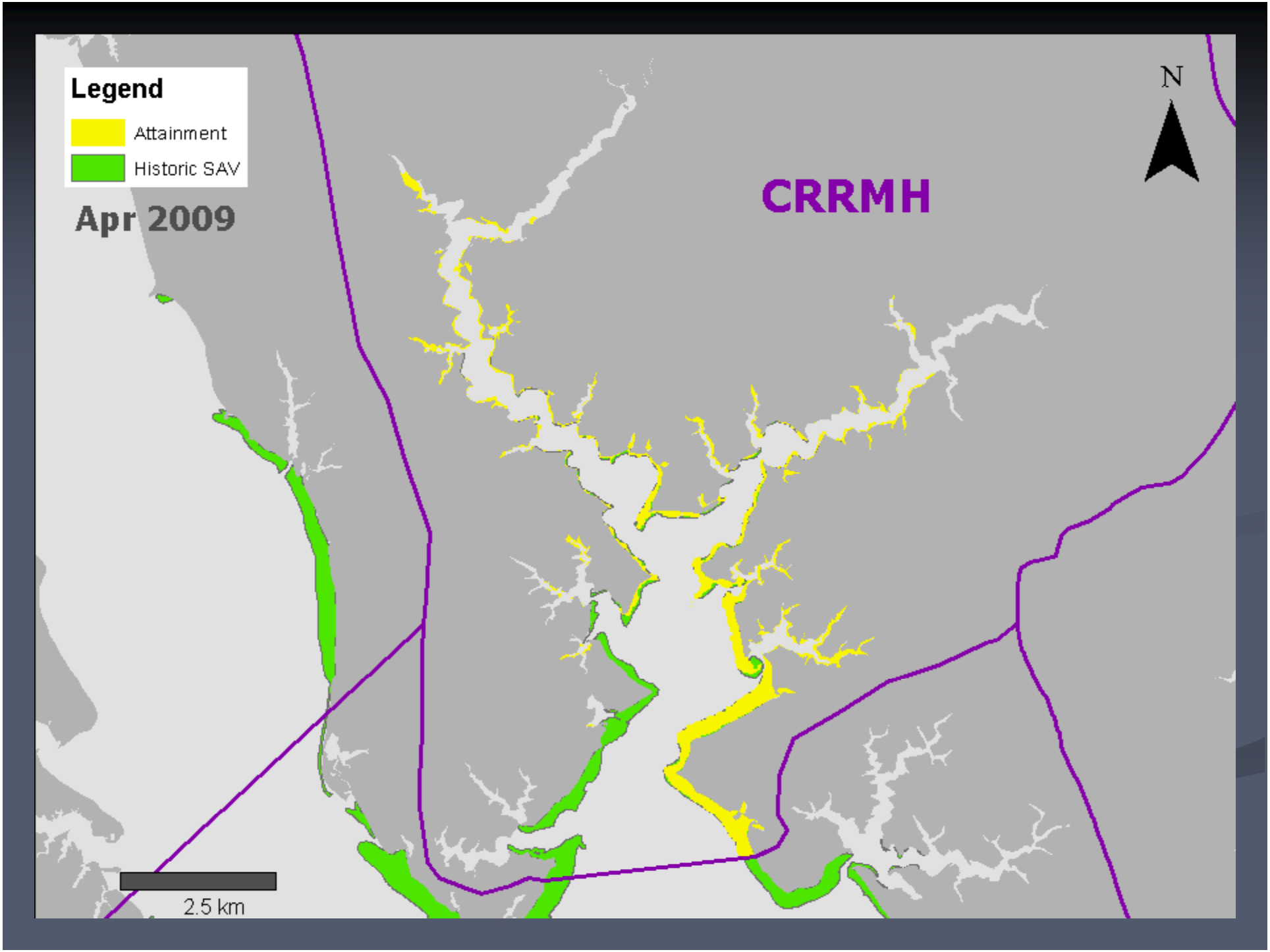
WC Met: WCA >= WCAG

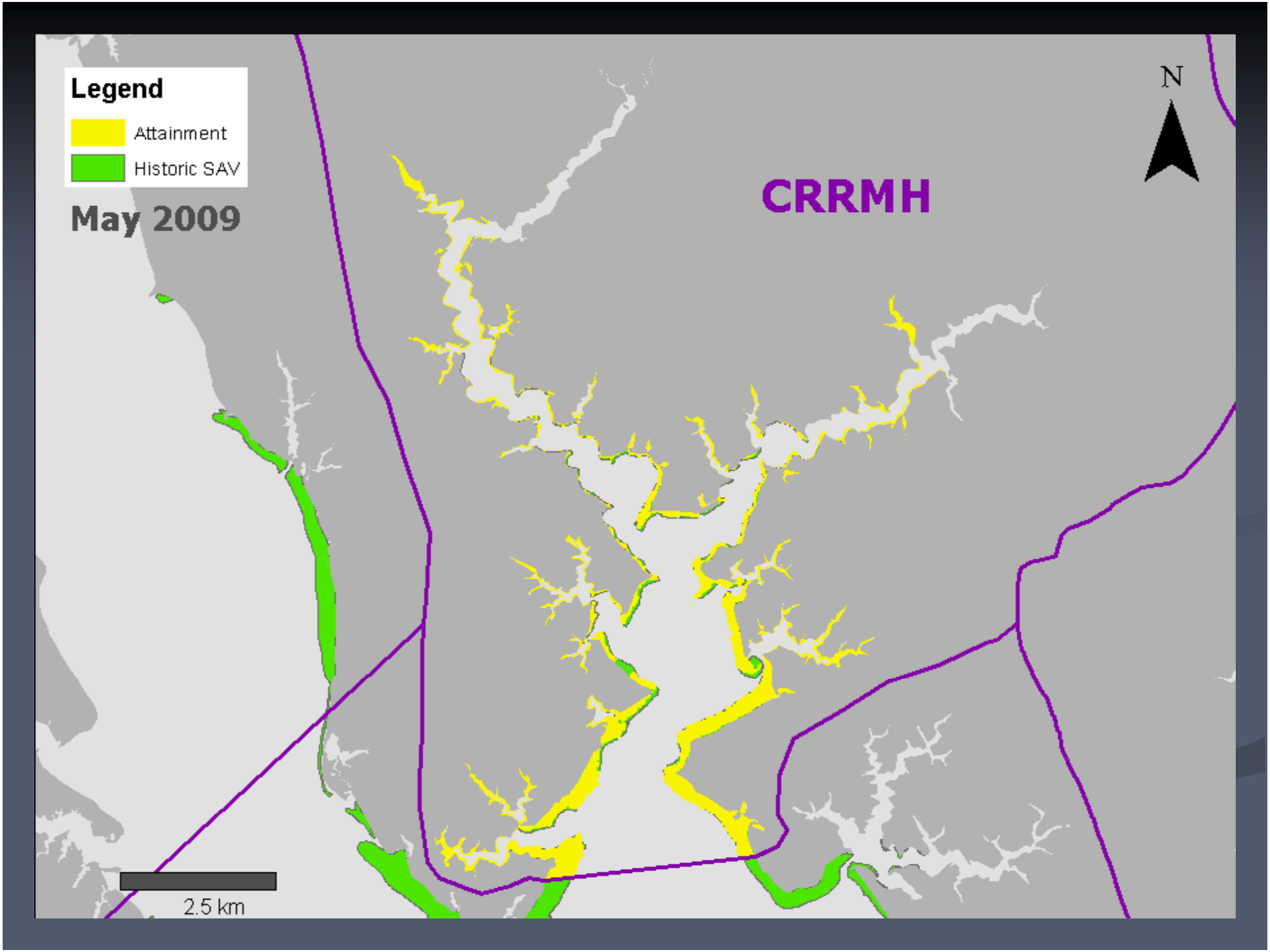
WC + SAV Met: CUSAV+NSWCA >= WCAG

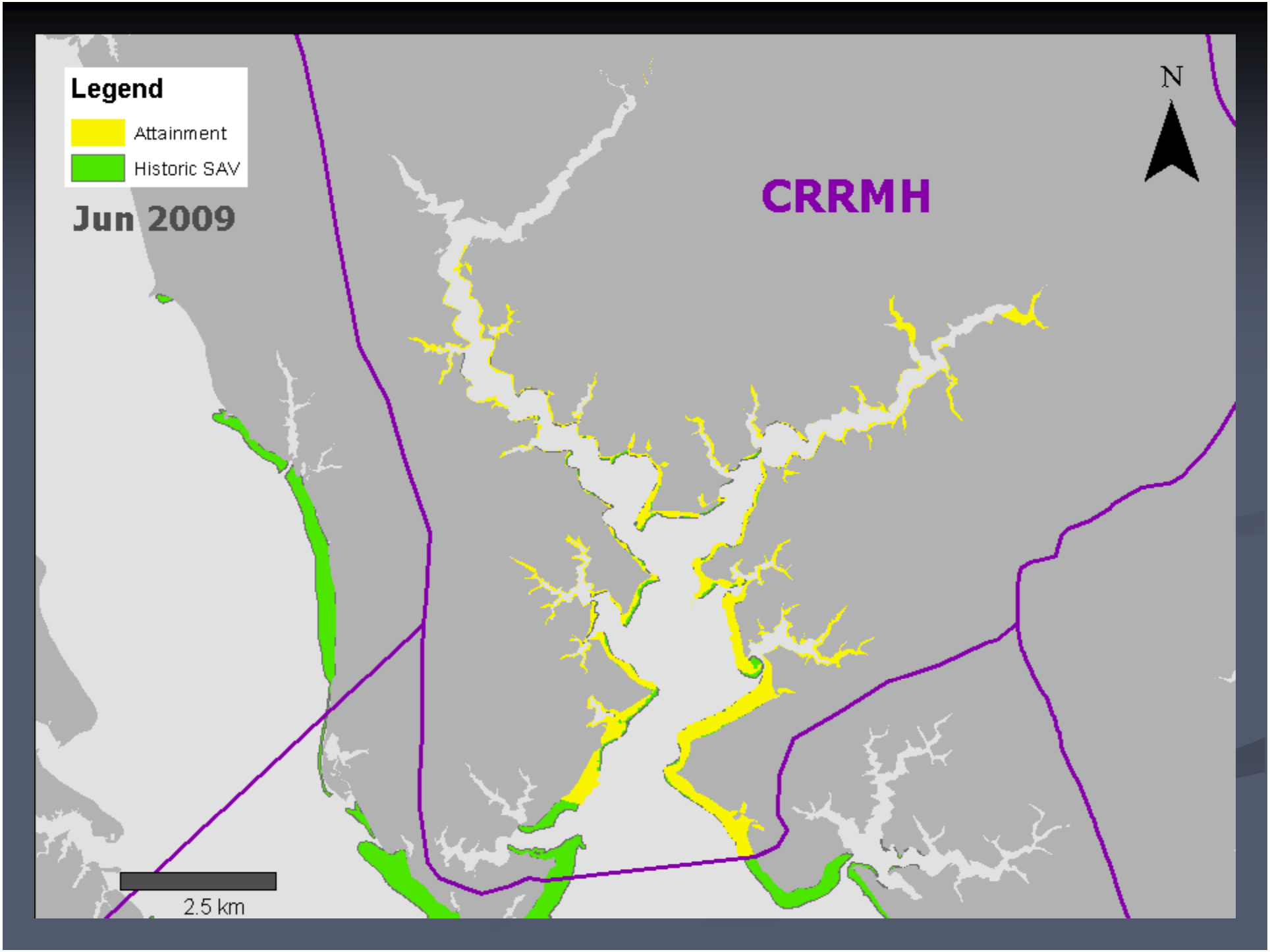
Spatial Evaluation of Water Clarity Exceedences

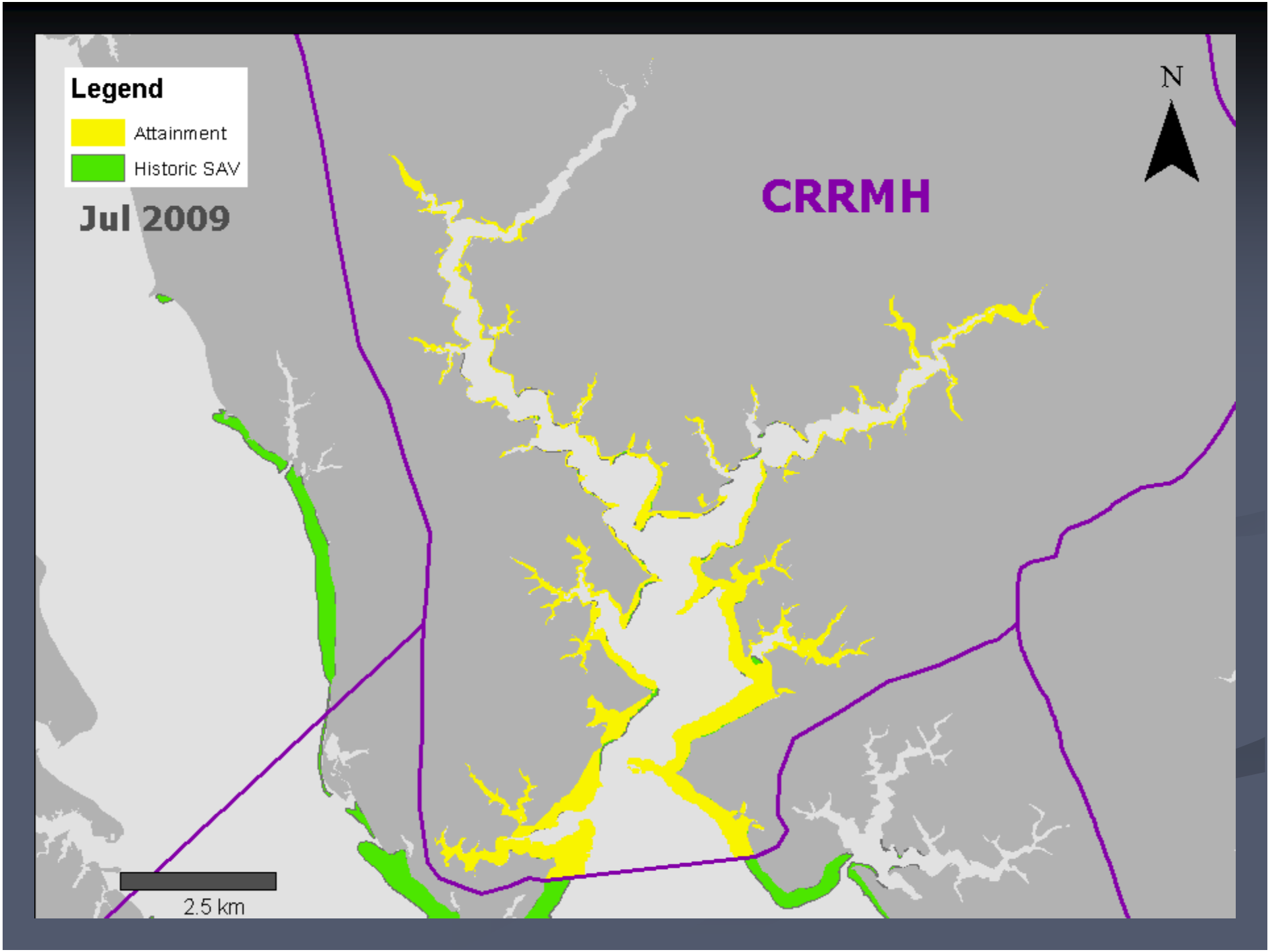


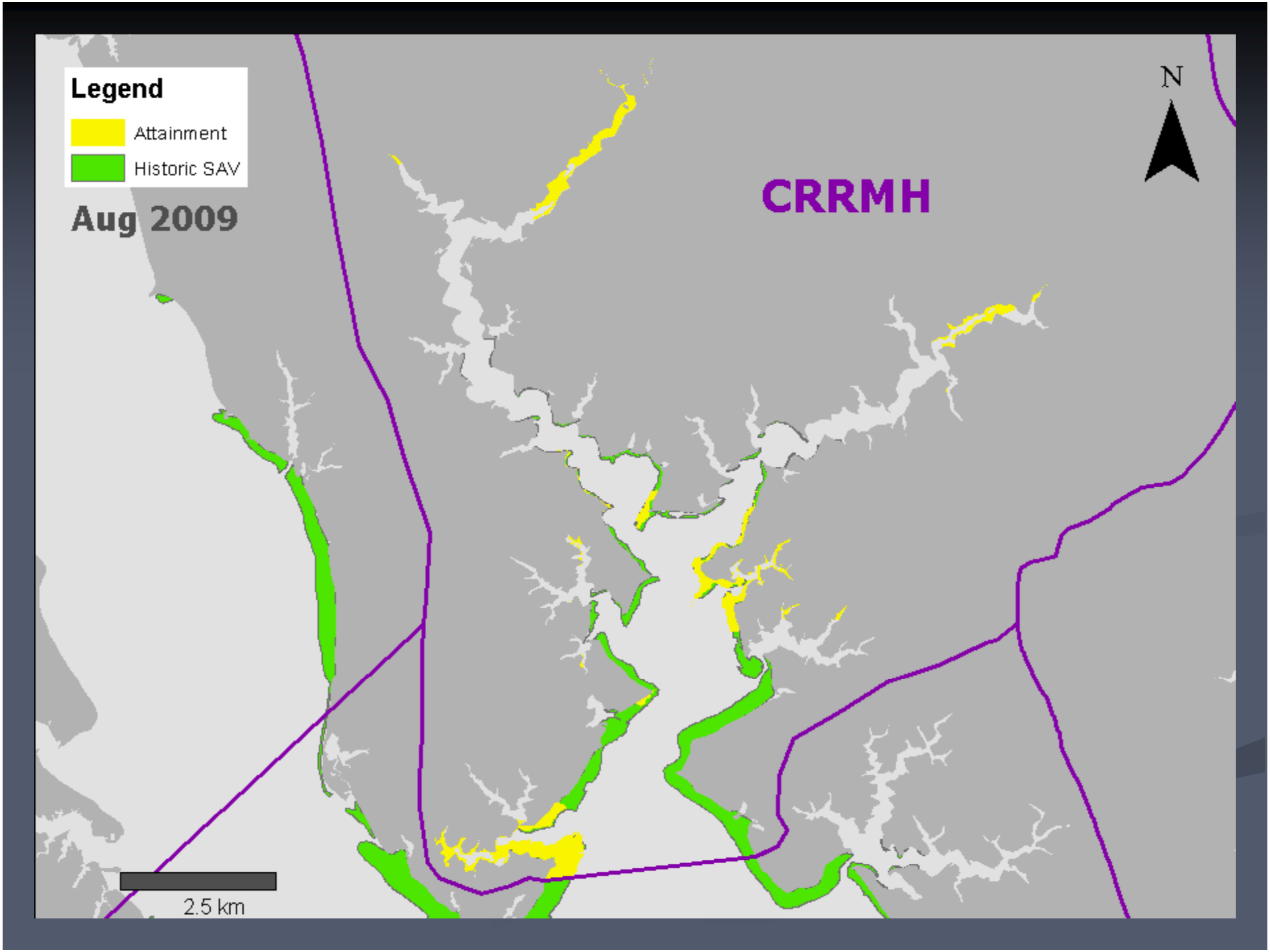

Legend
2009 SAV
Historic SAV
CRRMH Example
CRRMH
N
2.5 km

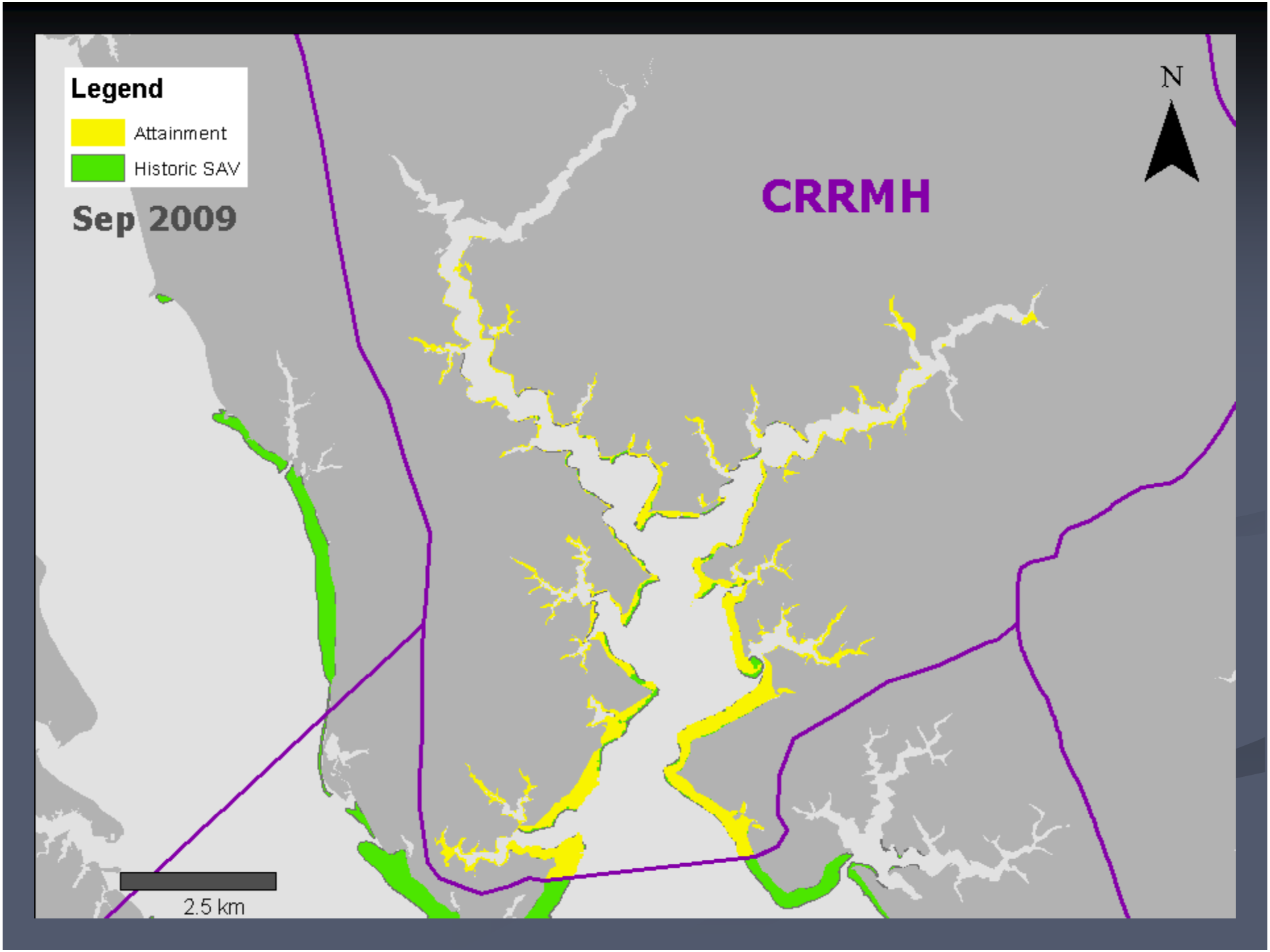

Legend
Attainment
Historic SAV
Apr 2009
CRRMH
N
2.5 km

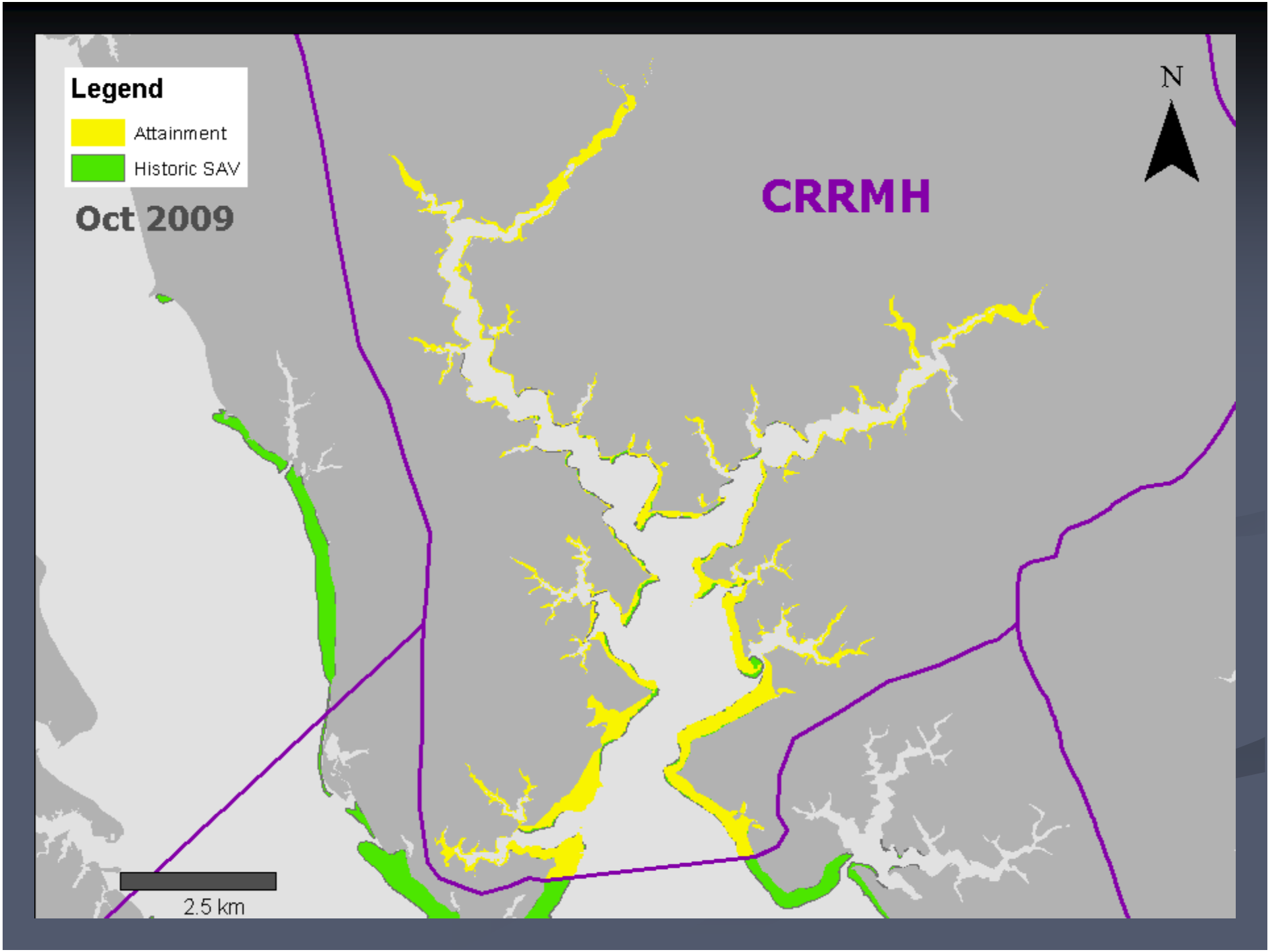

Legend
Attainment
Historic SAV
May 2009
CRRMH
N
2.5 km


Legend
Attainment
Historic SAV
Jun 2009
CRRMH
N
2.5 km


Legend
Attainment
Historic SAV
Jul 2009
CRRMH
N
2.5 km


Legend
Attainment
Historic SAV
Aug 2009
CRRMH
N
2.5 km


Legend
Attainment
Historic SAV
Sep 2009
CRRMH
N
2.5 km


Legend
Attainment
Historic SAV
Oct 2009
CRRMH
N
2.5 km

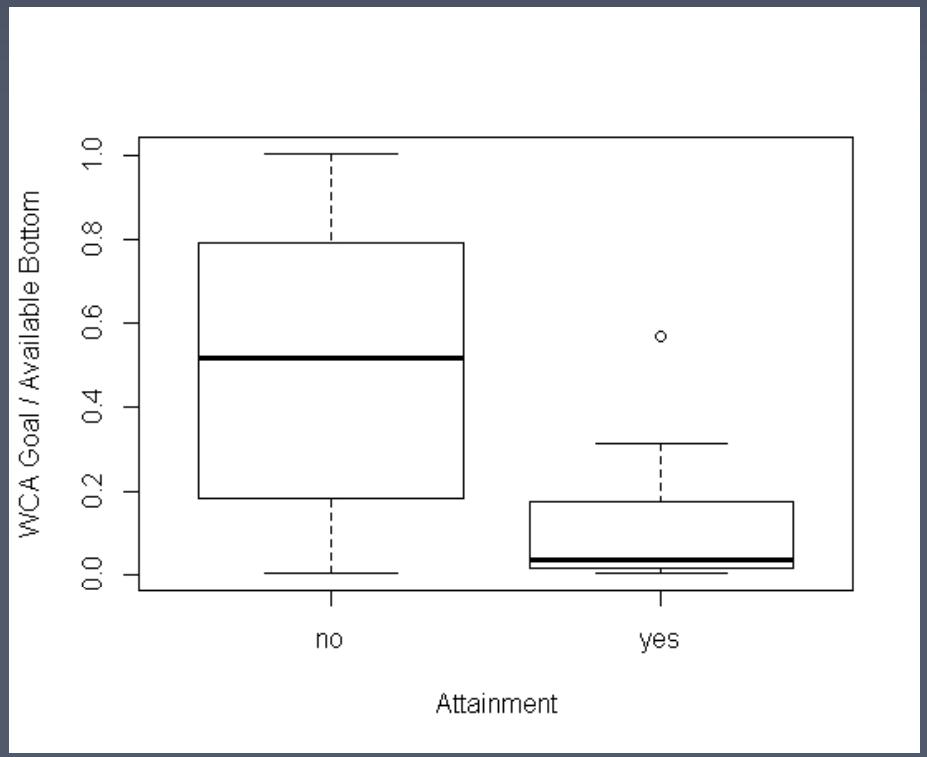
WCA issues

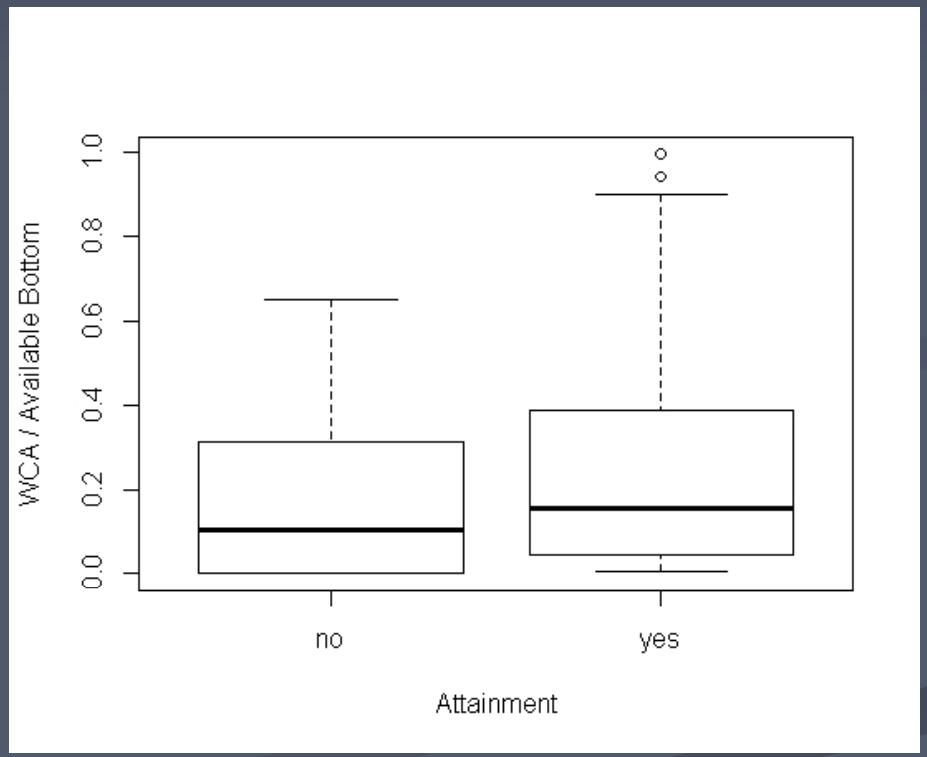
- WCA is spatially dynamic. Attainment areas shift cruise to cruise
- Does attainment occur in historic SAV areas?
- Goal based on 2.5 multiplier
  - Is it appropriate for all segments?
  - Is there enough available bottom?
- Small sample size. Mean of 8-10 cruises for annual assessment of single best year, but 30 for three year assessment period.

WCA issues cont.

- WCA goal\Total Available Bottom
  - Segments range from 0.5% to 100% of available bottom needing to attain to meet goal
  - >50%: 1 of 9 segments attain
  - <50% 10 of 13 segments attain
  - MOBPH and PIAMH WCA goal higher than total available bottom

Size of segment affects attainment



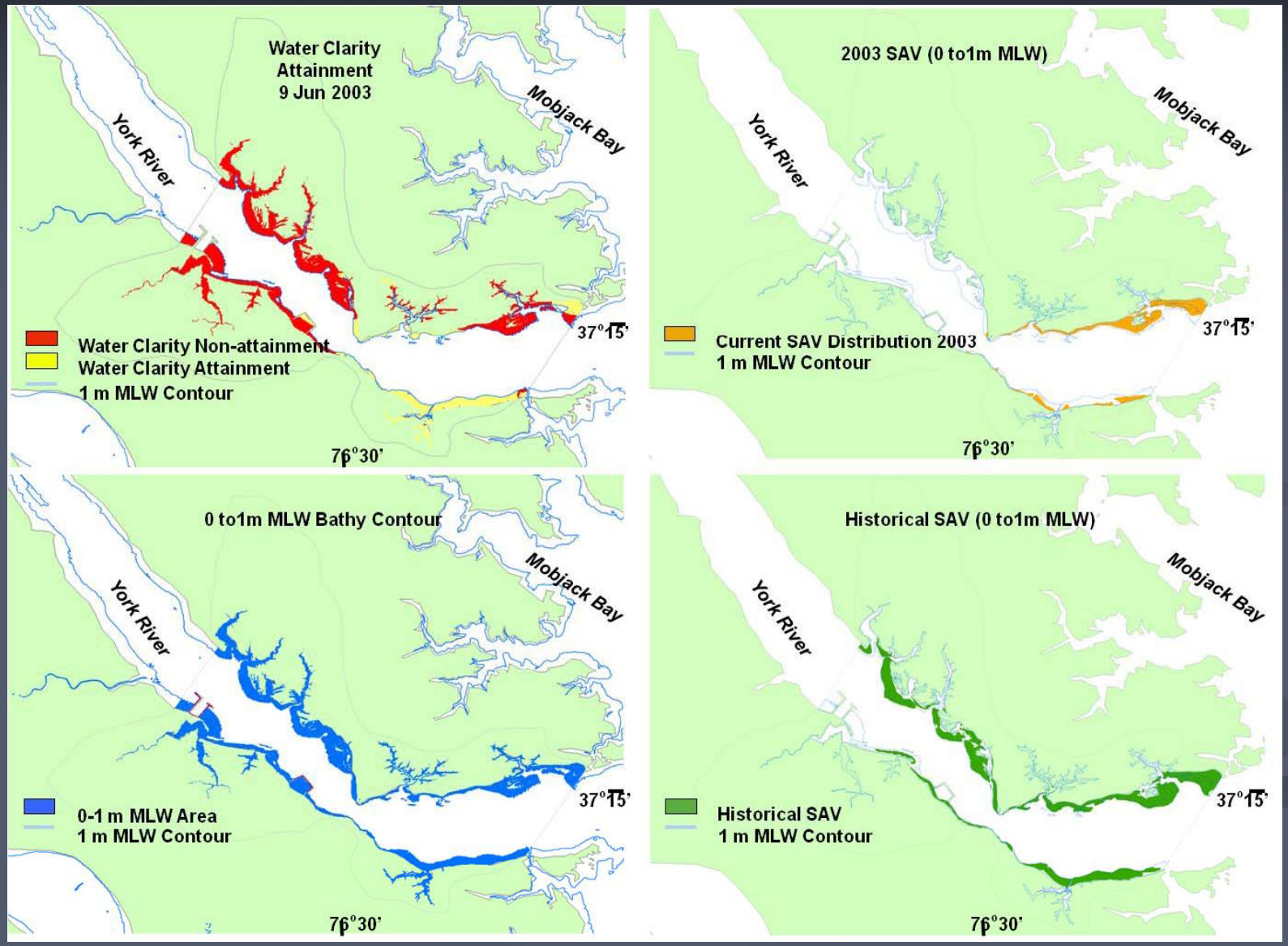


Discussion

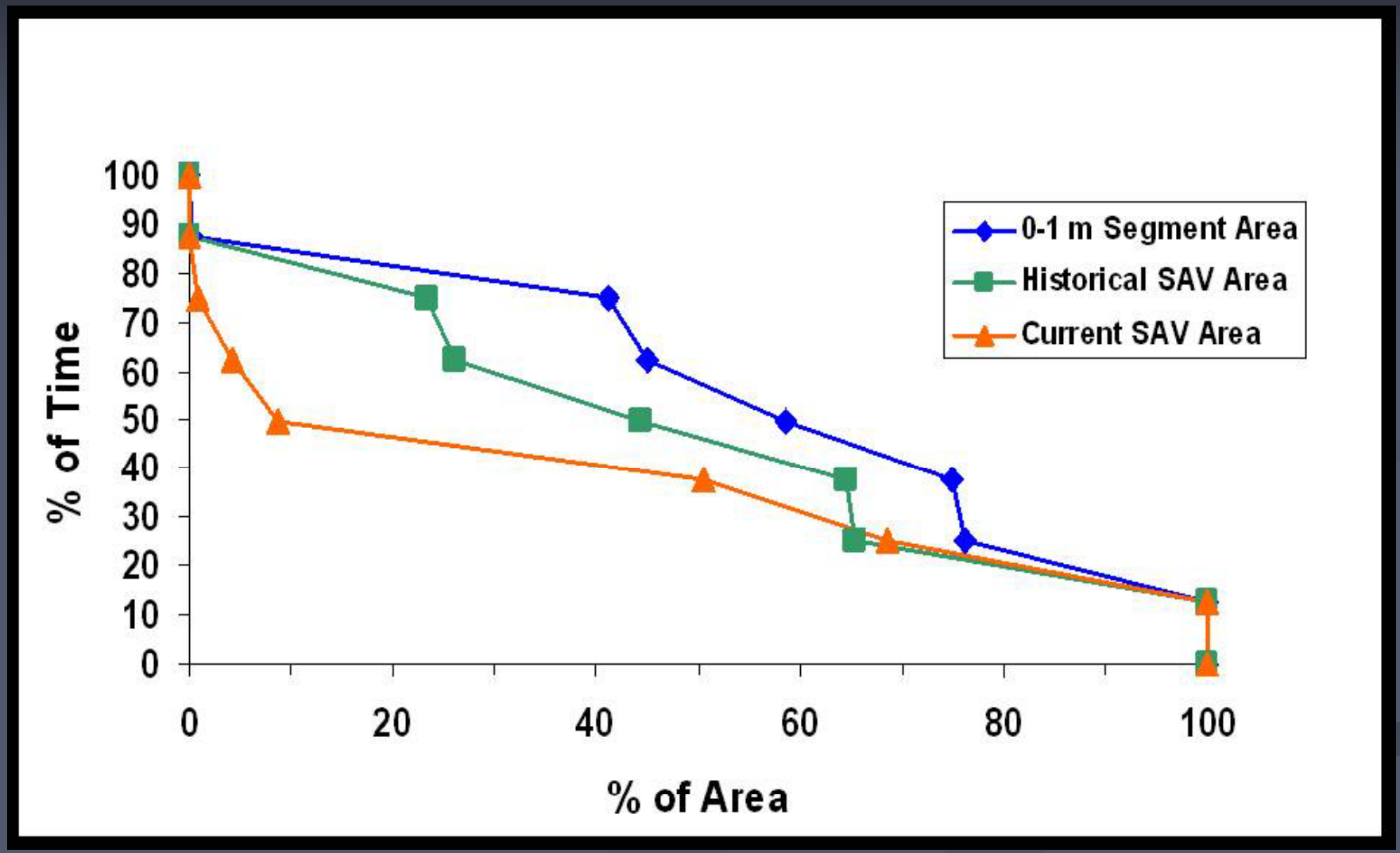
- Refocus analysis on areas where historic SAV occurred
- Utilize CFD approach and compare to biological developed reference curve.
- 2.5 multiplier may not be appropriate for all segments
- Incorporate CMON data by using sentinel monitoring sites to evaluate water clarity over time.

Use Of Biologically Based CFD to Assess Water Clarity Attainment

Water Clarity Attainment vs. Current and Histoircal SAV and Total Shallow Water Area

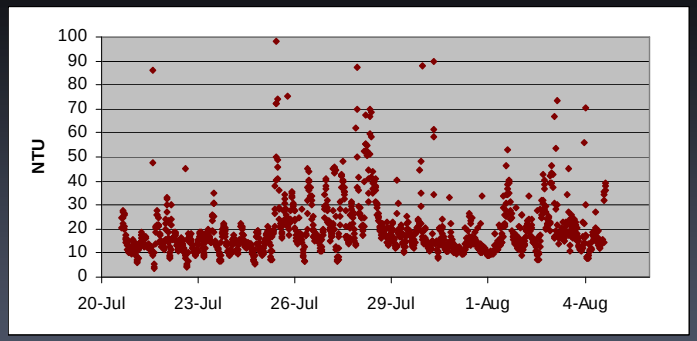


Biologically based CFD Curve Showing That Most of the Time Existing SAV beds have Less Water Clarity Exceedences



Use of Continuous Monitoring at Sentinel Sites to Assess Water Clarity

South Bay Turbidity (NTU)



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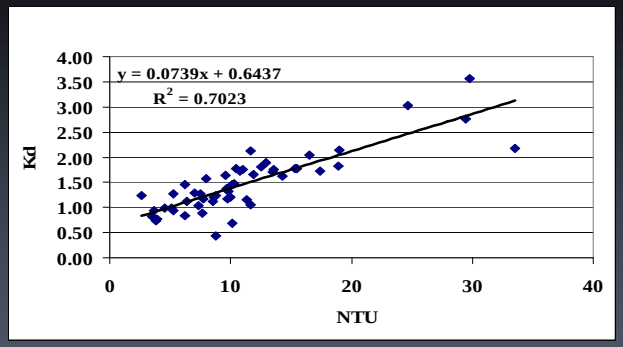
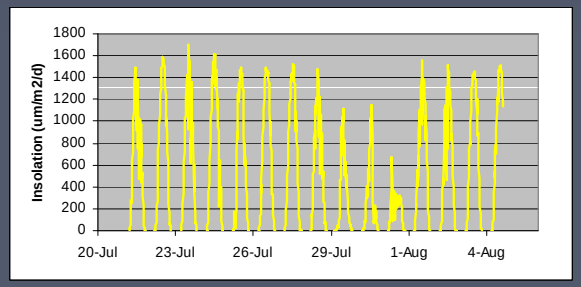
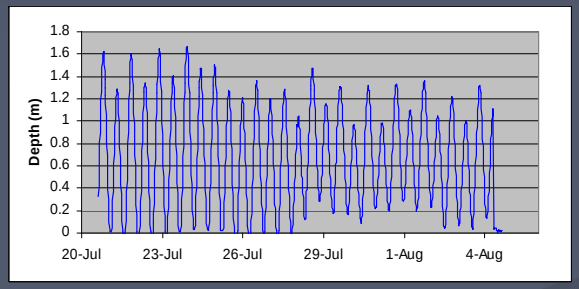
South Bay NTU vs K_d



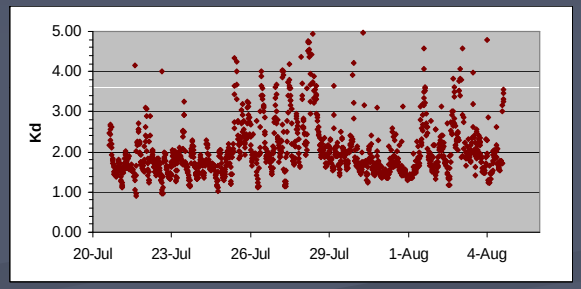
Insolation (I_0)



Water Depth (z)

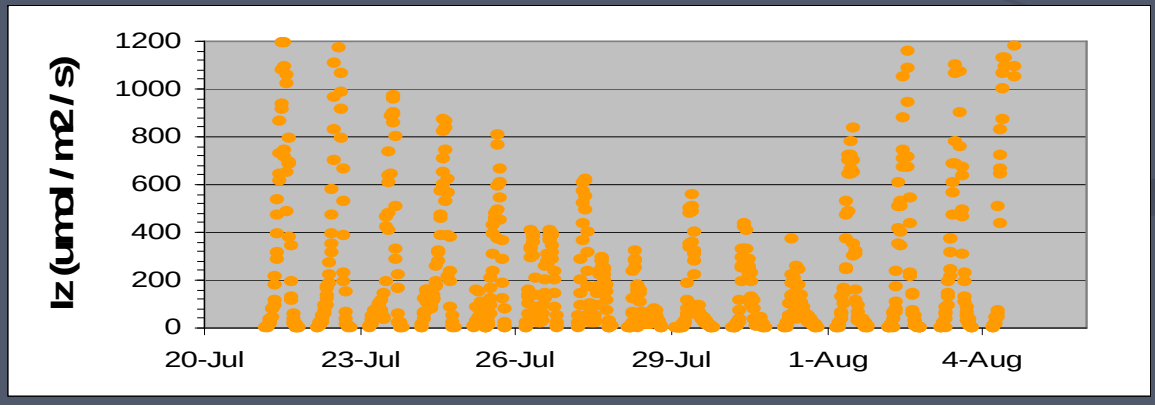


Light Attenuation (K_d)

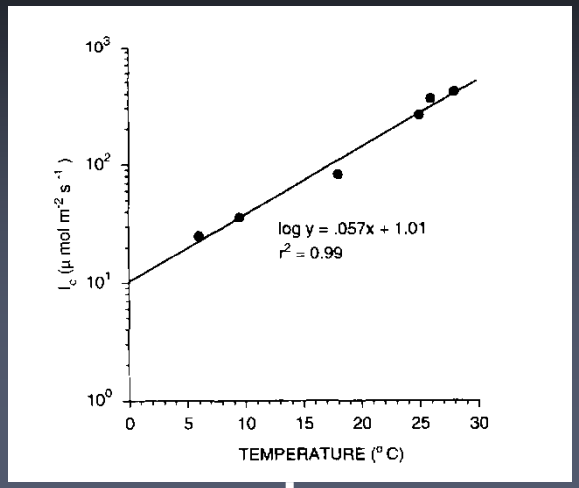


$$I_z = I_0 e^{-Kd*Z}$$

South Bay I_z

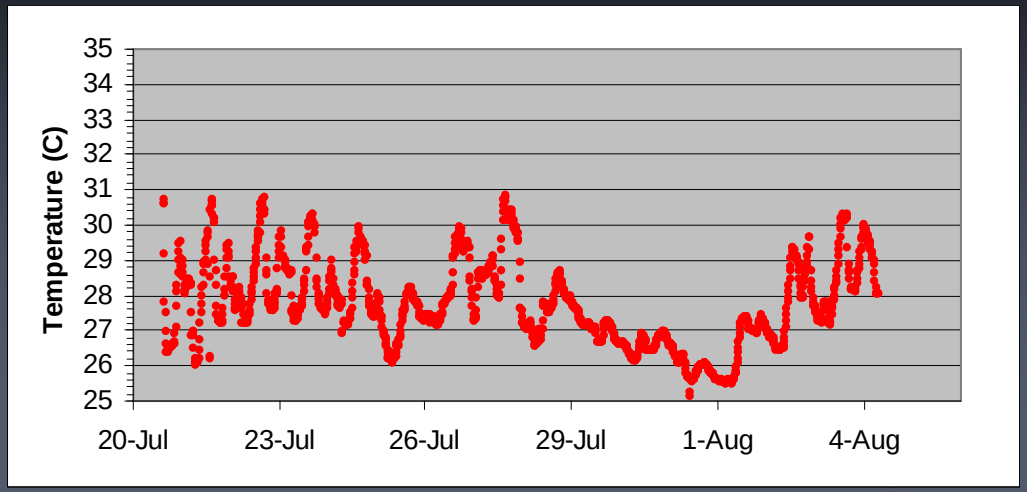


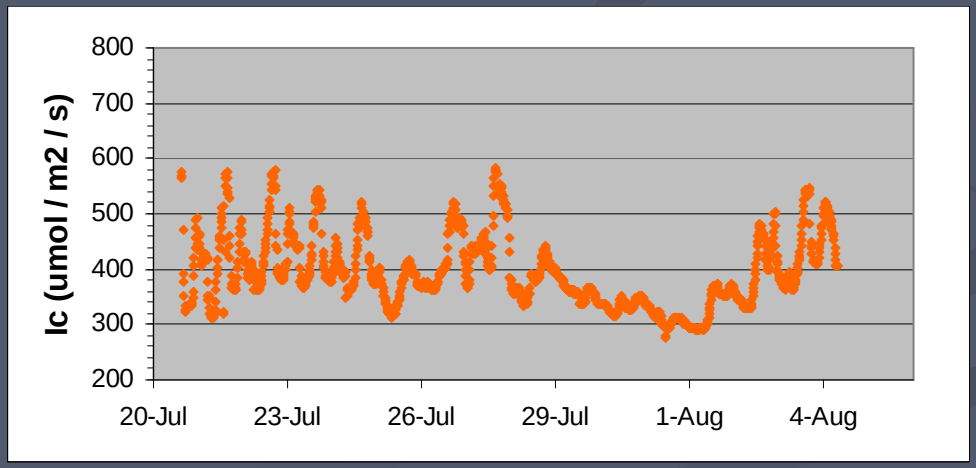
Eelgrass Community I_c vs Water Temp



(Moore et al. 1997 JEMBE)

South Bay Water Temp





South Bay I_c

Available light (I_z) as a proportion of eelgrass light requirements (I_C)

No ***Eelgrass***

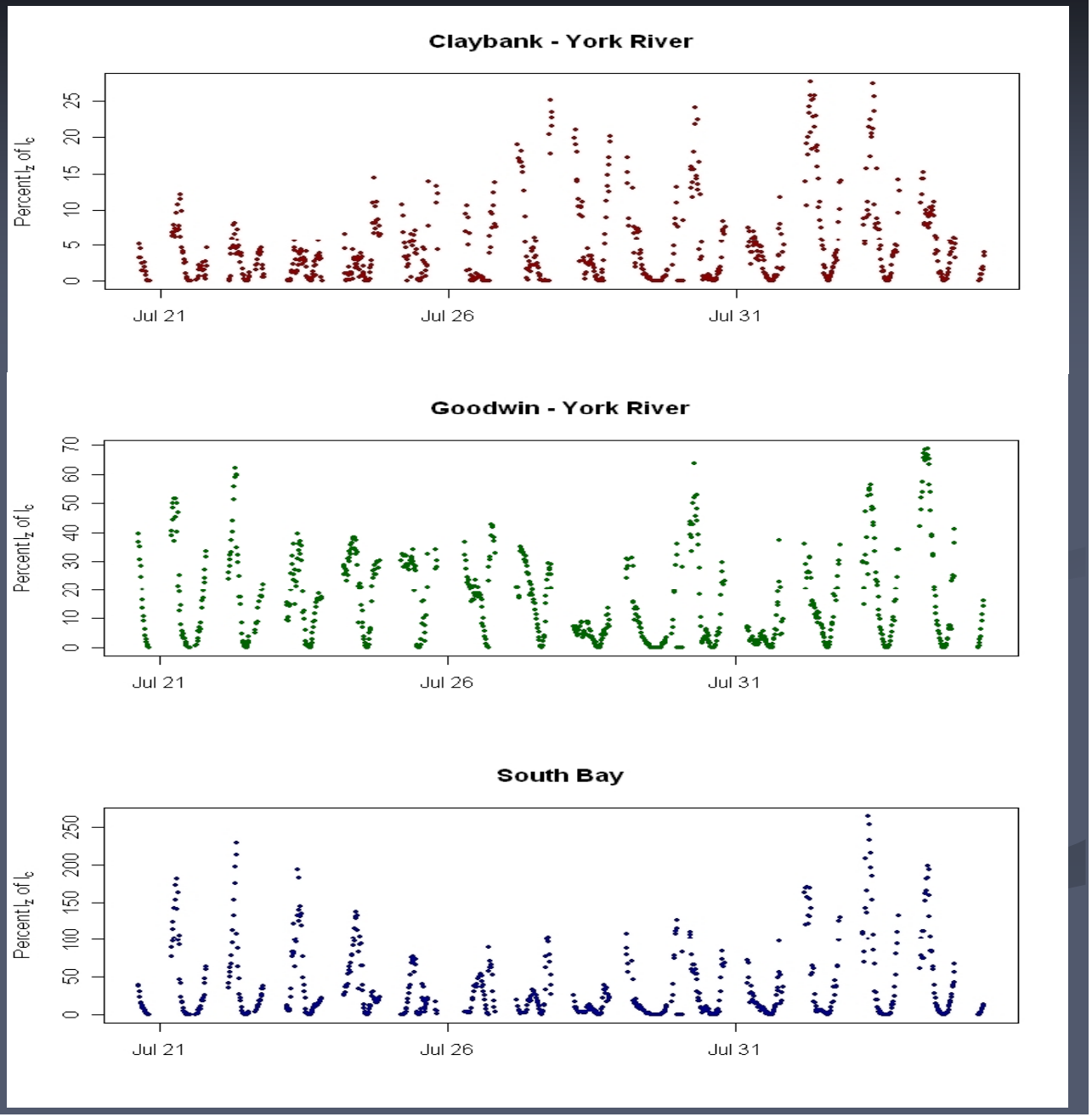
Mean I_z = 5% I_c

Stressed Eelgrass

Mean I_z = 16% I_c

Expanding Eelgrass

Mean I_z = 35% I_c



Thanks!