Analysis of Geo runs in Open Water

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Background and Motivation

- Geo runs are used to meter the impact of management changes in different basins of the Chesapeake Watershed to local segments of the Bay
- Geo runs have been used routinely in the past to measure the effect of geo runs in deep water segments
- Now, we are interested in the effect on surface water as well

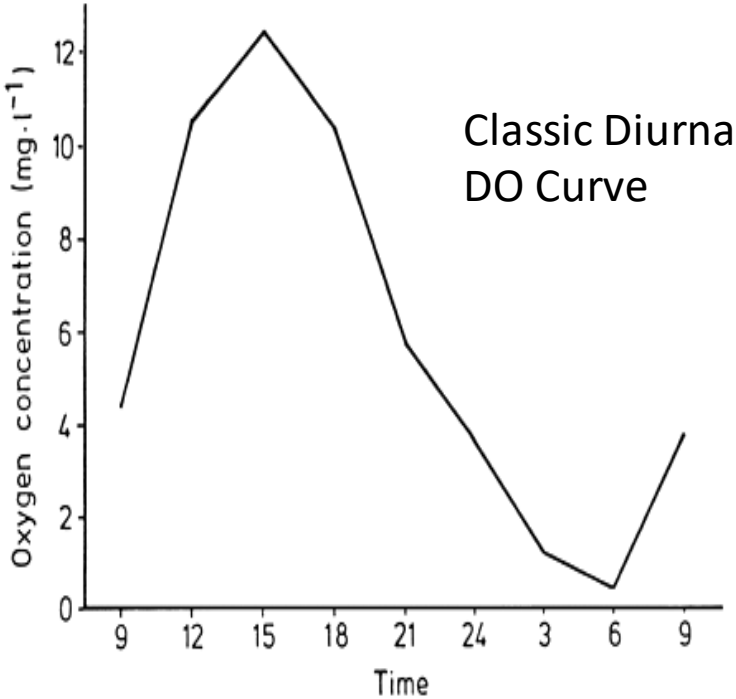
Background and Motivation

- Measuring the effect on surface water is less straight forward than deep water, as there are more transient effects happening at the surface as well as the small change in nutrients which the geo runs are used to test.
- There are two main indicators of segment health that could be used in the case of the geo runs: dissolved oxygen (DO) and Chlorophyll A (CHL)

The Problem With Using Open Water DO as a Metric for Geographically Changing Loads

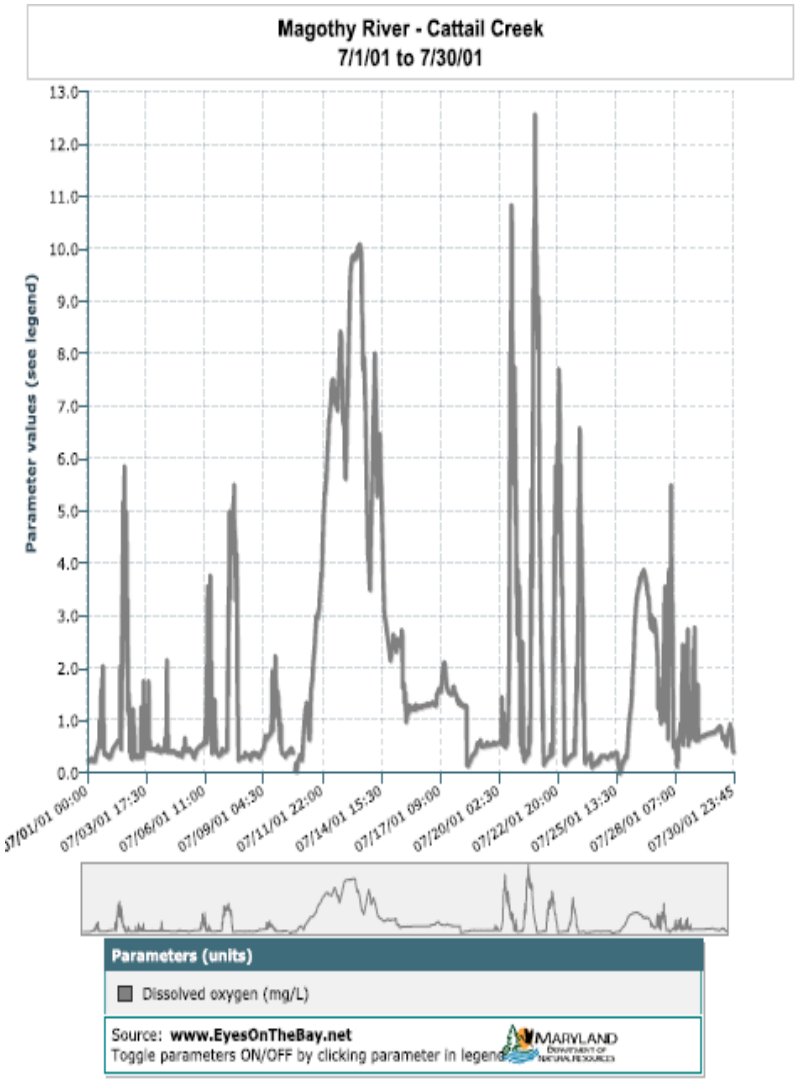
- Changes in nutrient loads change algal concentrations.
- But algae both evolve DO during photosynthesis and consume
- DO in respiration. Plus the atmosphere at the top of Open
- Water segments is an infinite source of DO…and the sediment
- at the bottom of many Open Water segments
- are an infinite sink of DO

Therefore, let's keep it simple and just use the direct response of nutrients loads → algal concentrations



Classic Diurnal Open Water DO Curve

Diurnal DO Response from Continuous Bay Monitoring



Methods

- The Estuary model (WQST) outputs CHL concentrations on a daily time step for all 3 dimensional cells which make up the 3D grid used in to model the estuary.
- A subset of these spatially unique cells are designated open water (OW)
- In general, OW is defined as a depth of 7 feet or less
- Additionally, the cell grid is split up into segments, known commonly as CB segments in the bay program

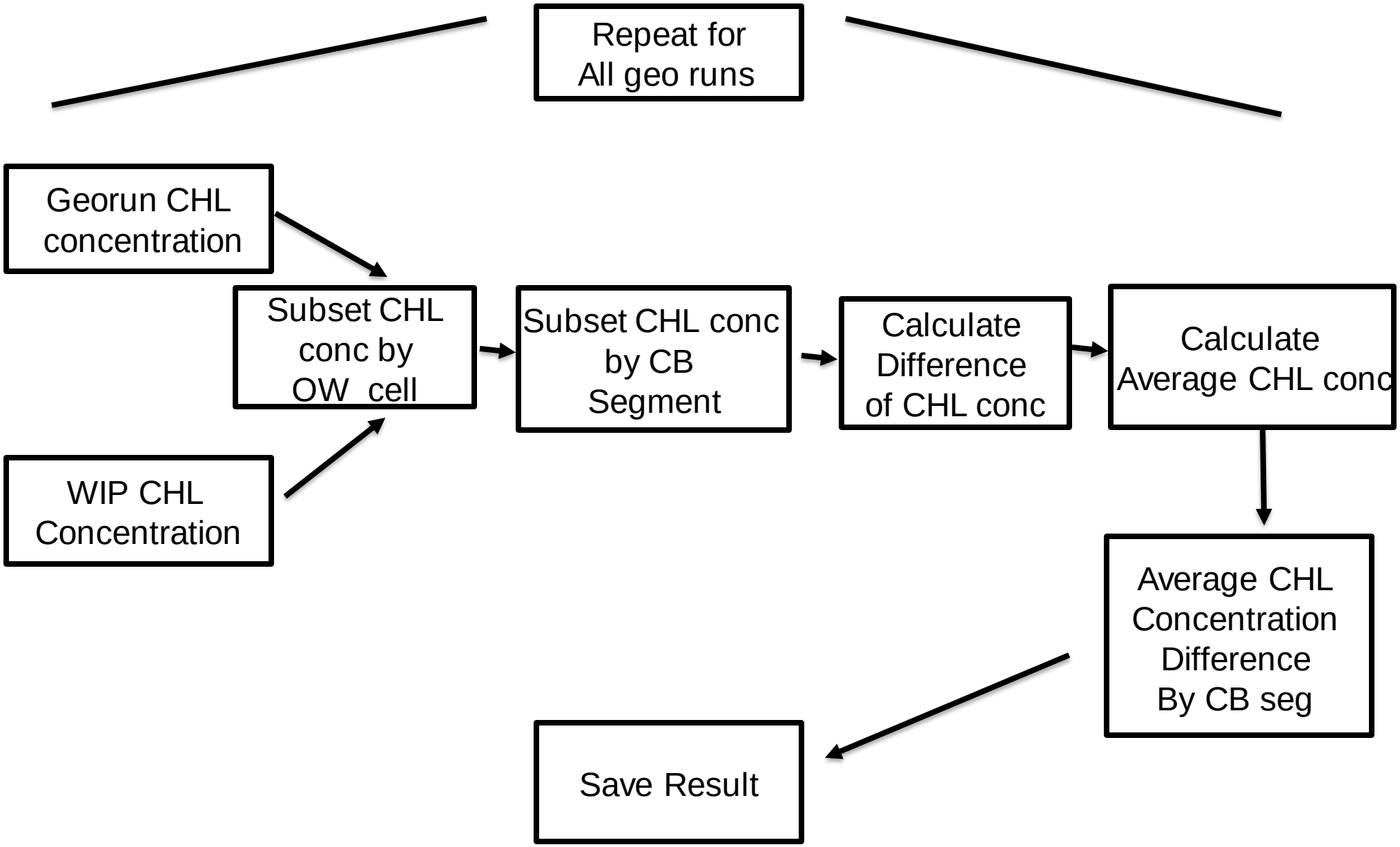
Methods

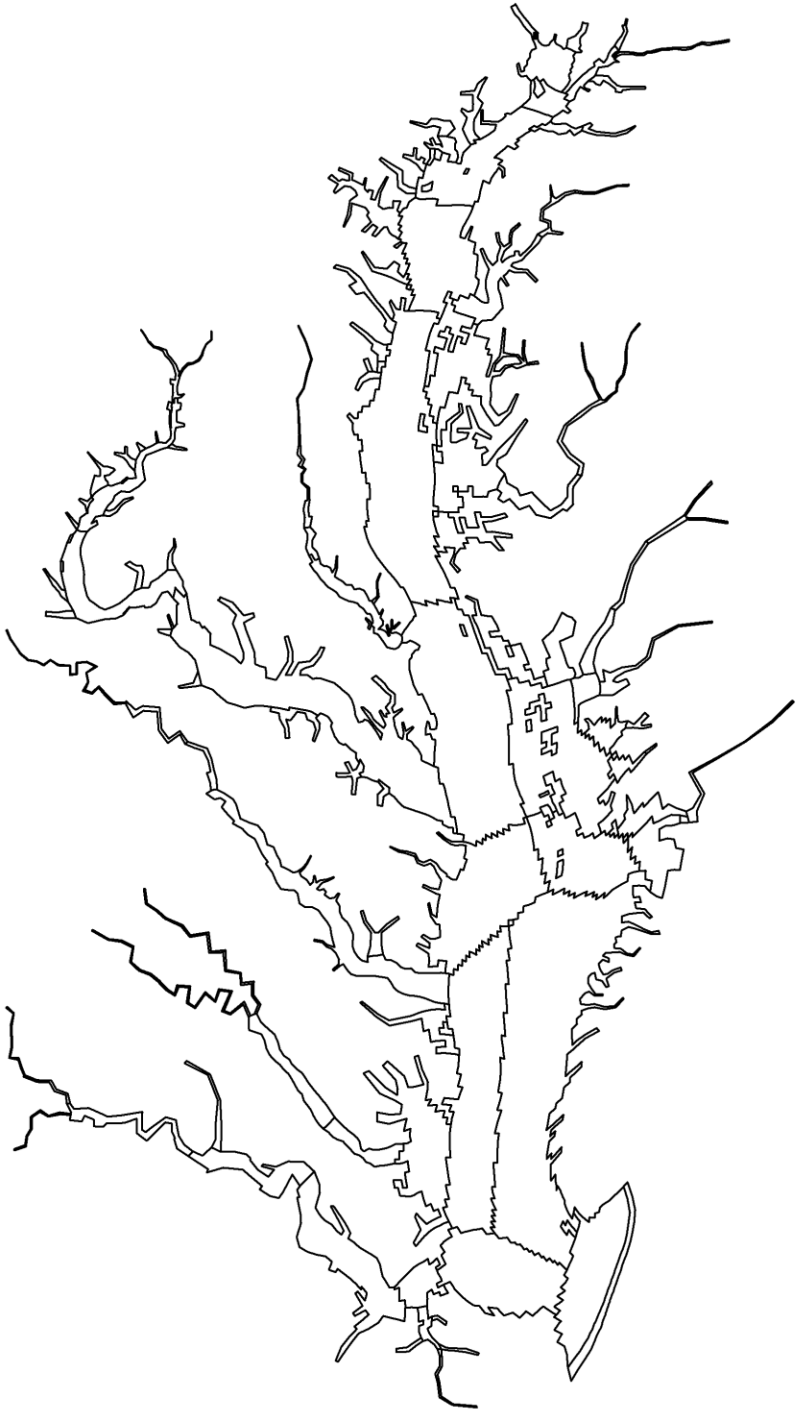
- The open water cells in each segment were used in this study to analyze the effect of geo runs
- Four geo runs were tested for a pilot scale analysis: Susquehanna N, Susquehanna P, James N, and James P

Methods

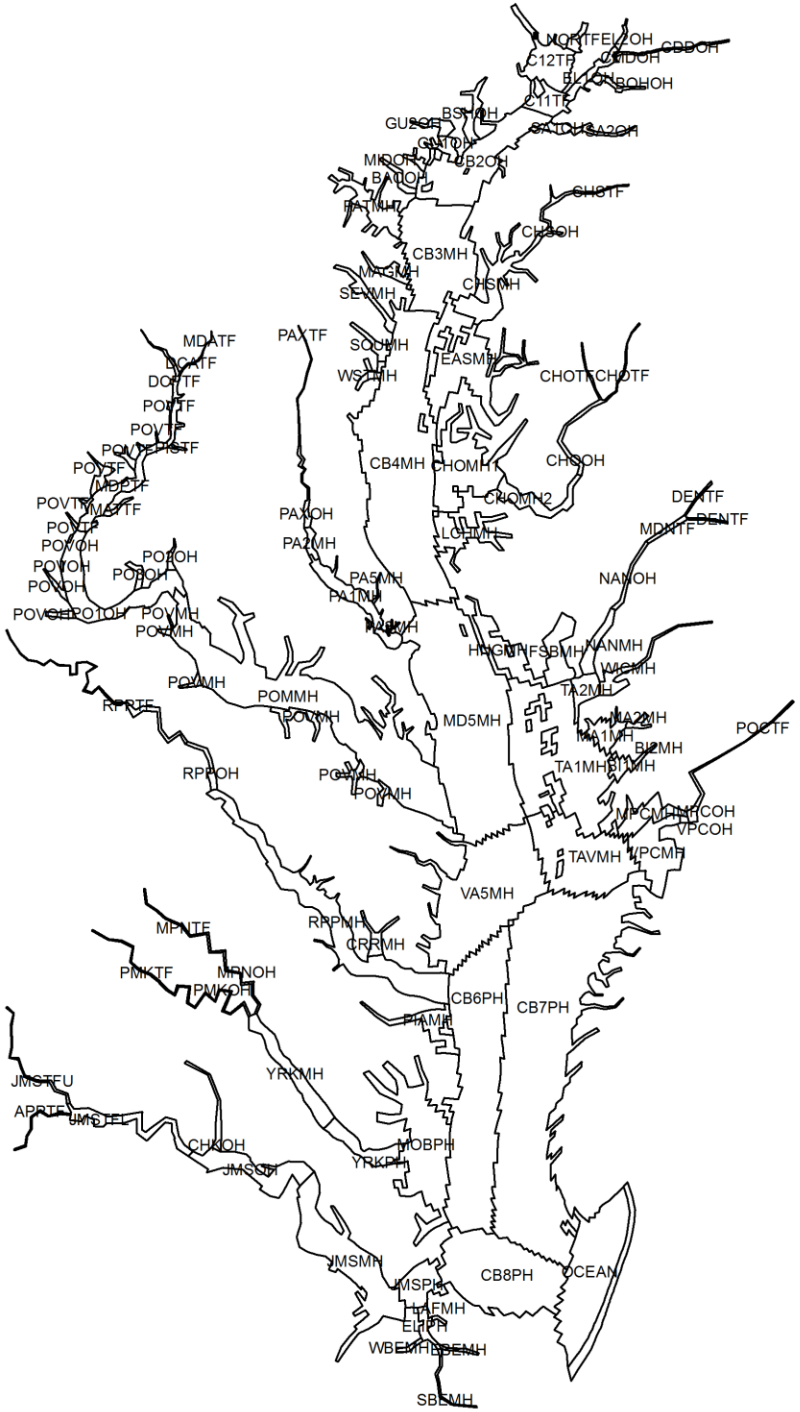
- The difference was calculated across unique time and space for each cell and time step, and the resulting differences were averaged within there corresponding CB segments
- This produces a rank-able average difference in CHL concentration split geographically by CB segments due to a geo run nutrient change in a specific area of the watershed
- The average was taken for spring and summer months for the 10 year period from 1991 through 2000.

Methods


Repeat for
All geo runs
Georun CHL
concentration
WIP CHL
Concentration
Subset CHL
conc by
OW cell
Subset CHL conc
by CB
Segment
Calculate
Difference
of CHL conc
Calculate
Average CHL conc
Average CHL
Concentration
Difference
By CB seg
Save Result



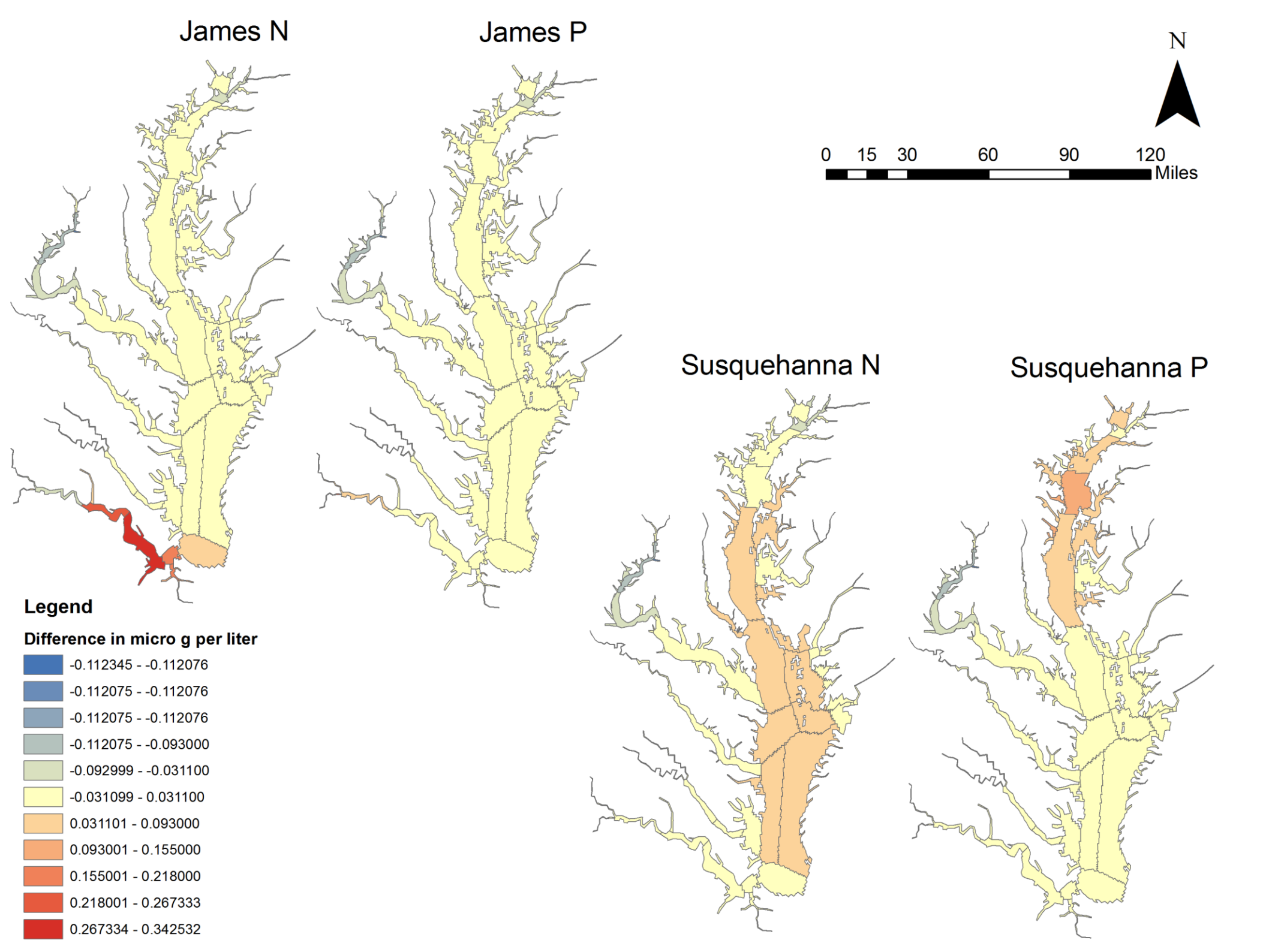
Geo runs are completed for the entire Bay



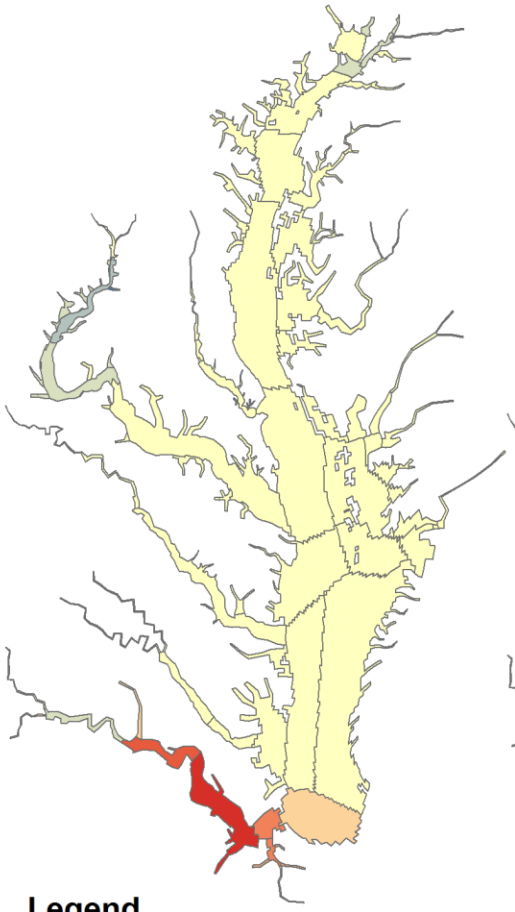
The Geo run analysis is completed for all Bay segments, calculating the average change in Chlorophyll concentration for each segment from 1991 through 2000 by subtracting the geo run estimate from the 2010 WIP estimate

Results

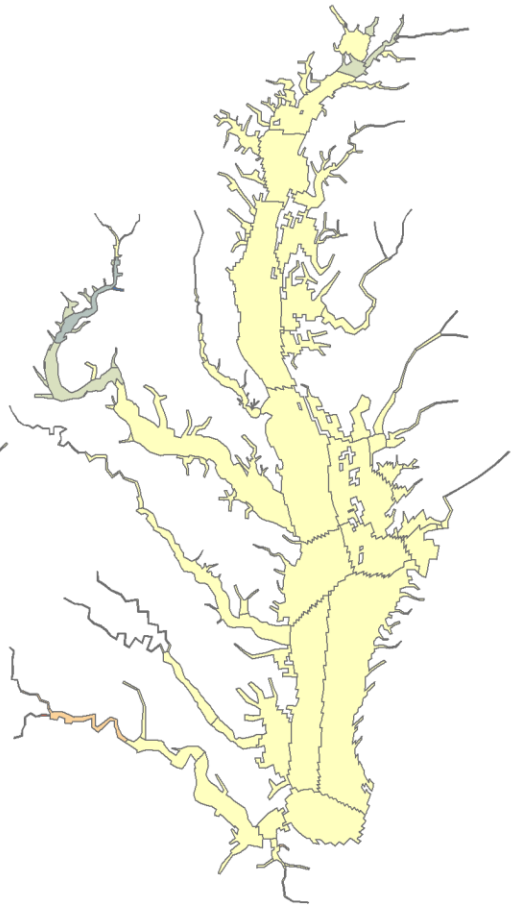
- The results indicate Chlorophyll is not without small surprises, but overall a usable indicator to provide geographic rankings of the effects on surface water sourced from the geo runs


James N
James P
N
0 15 30 60 90 120
Miles
Susquehanna N
Susquehanna P
Legend
Difference in micro g per liter
-0.112345 - -0.112076
-0.112075 - -0.112076
-0.112075 - -0.112076
-0.112075 - -0.093000
-0.092999 - -0.031100
-0.031099 - 0.031100
0.031101 - 0.093000
0.093001 - 0.155000
0.155001 - 0.218000
0.218001 - 0.267333
0.267334 - 0.342532

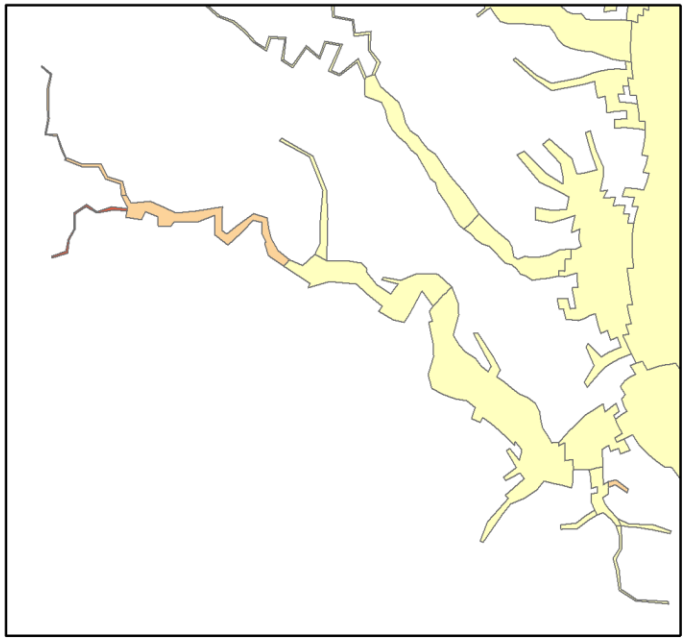
James N



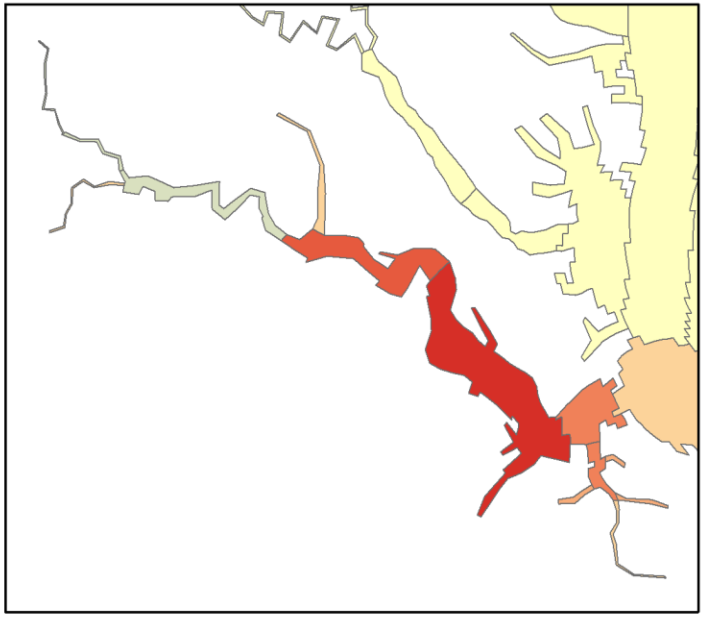
James P



James P



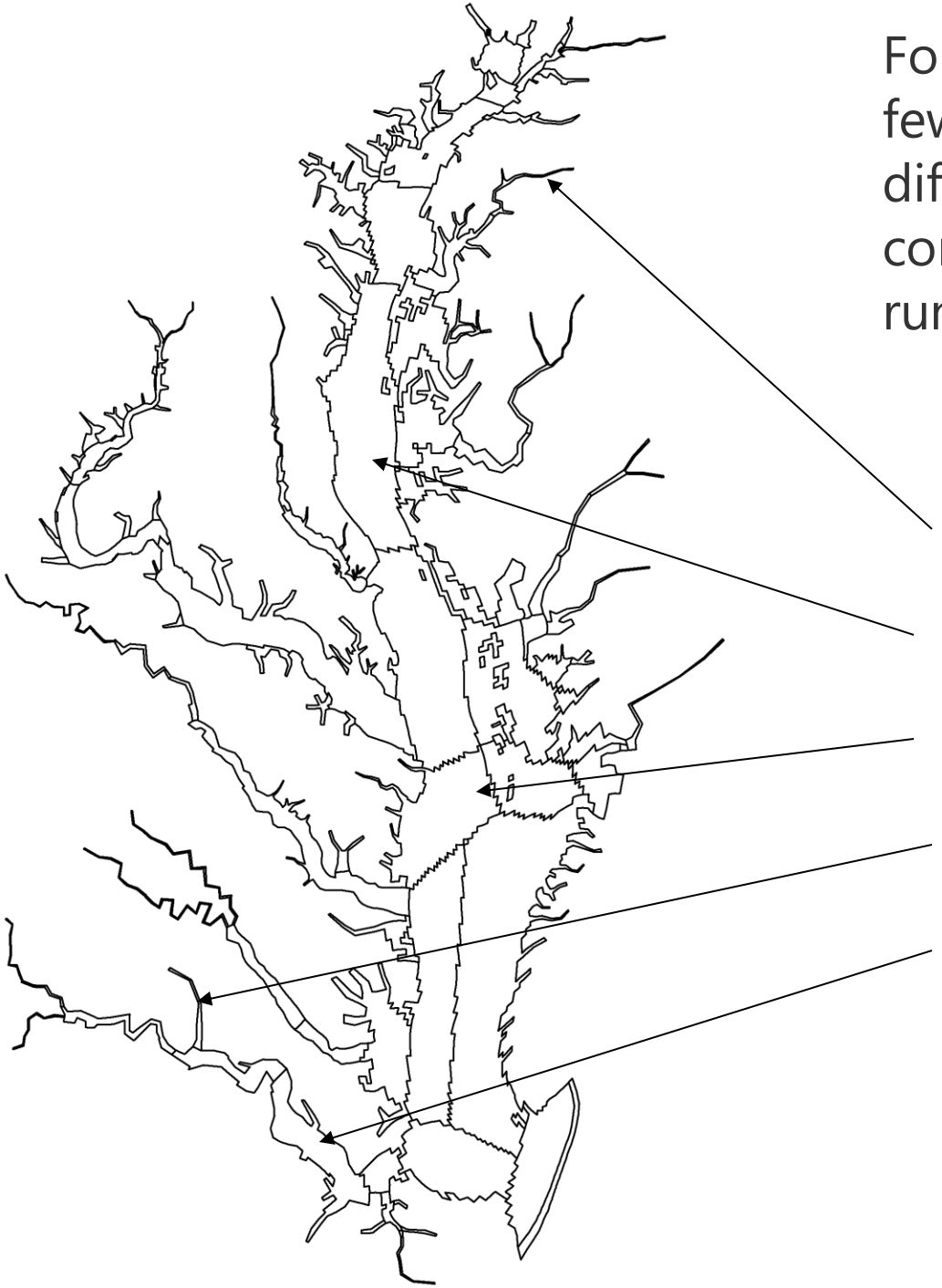
James N



Legend

Difference in micro g per liter

- -0.112345 - -0.112076
- -0.112075 - -0.112076
- -0.112075 - -0.112076
- -0.112075 - -0.093000
- -0.092999 - -0.031100
- -0.031099 - 0.031100
- 0.031101 - 0.093000
- 0.093001 - 0.155000
- 0.155001 - 0.218000
- 0.218001 - 0.267333
- 0.267334 - 0.342532



For a closer look, we will take a few individual segments from different parts of the Bay, and compare them across the geo runs

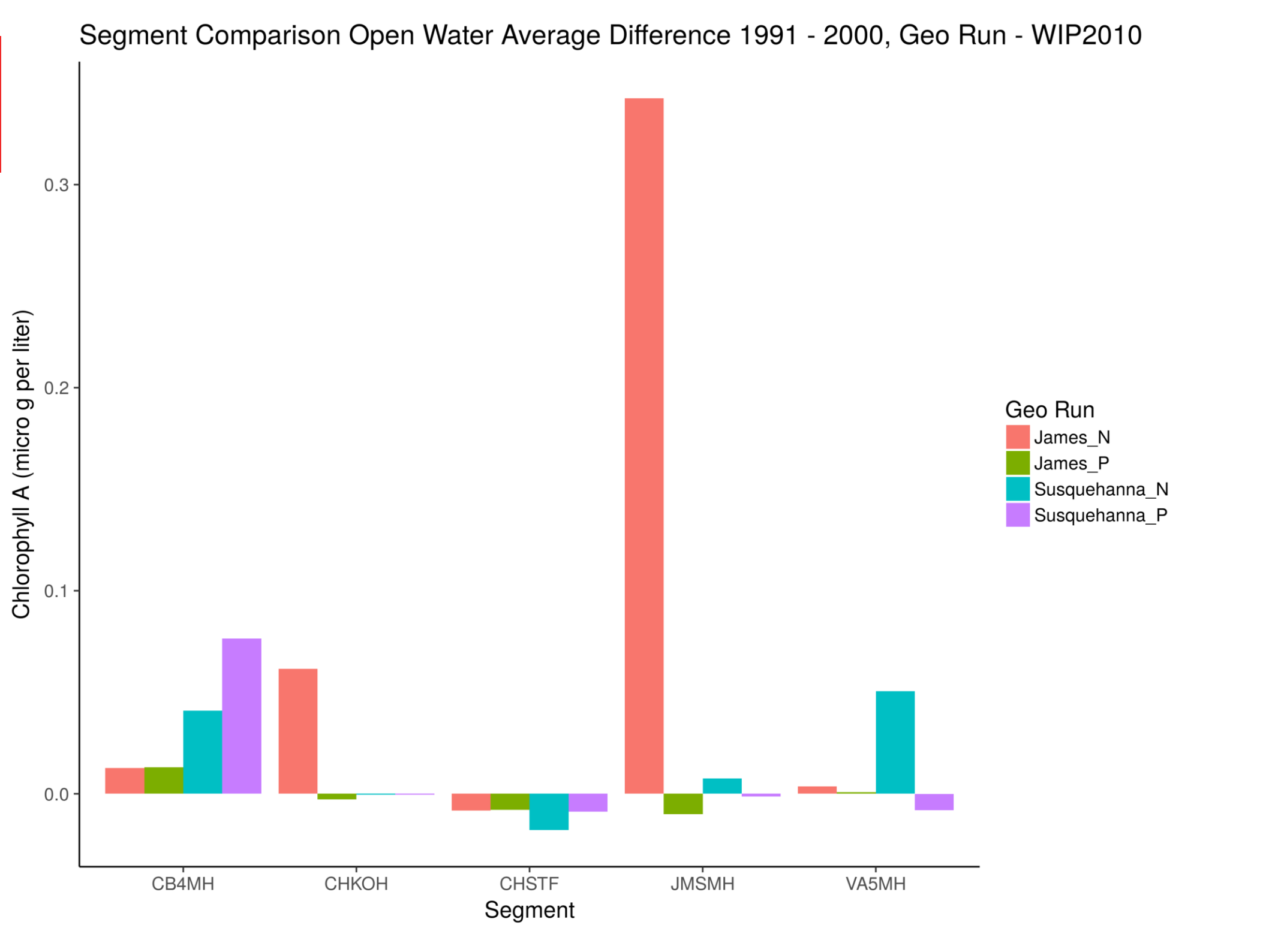
CHSTF

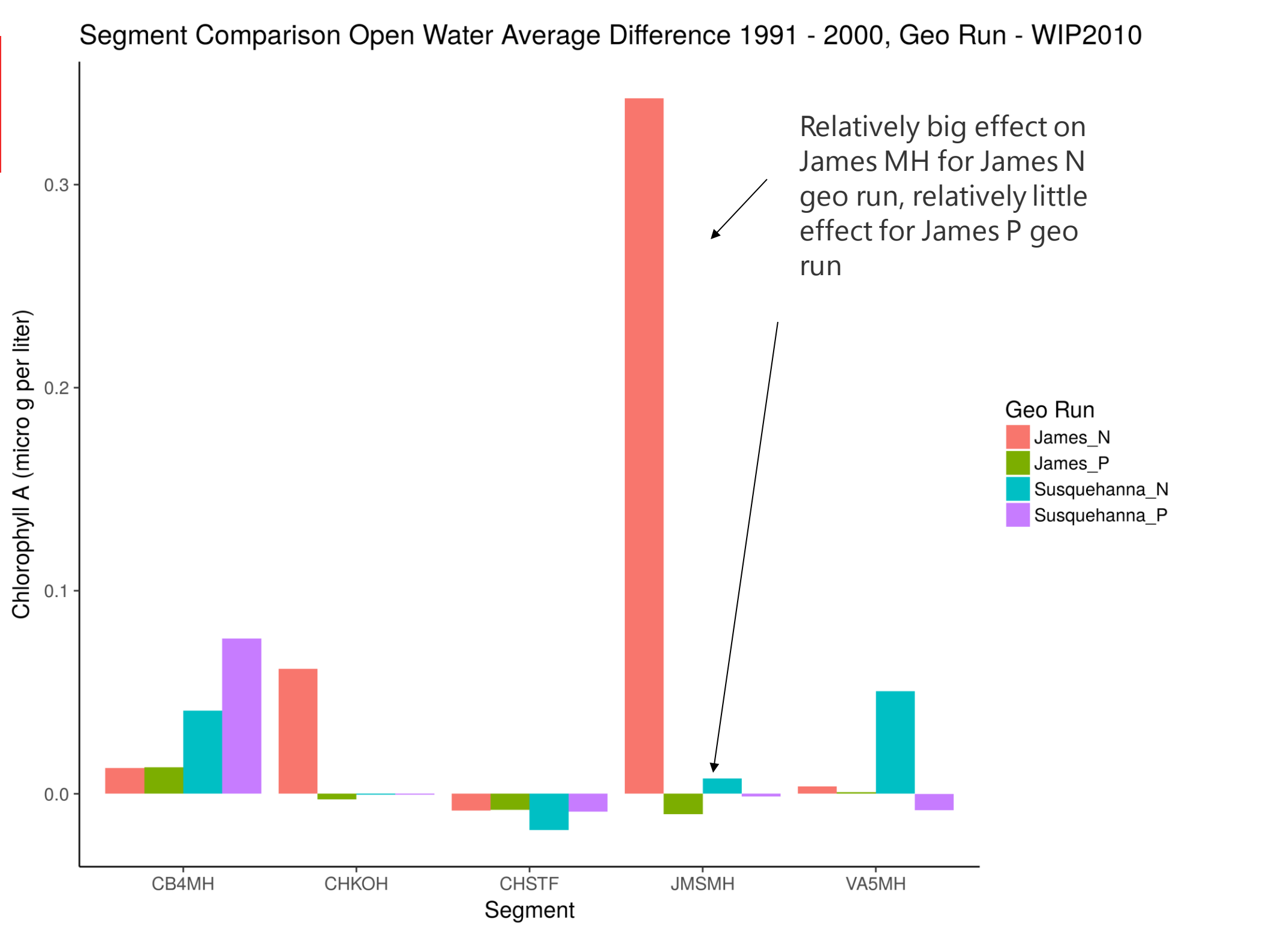
CB4MH

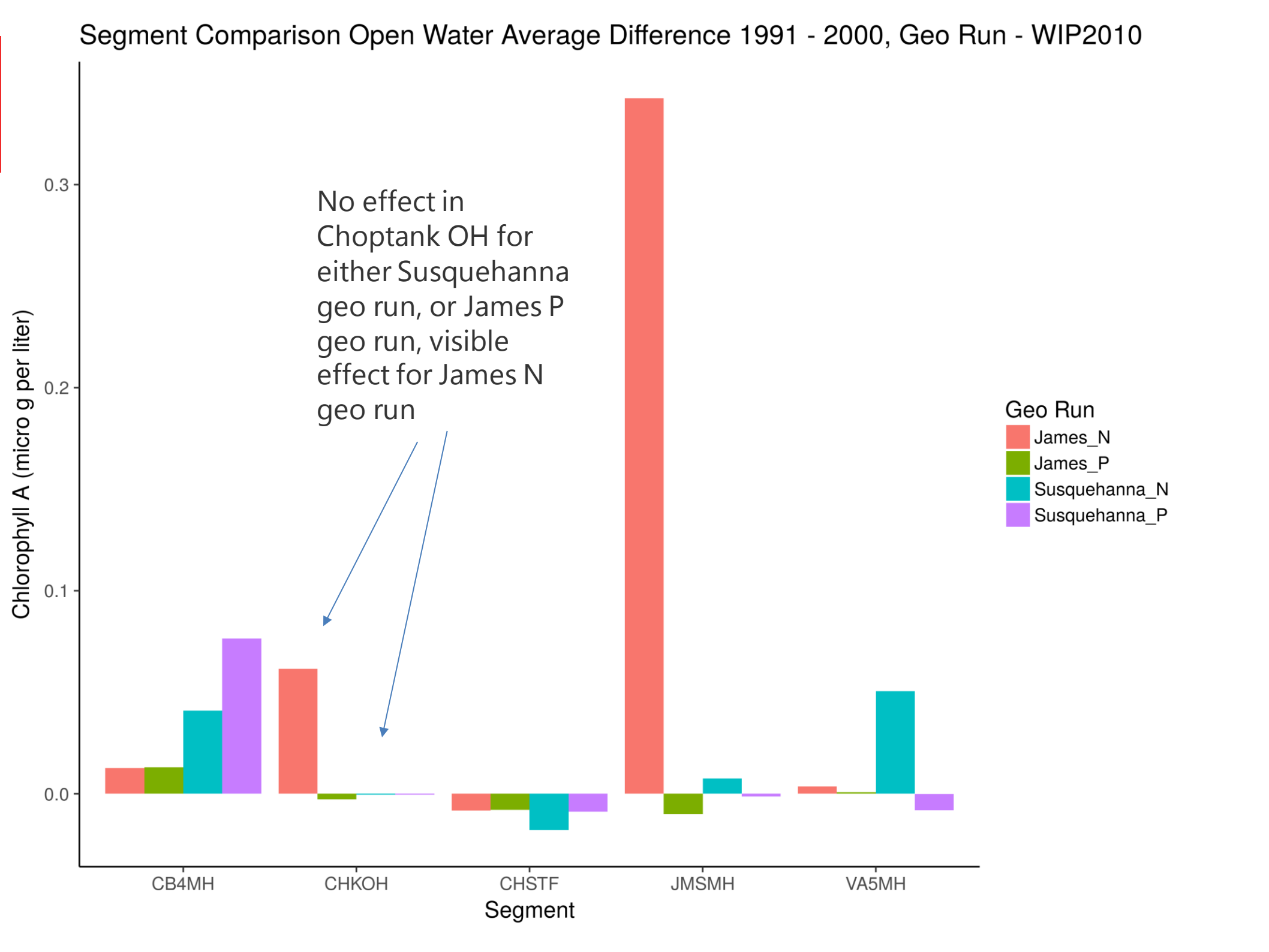
VA5MH

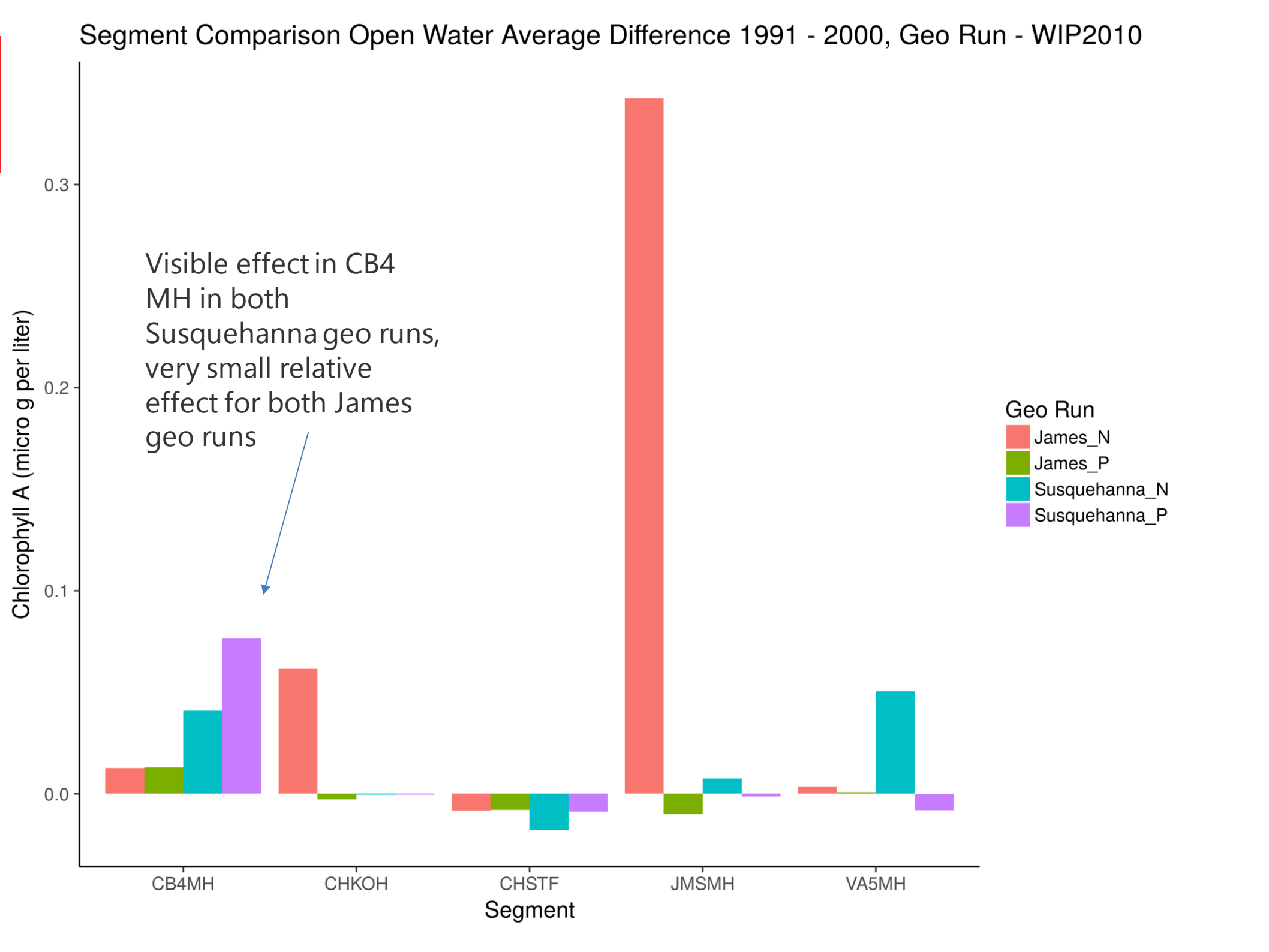
CHKOH

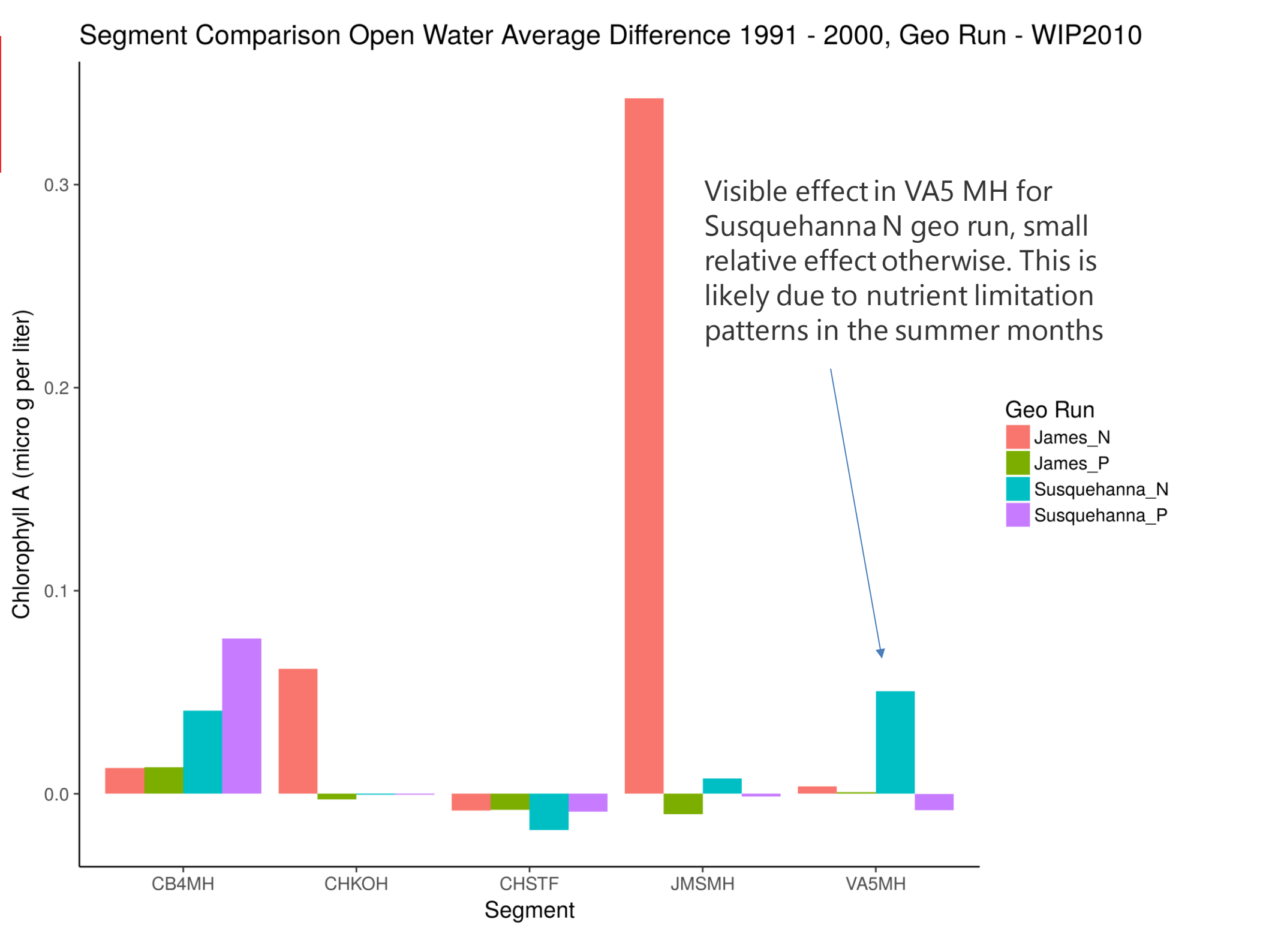
JMSMH

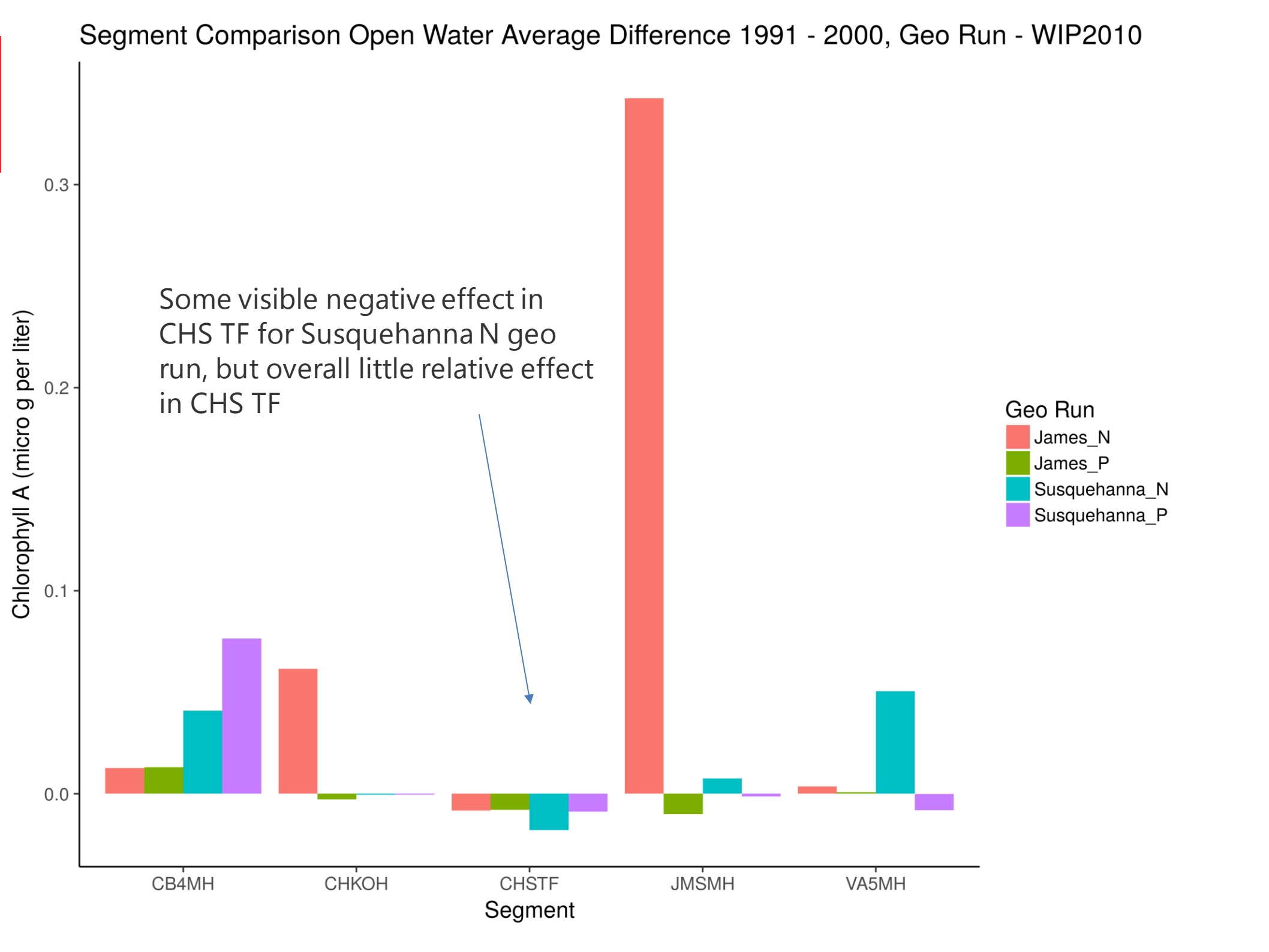

Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P

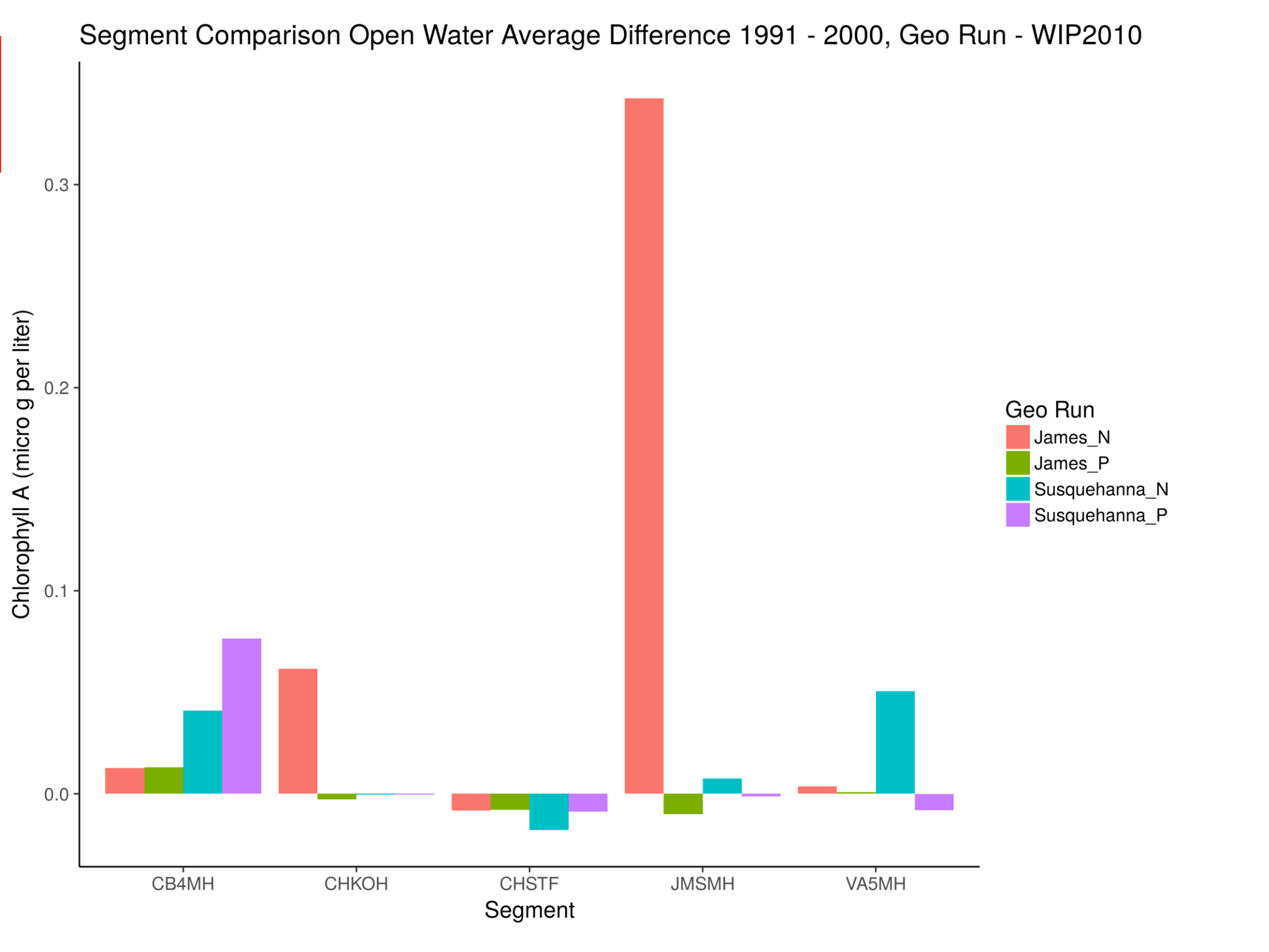

Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Relatively big effect on James MH for James N geo run, relatively little effect for James P geo run
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P


Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
No effect in Choptank OH for either Susquehanna geo run, or James P geo run, visible effect for James N geo run
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P


Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Visible effect in CB4 MH in both Susquehanna geo runs, very small relative effect for both James geo runs
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P


Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Visible effect in VA5 MH for Susquehanna N geo run, small relative effect otherwise. This is likely due to nutrient limitation patterns in the summer months
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P


Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Some visible negative effect in CHS TF for Susquehanna N geo run, but overall little relative effect in CHS TF
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P


Segment Comparison Open Water Average Difference 1991 - 2000, Geo Run - WIP2010
Chlorophyll A (micro g per liter)
0.3
0.2
0.1
0.0
CB4MH
CHKOH
CHSTF
JMSMH
VA5MH
Segment
Geo Run
James_N
James_P
Susquehanna_N
Susquehanna_P

Summary

- An indicator of the effect geo runs have on local, open waters is of interest
- We have built a process to calculate the estimated average difference of Chlorophyll in the open waters of the Chesapeake Bay due to geo runs
- This method appears to provide a usable indicator for the effect geographically isolated changes in nutrient loads have on local, open water quality for individual Chesapeake Bay segments

Next Steps

- Set up geo runs with final Phase 6 model and decisions
- Run selected geo runs (Susquehanna N & P, James N & P) with 1, 2, 5, and 10 MM pound increases
- Analyze results for consistent response across nutrient increases
- Use results to guide decision for analysis method on all geo runs