Open Water Geo run Analysis

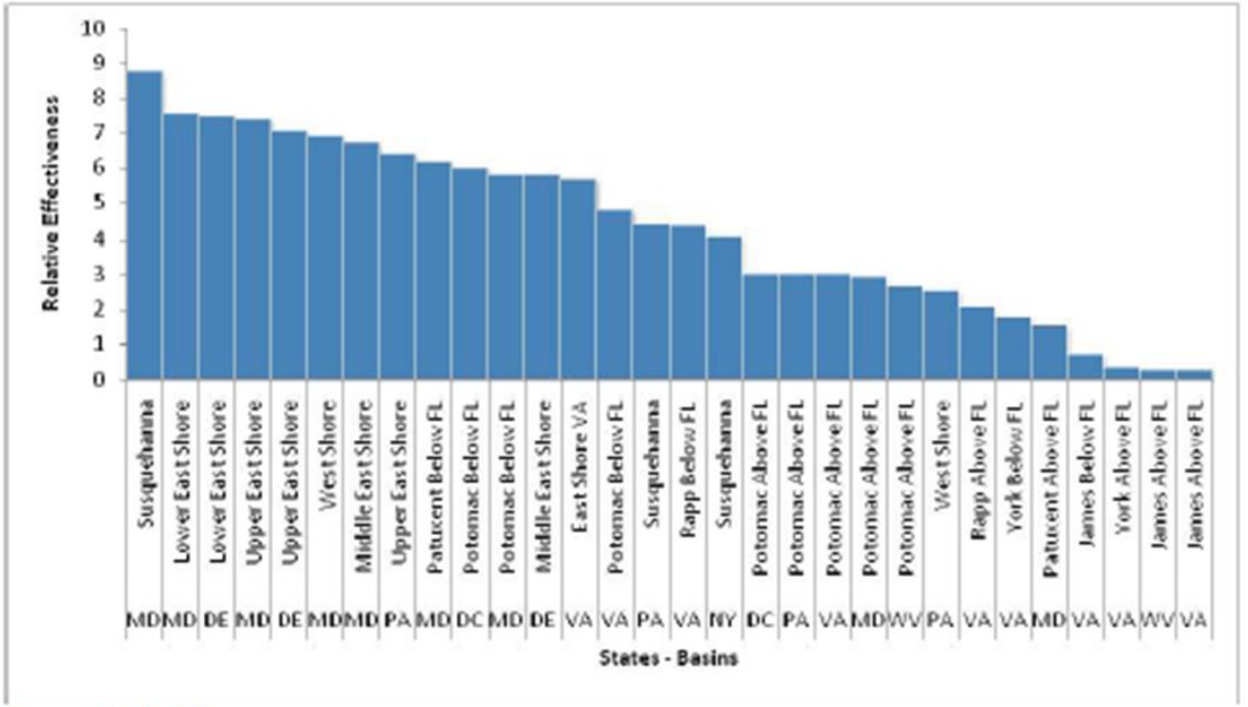
Andrew Sommerlot, Richard Tian, Gopal Bhatt,
Lew Linker, Gary Shenk

Background and Motivation

- Geo runs are used as a metric of 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 designated uses.
- Now, we are interested in the effect on Open Water designated uses as well.

Background and Motivation

- Geo runs have been used routinely in the past to measure the effect of geo runs in deep water segments (Chesapeake Bay TMDL Document, 2010).



Source: Table 6-3

Figure 6-4. Relative effectiveness for nitrogen for the watershed jurisdictions and major rivers basins, above and below the fall line, in descending order.

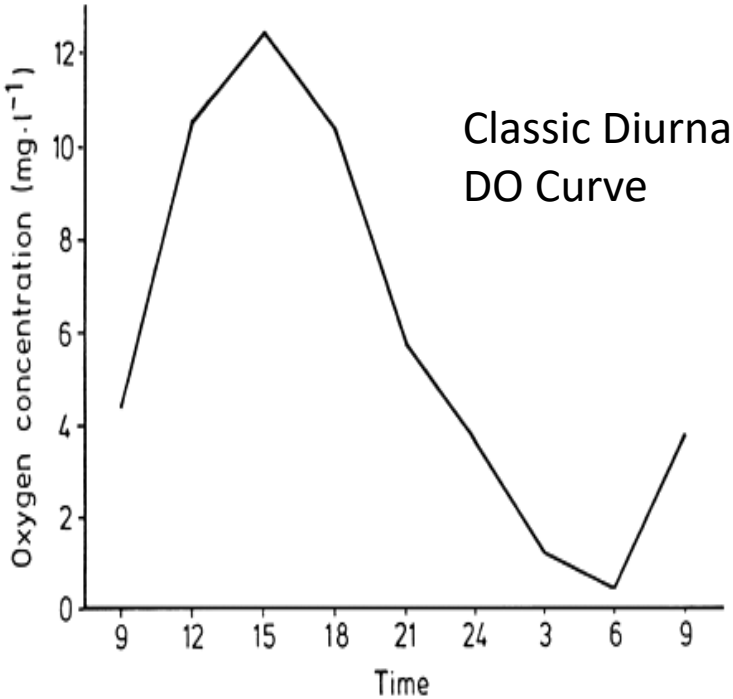
Background and Motivation

- Measuring the effect on Open 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

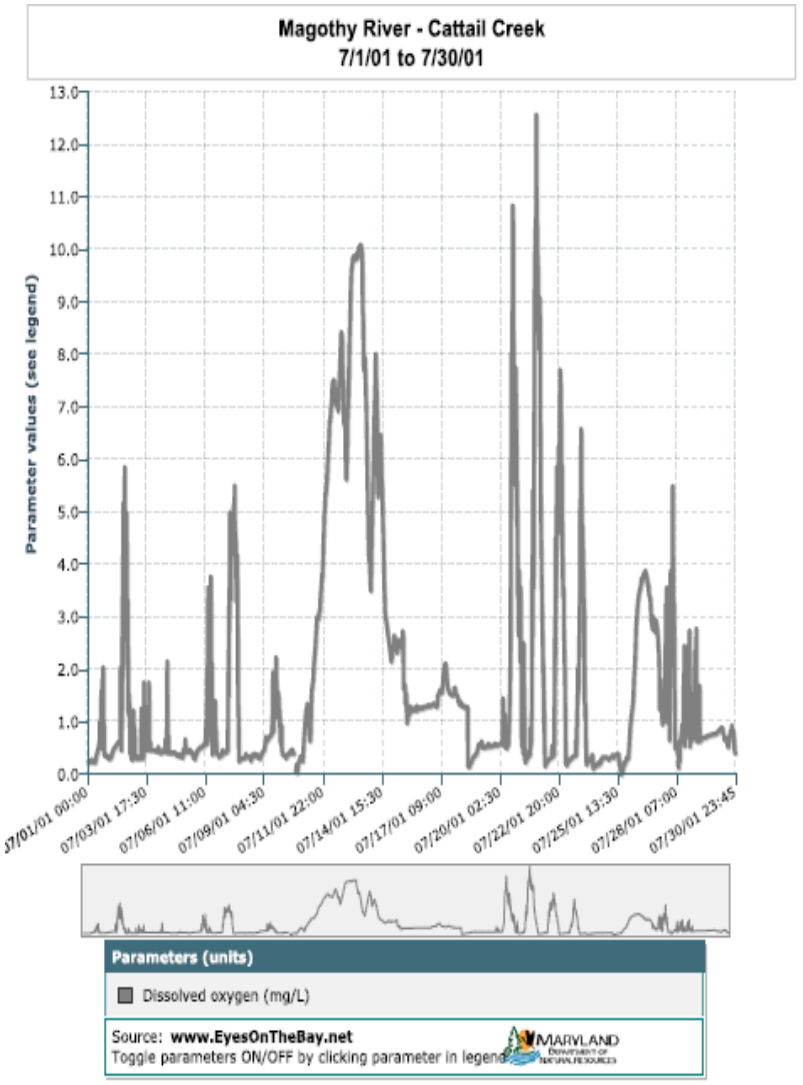
Changes in nutrient loads change algal concentrations. But algae both evolve DO during photosynthesis and consume DO in respiration. Plus the atmosphere at the top of Open Water segments is an infinite source of DO…and the sediment at the bottom of many Open Water segments are an infinite sink of DO.

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



Classic Diurnal Open Water DO Curve

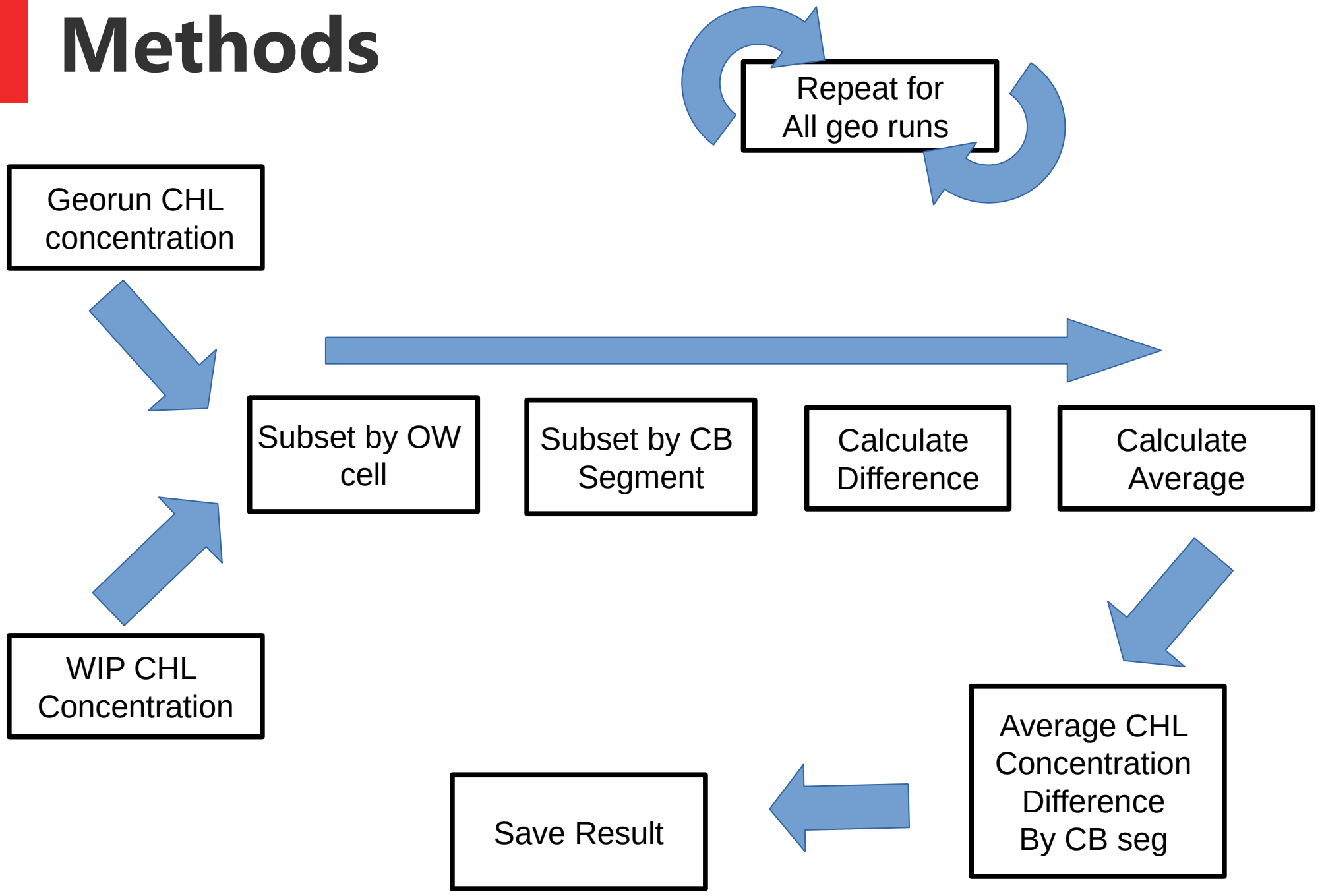
Diurnal DO Response from Continuous Bay Monitoring



Methods

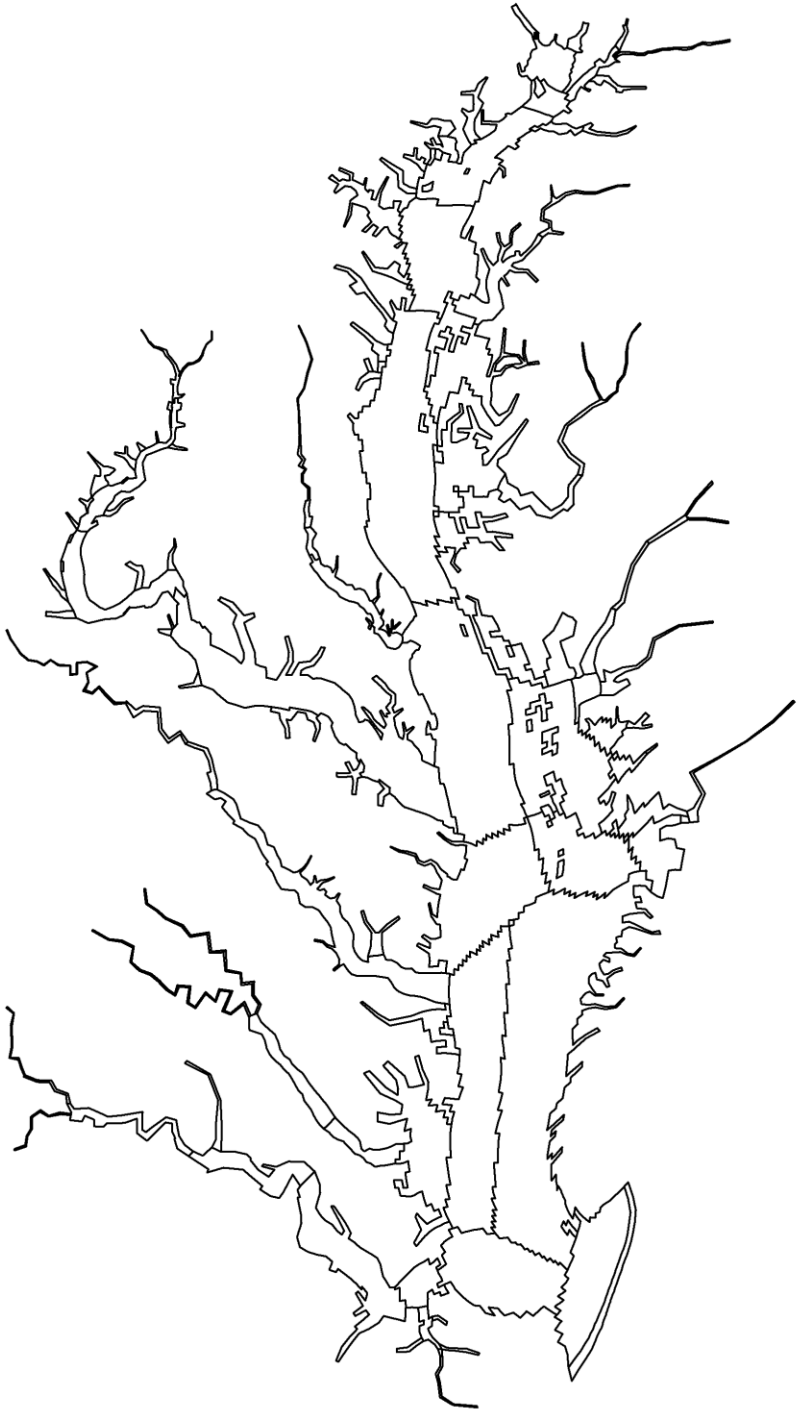
- The WQSTM outputs CHL concentrations on a daily time step for all 3 dimensional cells which make up the 3D grid used to model the estuary.
- A subset of these spatially unique cells are designated Open Water (OW).
- In general, OW is defined as a depth of 7 feet or less.
- Additionally, the cell grid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

Methods

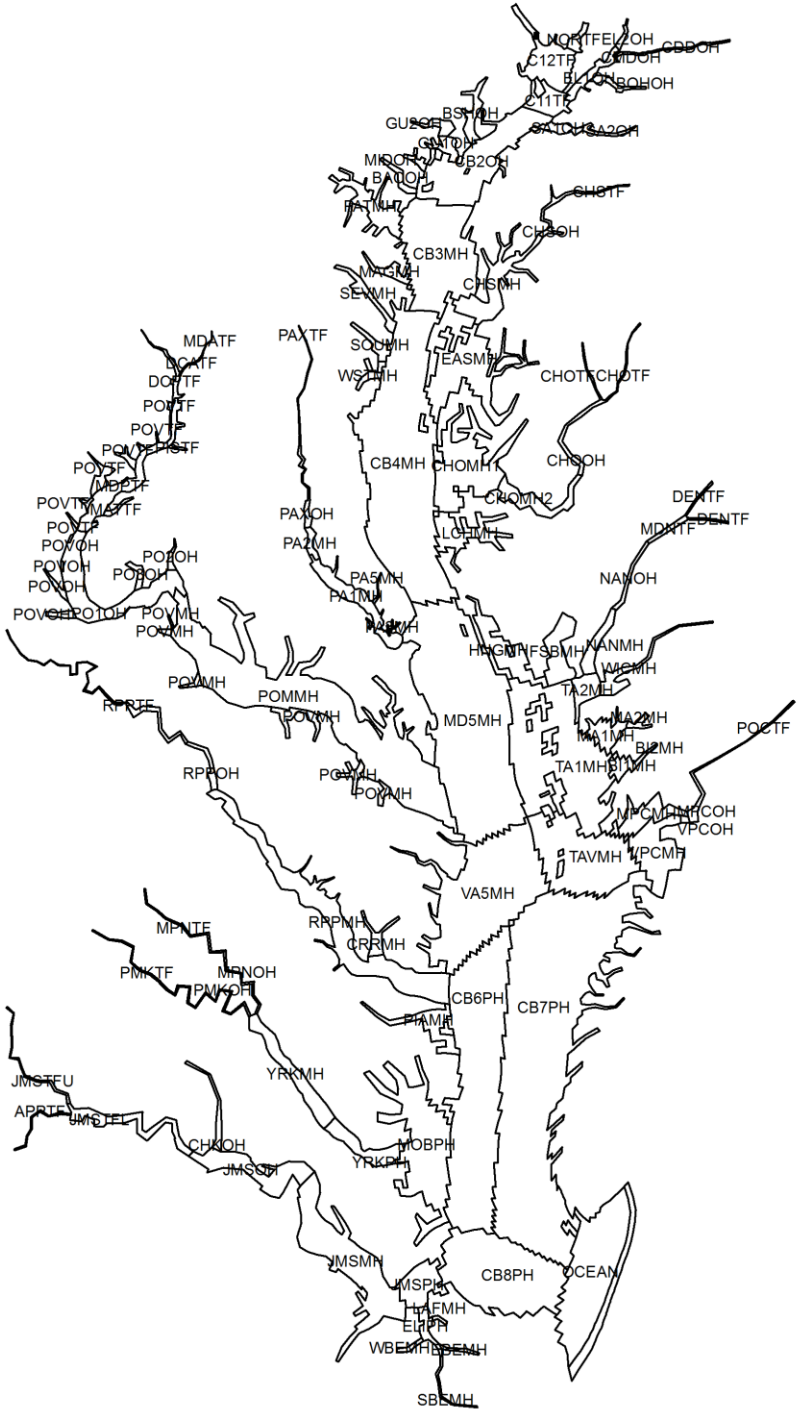

Repeat for
All geo runs
Georun CHL
concentration
Subset by OW
cell
Subset by CB
Segment
Calculate
Difference
Calculate
Average
WIP CHL
Concentration
Average CHL
Concentration
Difference
By CB seg
Save Result

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 analysis with 3 different nutrient levels each (A total of 24 geo runs).



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.

Methods

Geo run nutrient addition

“scenarios”

N addition in MM lbs	P addition in MM lbs
1	0.1
5	0.5
10	1

Methods

Geo run geography “scenarios”

Choptank

James

Rappahannock

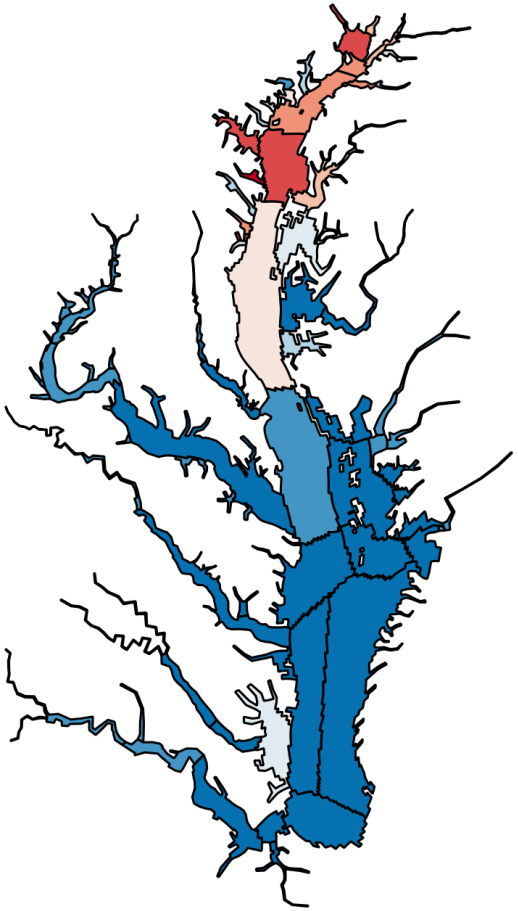
Susquehanna

Results

- The results indicate chlorophyll is not without surprises, but overall a usable indicator to provide geographic rankings of the effects on surface Open Water from nutrient loads sourced from the geo runs.
- There are still instances of negative “increases” in chlorophyll levels.
- Meaning, sometimes, on an average annual basis, addition of nutrients in a particular geography may actually decrease CHL levels in a particular Chesapeake Bay segment.

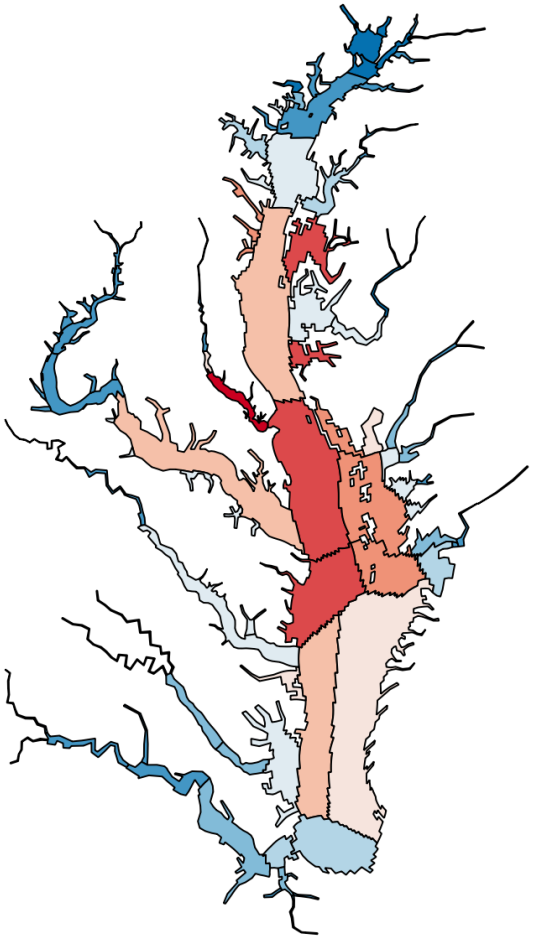
Results

P Response



Follows nutrient limitation patterns

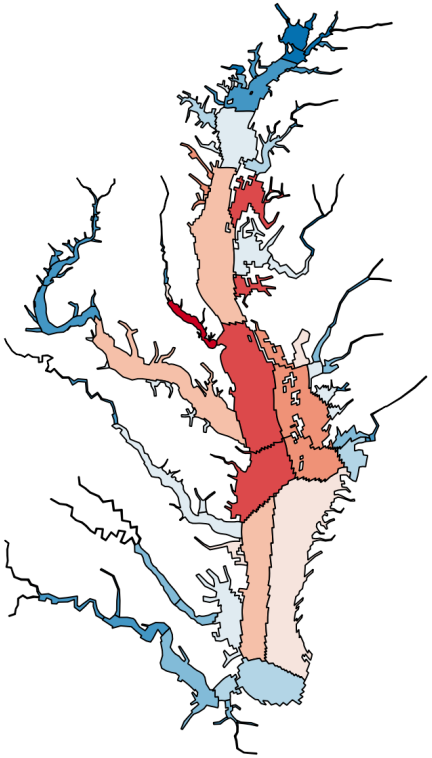
N Response



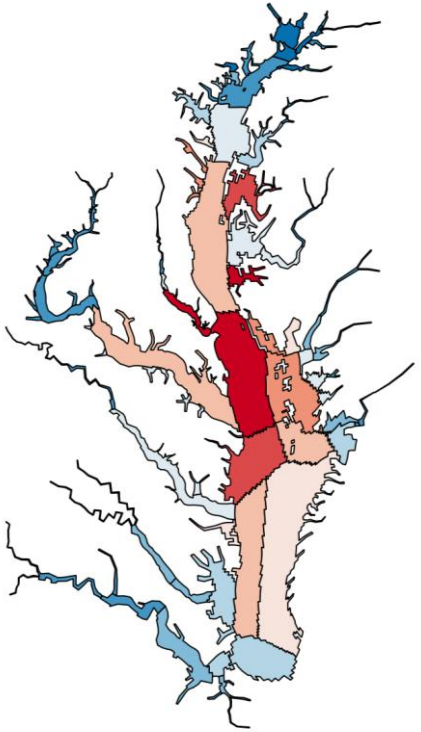
Results

Relatively similar through time subsets

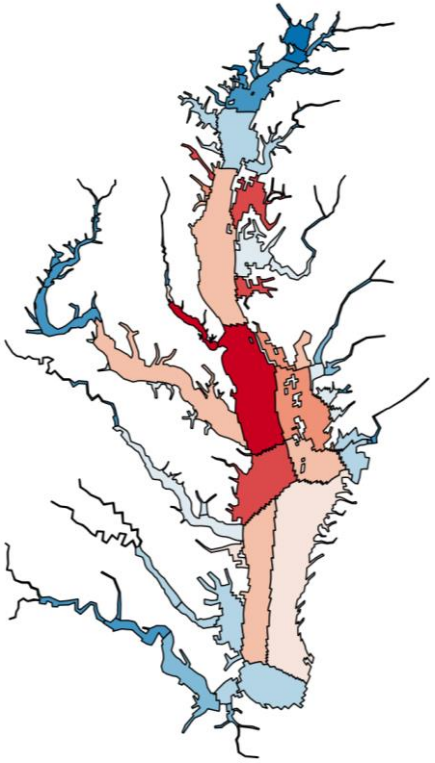
All Season



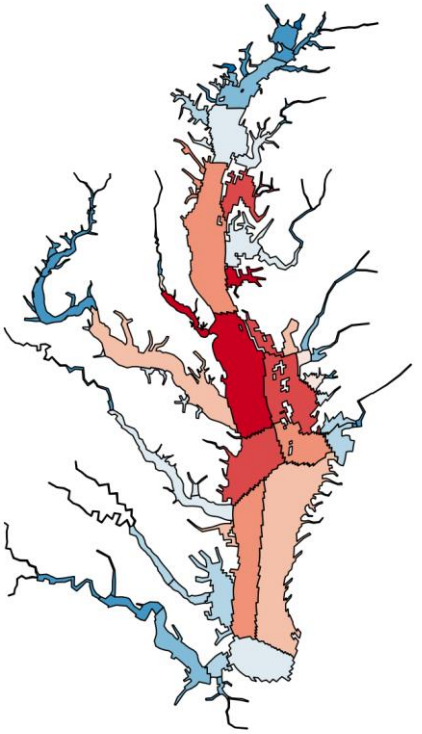
Spring

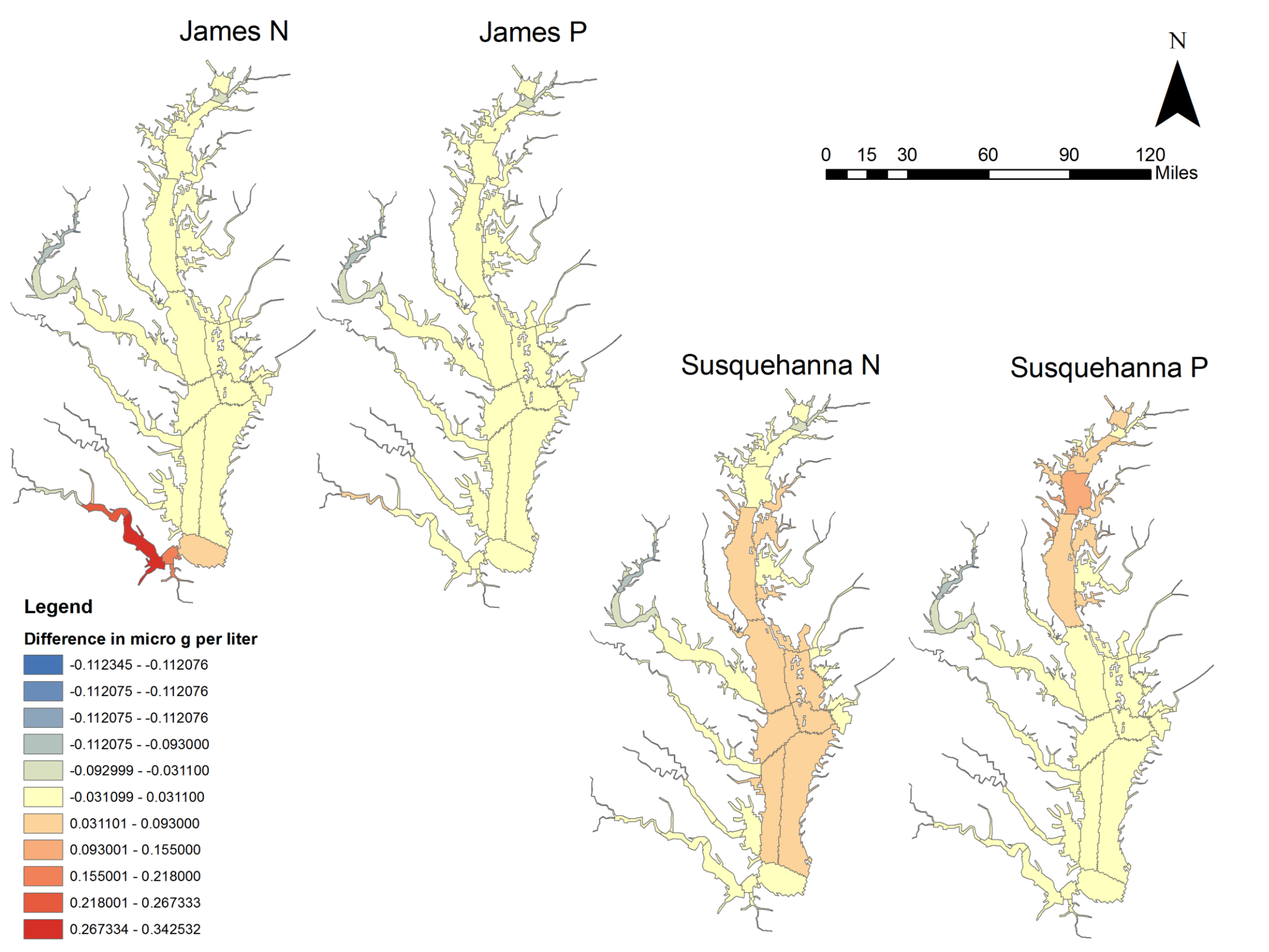


June

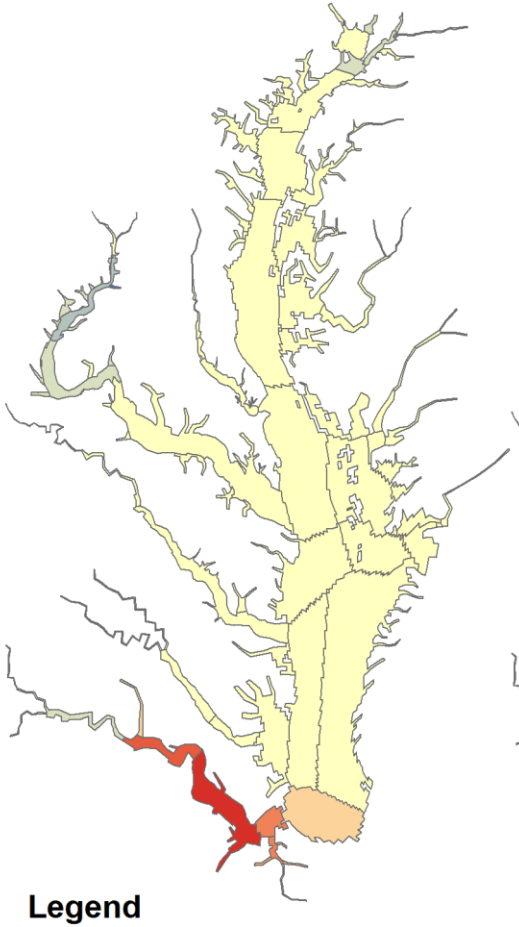


Summer

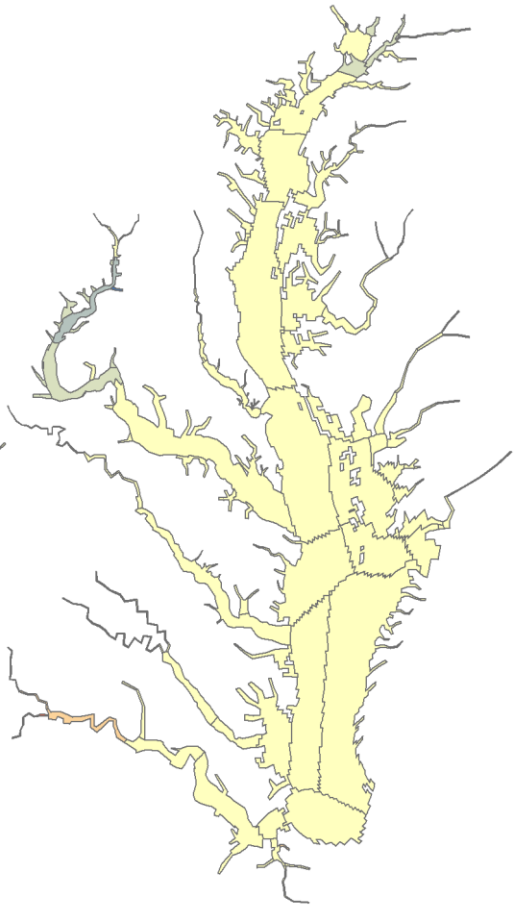



James N
James P
Susquehanna N
Susquehanna P
N
0 15 30 60 90 120
Miles
Legend
Difference in micro g per liter
-0.112345 - -0.112076
-0.112075 - -0.112076
-0.112075 - -0.112076
-0.112075 - -0.093000
-0.092999 - -0.031100
-0.031099 - 0.031100
0.031101 - 0.093000
0.093001 - 0.155000
0.155001 - 0.218000
0.218001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

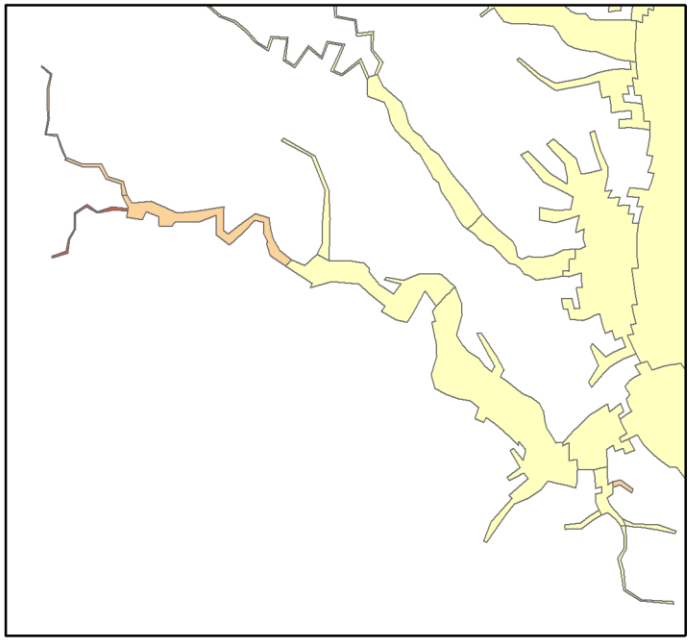
James N



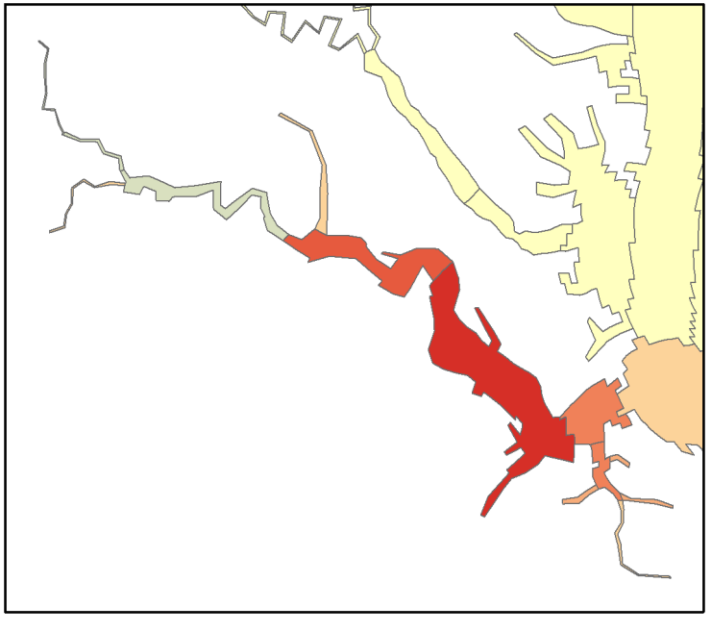
James P



James P



James N



Legend

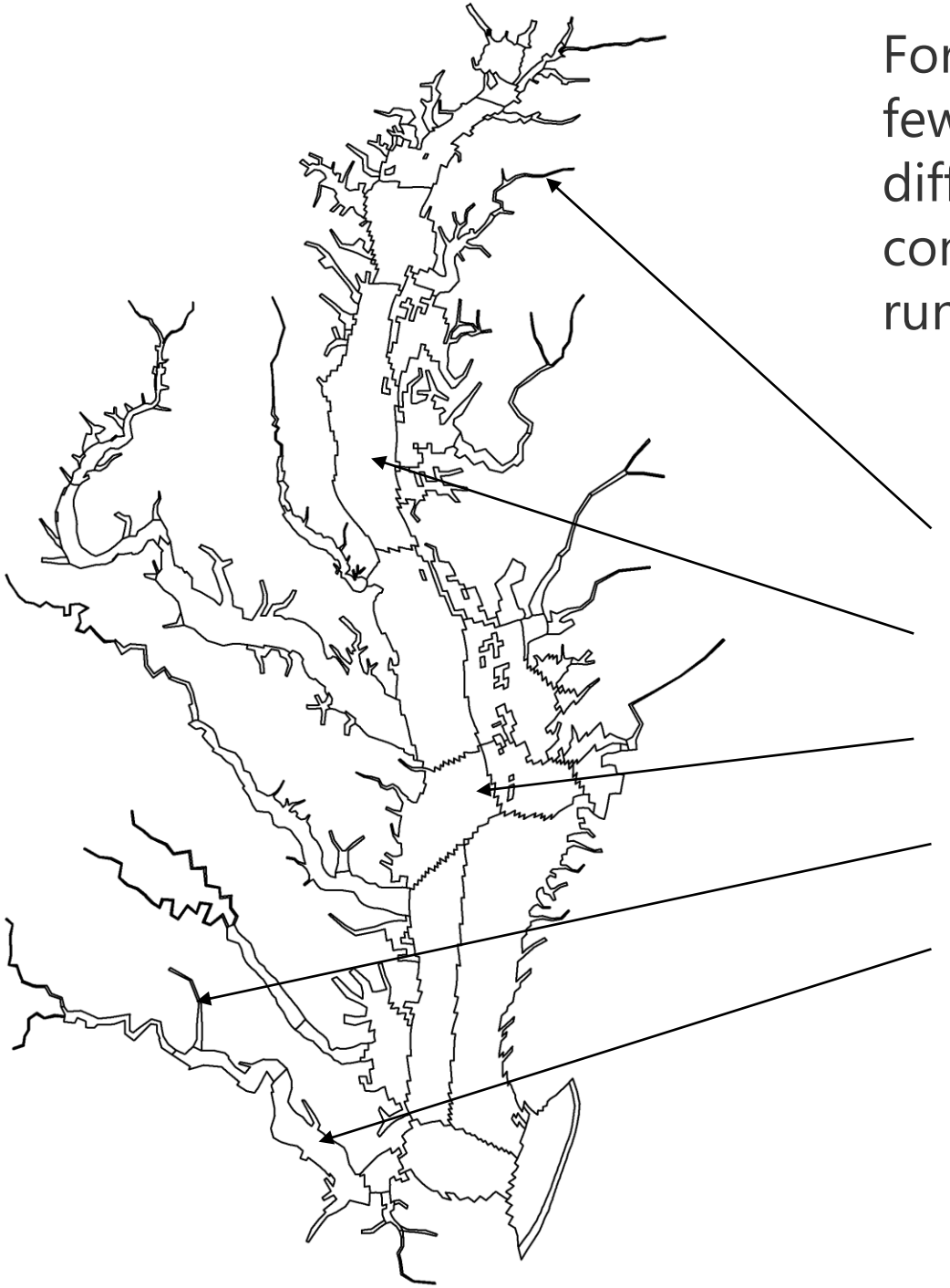
Difference in micro g per liter

- -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

Results

The up-coming bar charts were calculated in the following way:

$$\frac{\text{Average Annual CHL Difference}}{\text{MM lbs of Nutrient Added}}$$



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

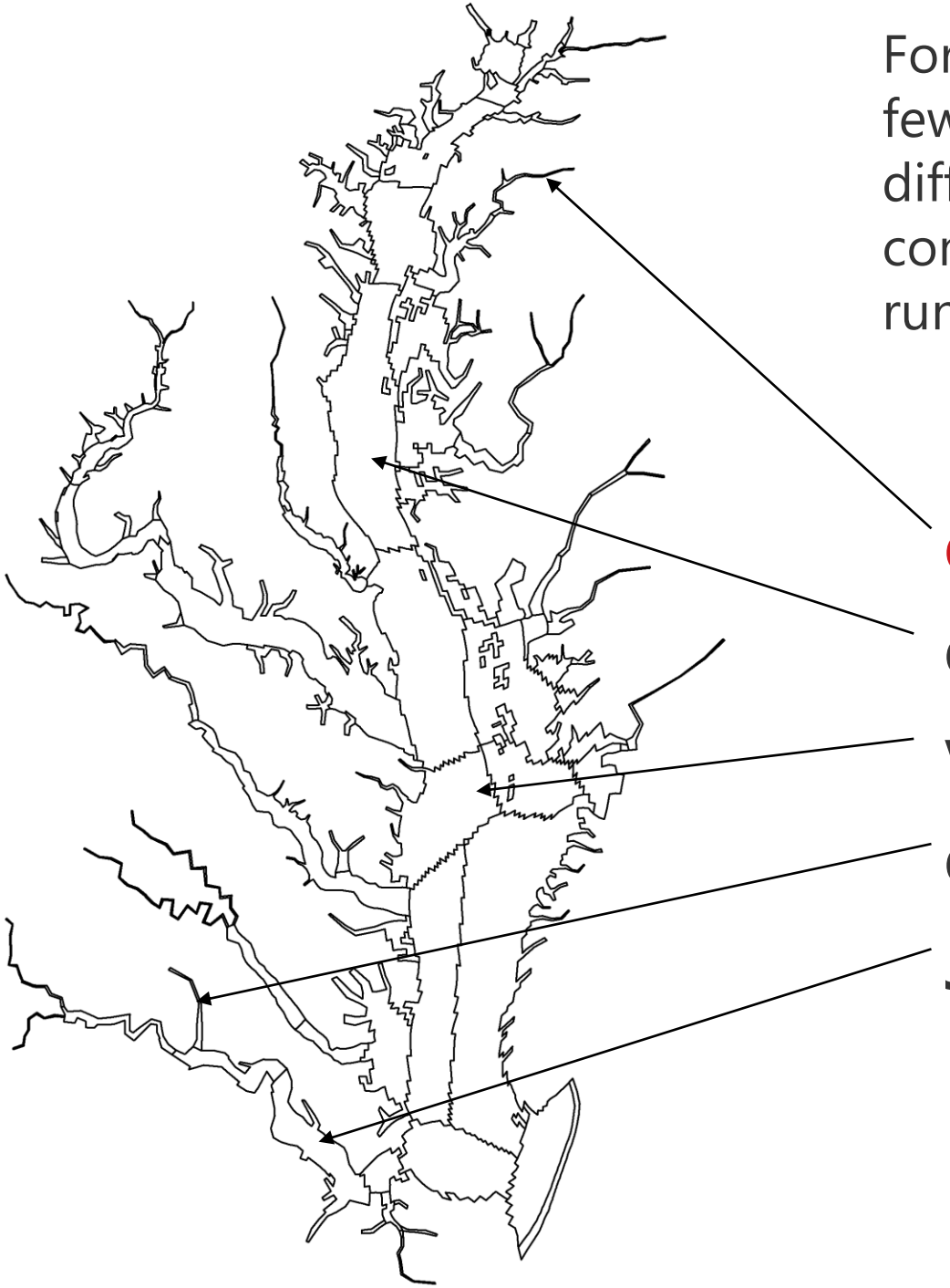
CHSTF

CB4MH

VA5MH

CHKOH

JMSMH



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

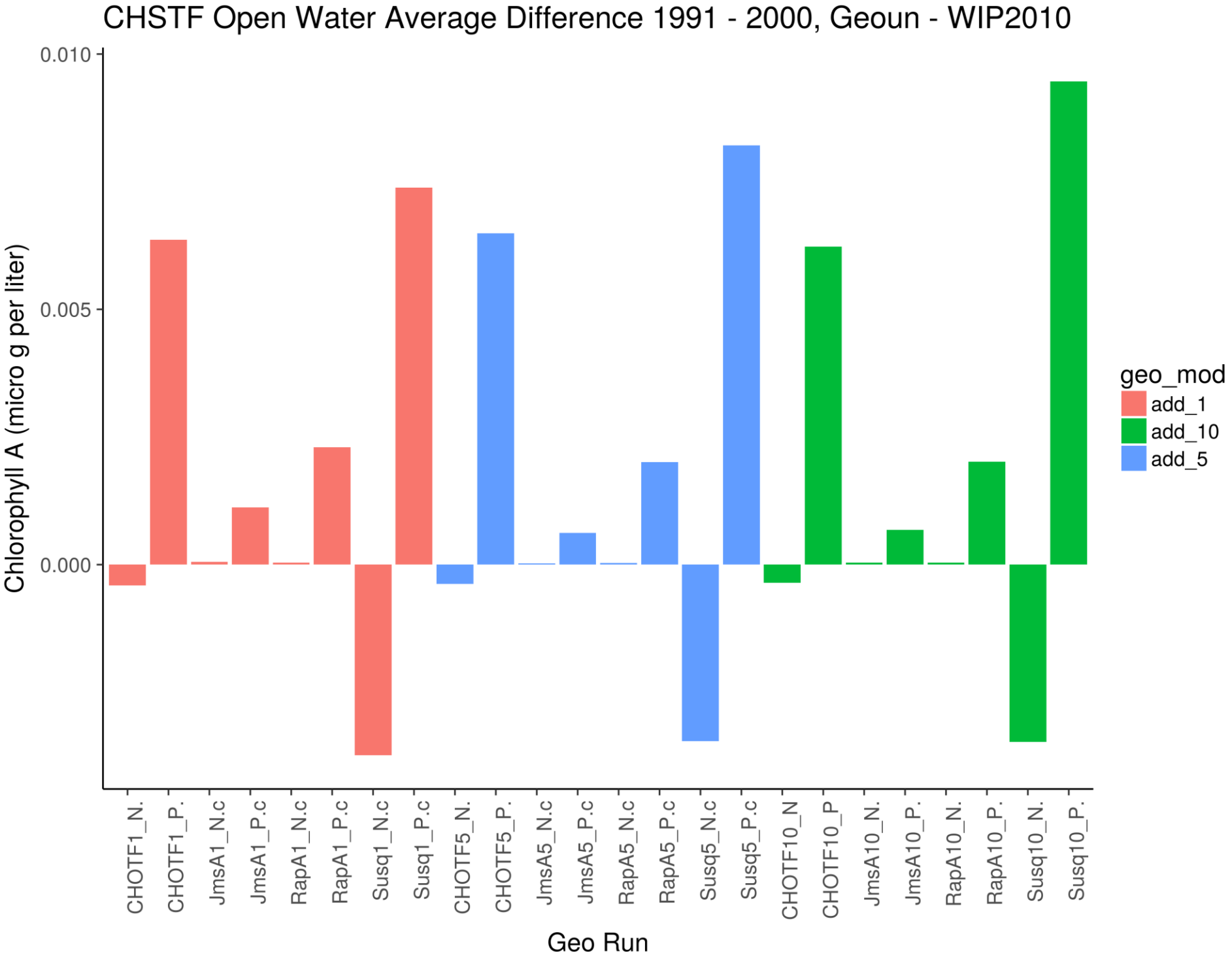
CHSTF

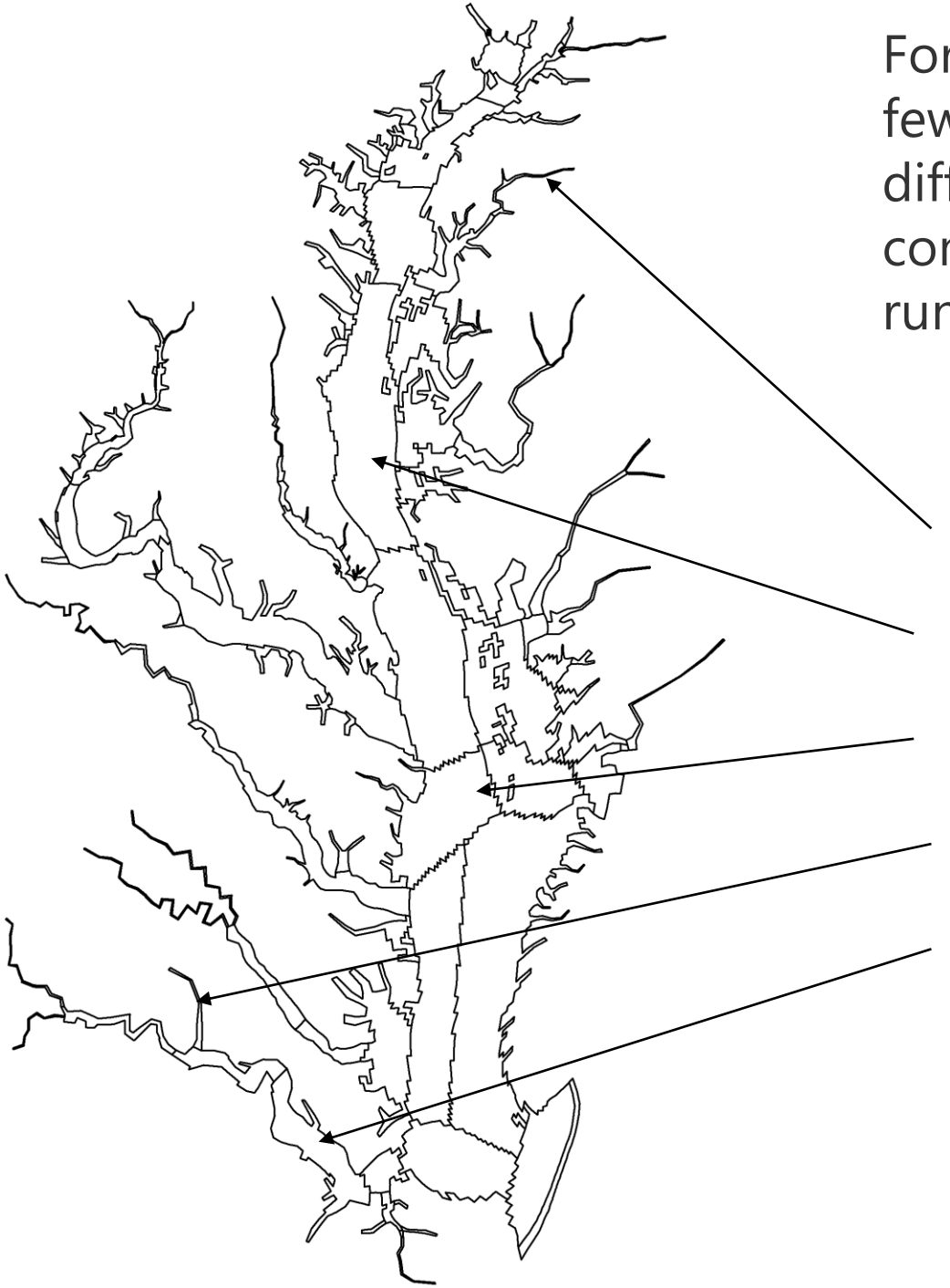
CB4MH

VA5MH

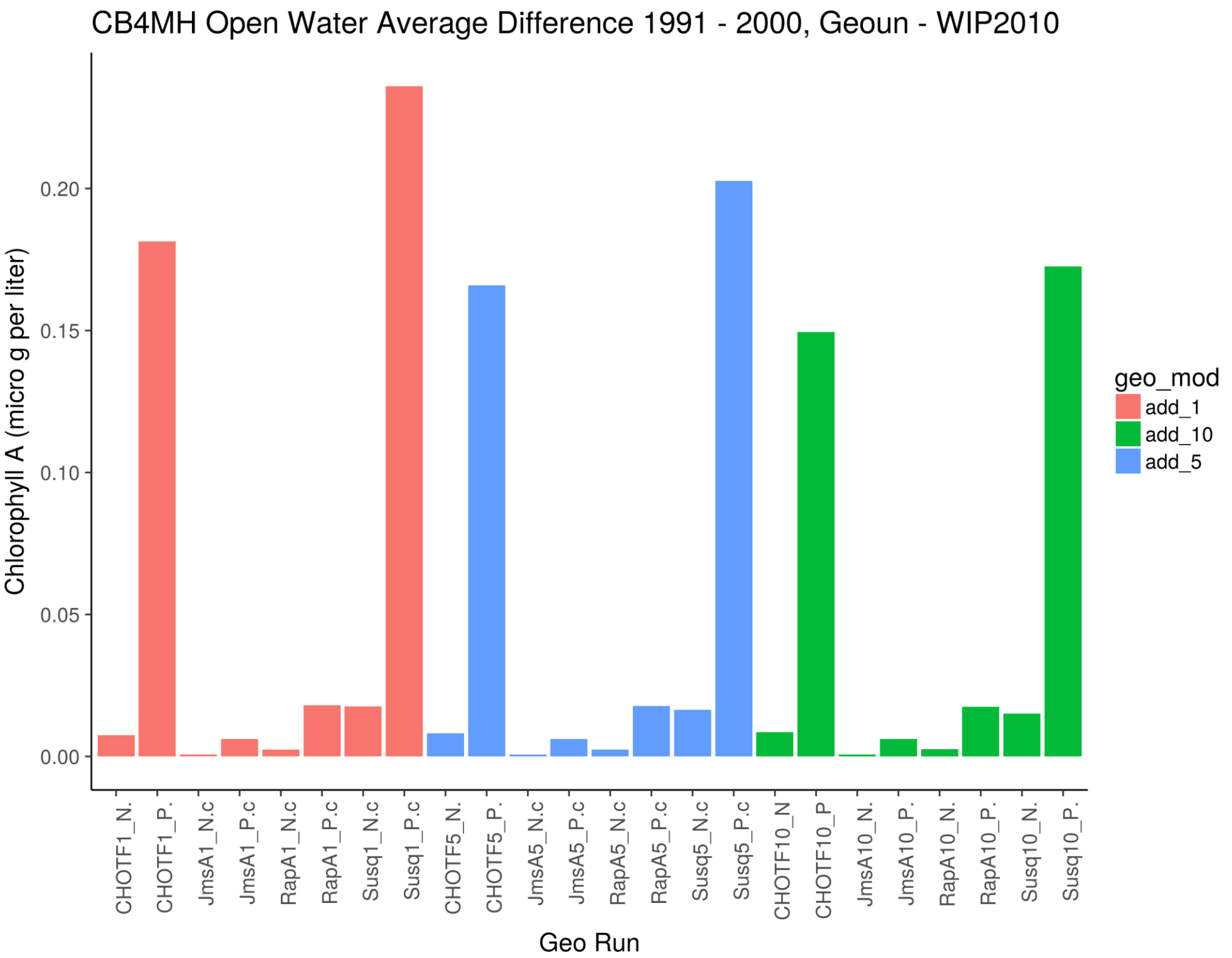
CHKOH

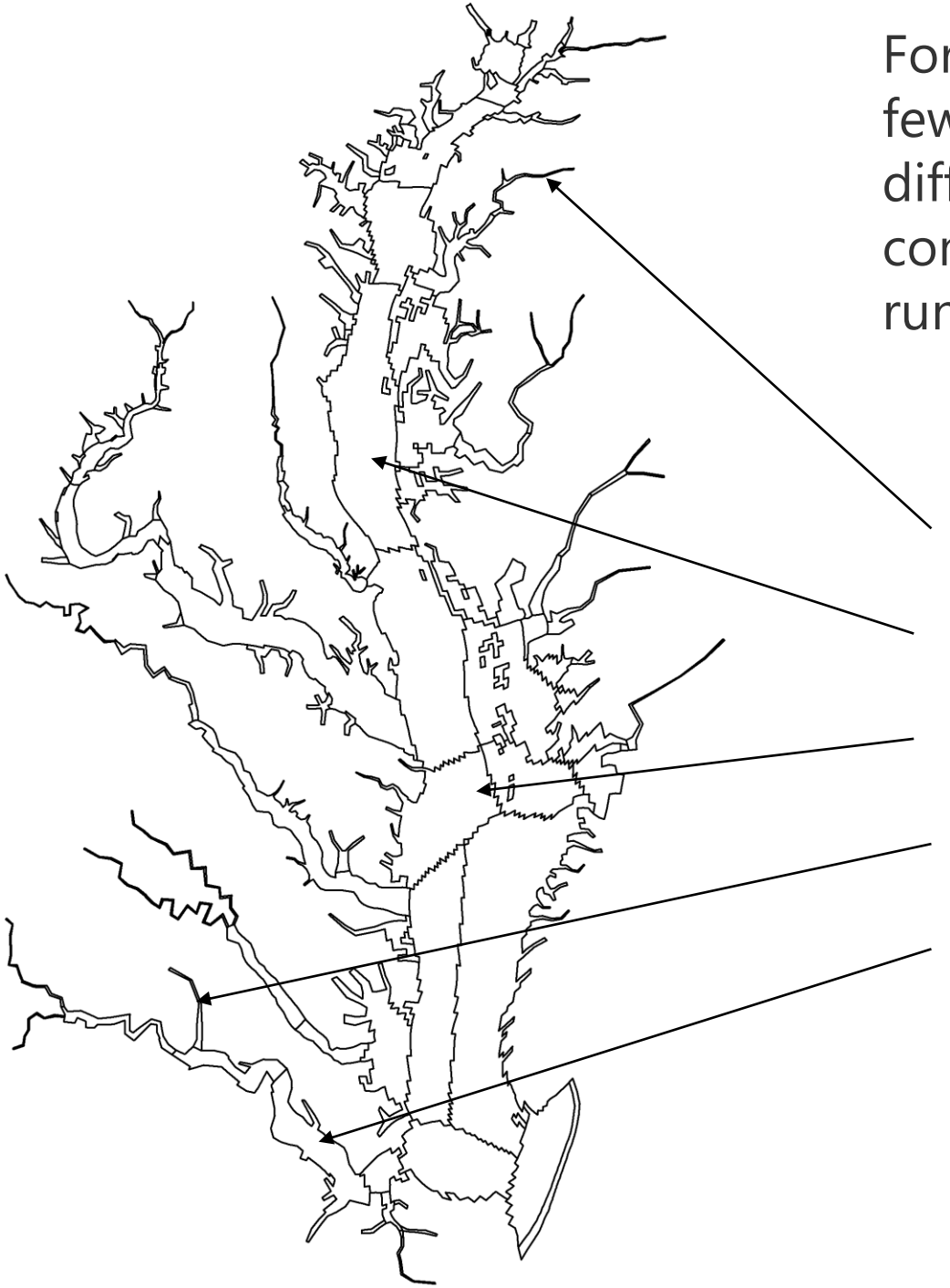
JMSMH


CHSTF Open Water Average Difference 1991 - 2000, Geoun - WIP2010
0.010
0.005
0.000
Chlorophyll A (micro g per liter)
CHOTF1_N.
CHOTF1_P.
JmsA1_N.c
JmsA1_P.c
RapA1_N.c
RapA1_P.c
Susq1_N.c
Susq1_P.c
CHOTF5_N.
CHOTF5_P.
JmsA5_N.c
JmsA5_P.c
RapA5_N.c
RapA5_P.c
Susq5_N.c
Susq5_P.c
CHOTF10_N
CHOTF10_P
JmsA10_N.
JmsA10_P.
RapA10_N.
RapA10_P.
Susq10_N.
Susq10_P.
Geo Run
geo_mod
add_1
add_10
add_5



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


CB4MH Open Water Average Difference 1991 - 2000, Geoun - WIP2010
Chlorophyll A (micro g per liter)
0.20
0.15
0.10
0.05
0.00
CHOTF1_N.
CHOTF1_P.
JmsA1_N.c
JmsA1_P.c
RapA1_N.c
RapA1_P.c
Susq1_N.c
Susq1_P.c
CHOTF5_N.
CHOTF5_P.
JmsA5_N.c
JmsA5_P.c
RapA5_N.c
RapA5_P.c
Susq5_N.c
Susq5_P.c
CHOTF10_N
CHOTF10_P
JmsA10_N.
JmsA10_P.
RapA10_N.
RapA10_P.
Susq10_N.
Susq10_P.
Geo Run
geo_mod
add_1
add_10
add_5



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

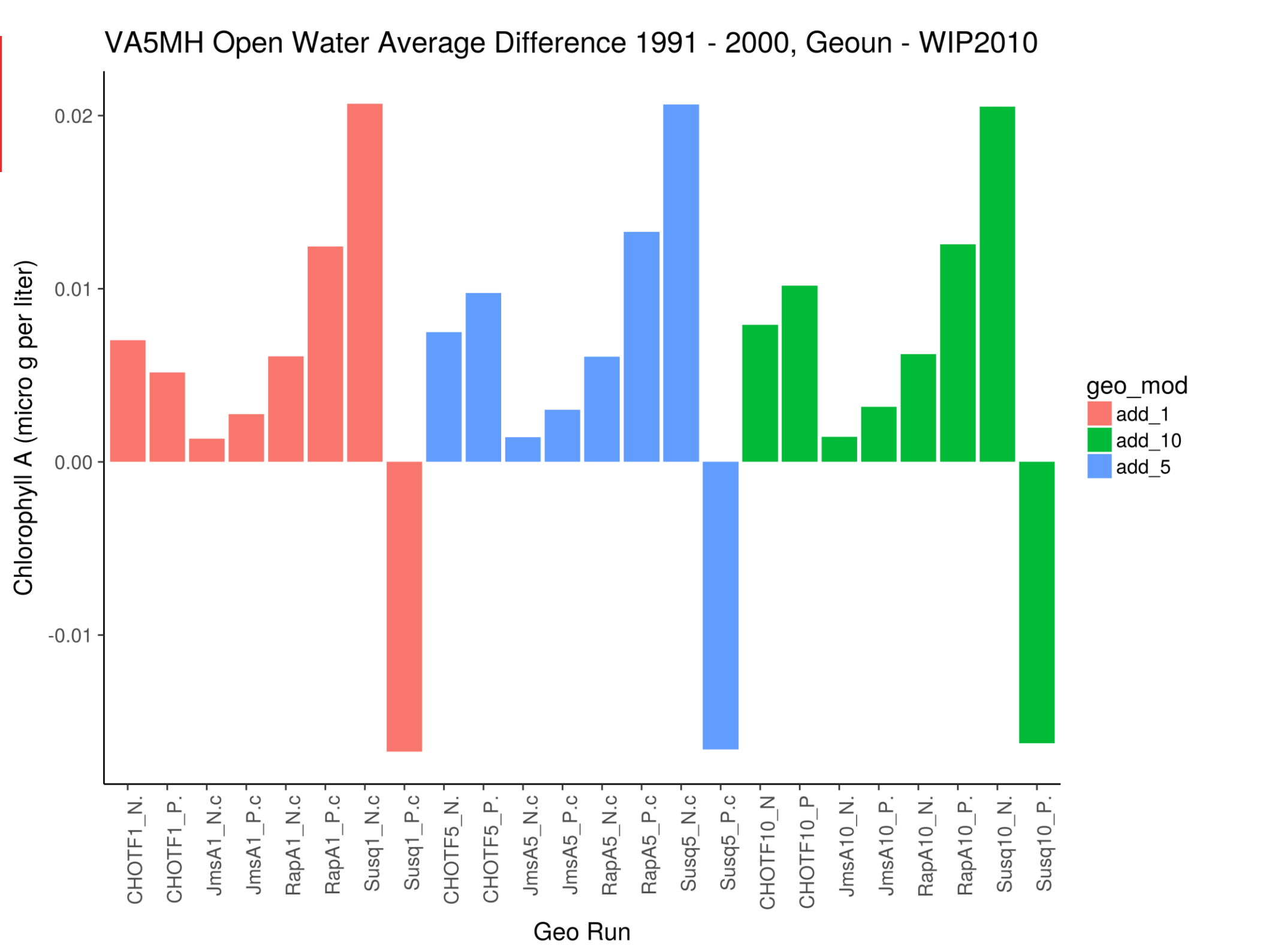
CHSTF

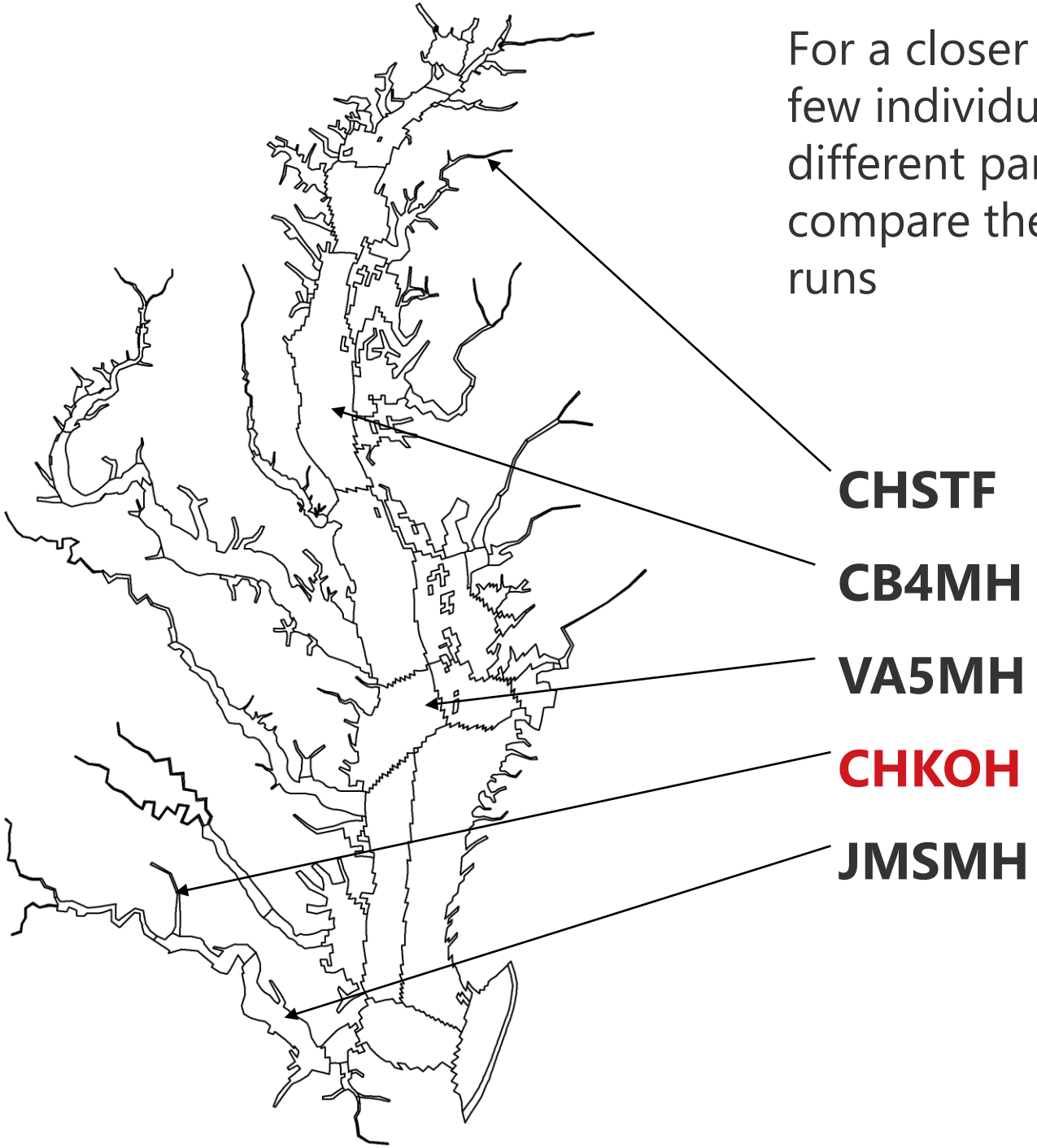
CB4MH

VA5MH

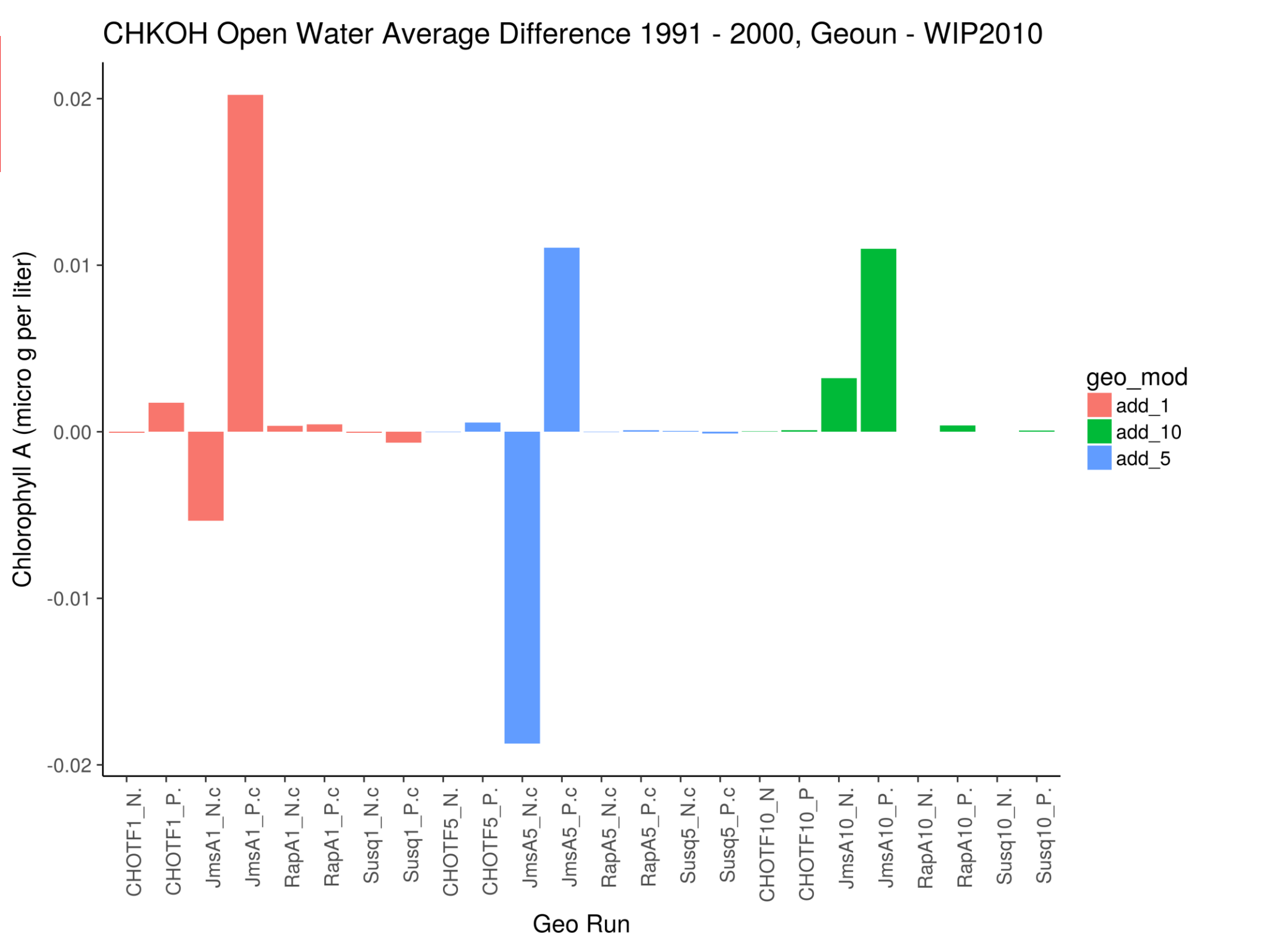
CHKOH

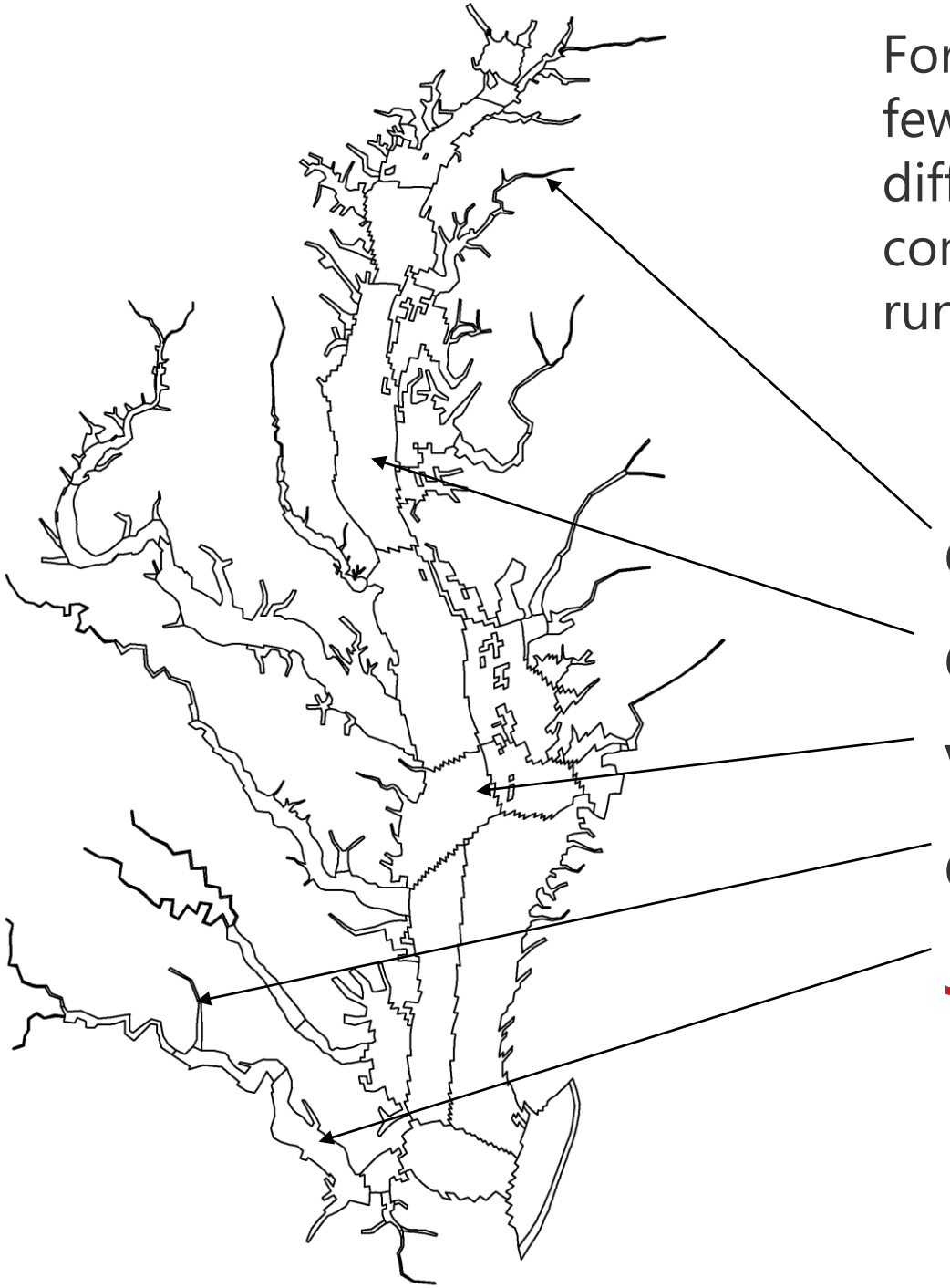
JMSMH


VA5MH Open Water Average Difference 1991 - 2000, Geoun - WIP2010
Chlorophyll A (micro g per liter)
0.02
0.01
0.00
-0.01
CHOTF1_N.
CHOTF1_P.
JmsA1_N.c
JmsA1_P.c
RapA1_N.c
RapA1_P.c
Susq1_N.c
Susq1_P.c
CHOTF5_N.
CHOTF5_P.
JmsA5_N.c
JmsA5_P.c
RapA5_N.c
RapA5_P.c
Susq5_N.c
Susq5_P.c
CHOTF10_N
CHOTF10_P
JmsA10_N.
JmsA10_P.
RapA10_N.
RapA10_P.
Susq10_N.
Susq10_P.
Geo Run
geo_mod
add_1
add_10
add_5



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


CHKOH Open Water Average Difference 1991 - 2000, Geoun - WIP2010
Chlorophyll A (micro g per liter)
0.02
0.01
0.00
-0.01
-0.02
CHOTF1_N.
CHOTF1_P.
JmsA1_N.c
JmsA1_P.c
RapA1_N.c
RapA1_P.c
Susq1_N.c
Susq1_P.c
CHOTF5_N.
CHOTF5_P.
JmsA5_N.c
JmsA5_P.c
RapA5_N.c
RapA5_P.c
Susq5_N.c
Susq5_P.c
CHOTF10_N
CHOTF10_P
JmsA10_N.
JmsA10_P.
RapA10_N.
RapA10_P.
Susq10_N.
Susq10_P.
Geo Run
geo_mod
add_1
add_10
add_5



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

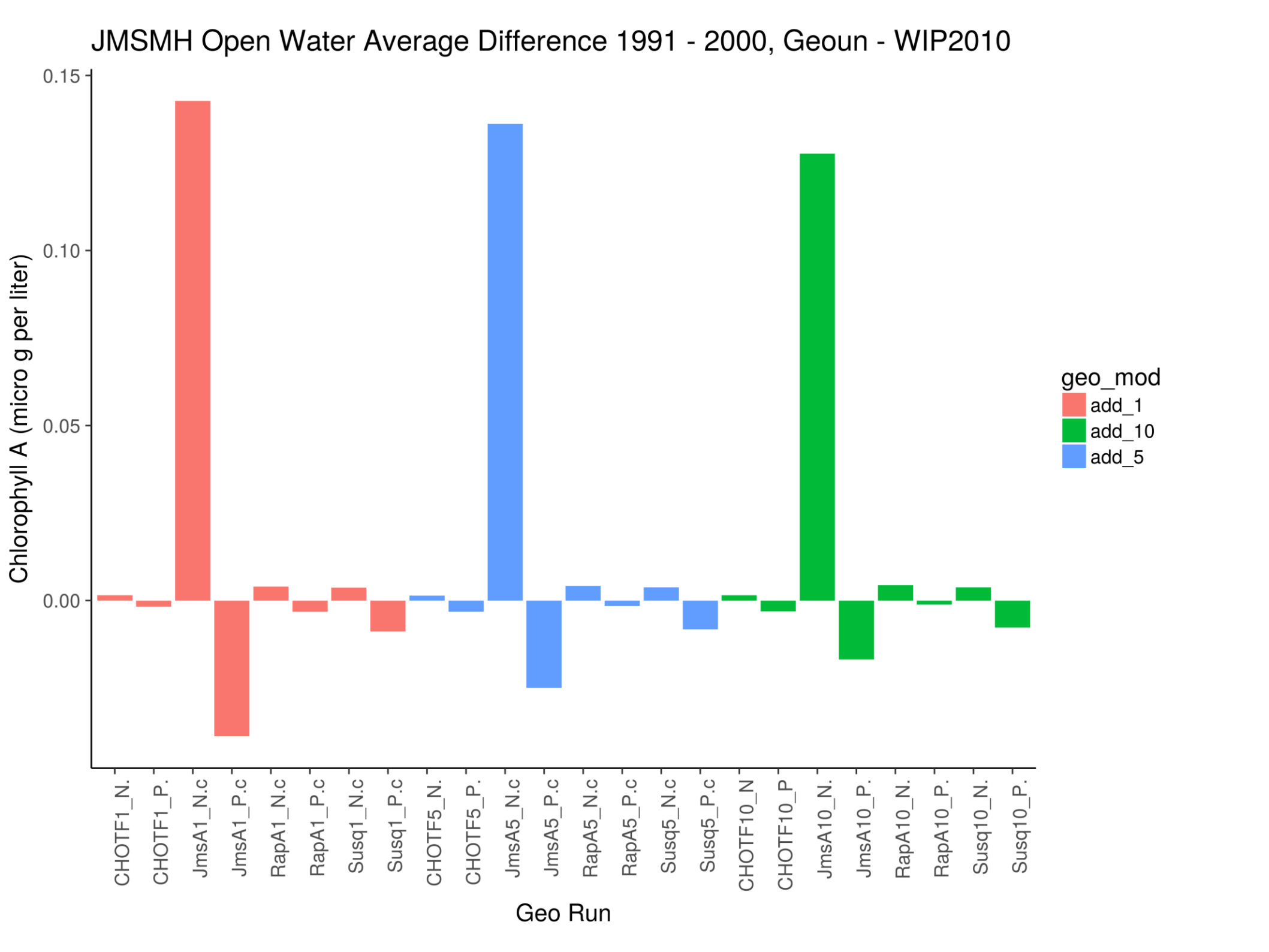
CHSTF

CB4MH

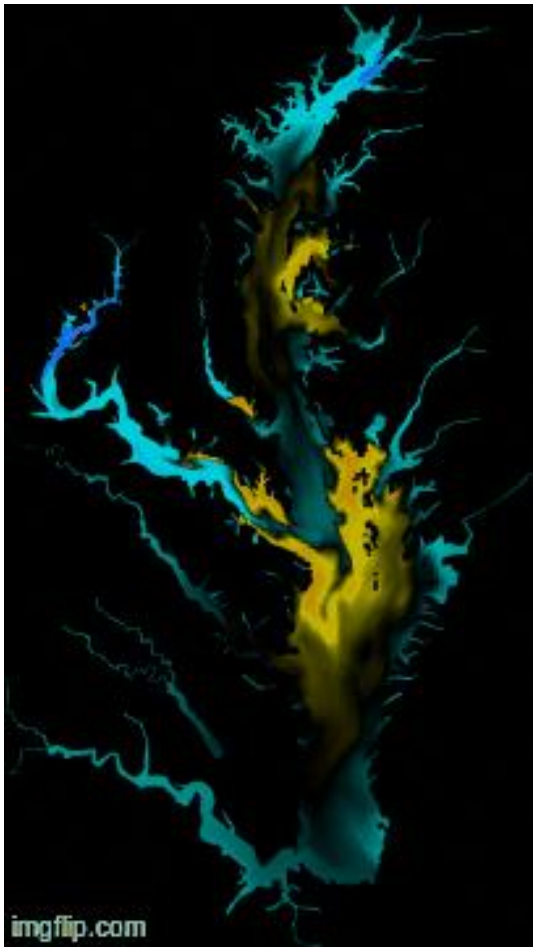
VA5MH

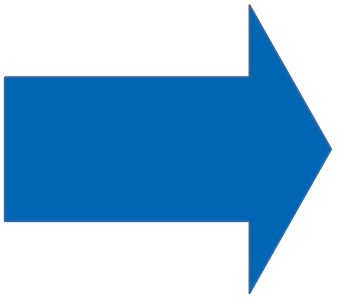
CHKOH

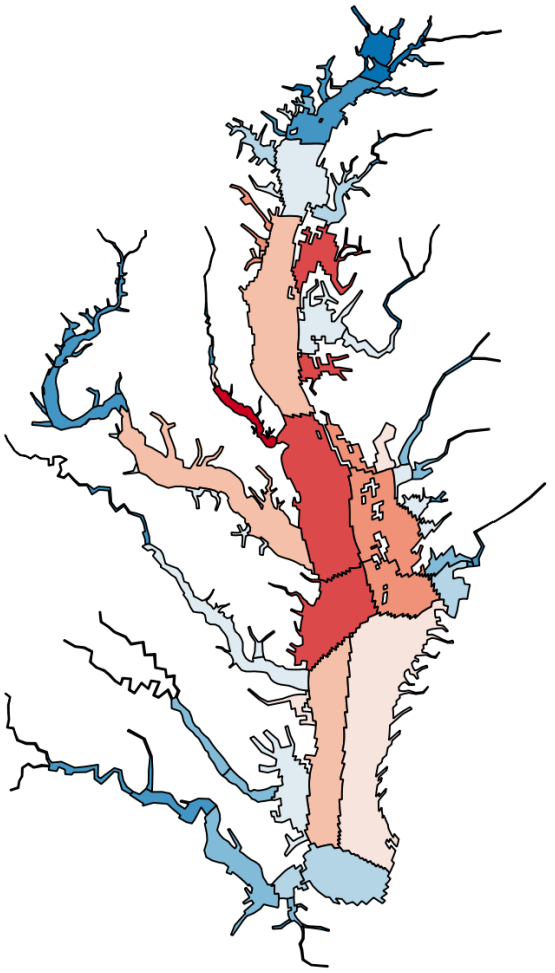
JMSMH


JMSMH Open Water Average Difference 1991 - 2000, Geoun - WIP2010
Chlorophyll A (micro g per liter)
0.15
0.10
0.05
0.00
CHOTF1_N.
CHOTF1_P.
JmsA1_N.c
JmsA1_P.c
RapA1_N.c
RapA1_P.c
Susq1_N.c
Susq1_P.c
CHOTF5_N.
CHOTF5_P.
JmsA5_N.c
JmsA5_P.c
RapA5_N.c
RapA5_P.c
Susq5_N.c
Susq5_P.c
CHOTF10_N
CHOTF10_P
JmsA10_N.
JmsA10_P.
RapA10_N.
RapA10_P.
Susq10_N.
Susq10_P.
Geo Run
geo_mod
add_1
add_10
add_5

Summary







The Stanley Cup at the Bay Program Office