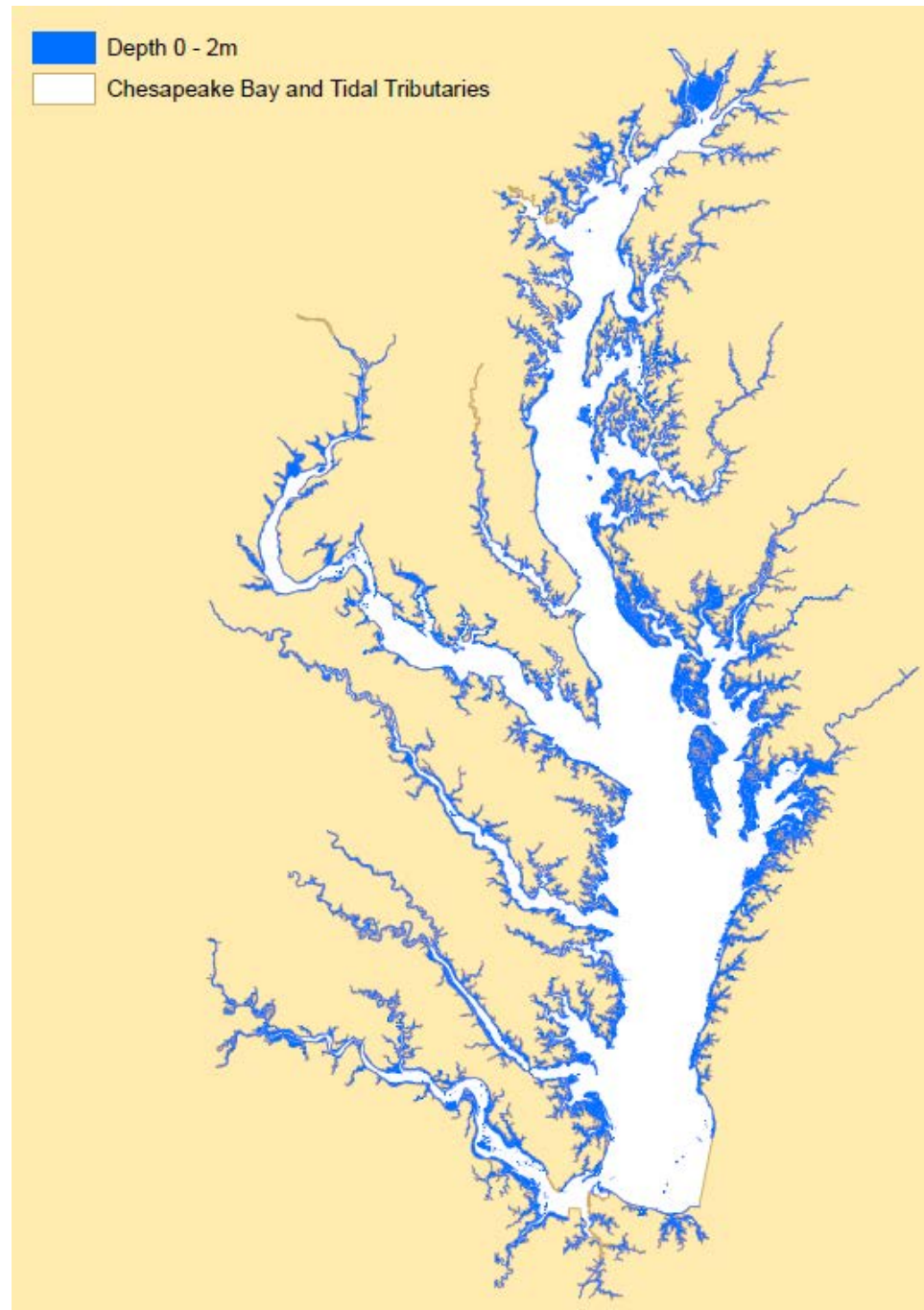


Residence time estimates

Options, data available

- Goal:

- To identify a continuum of conditions that determines dominant controls on local water clarity
- To suggest thresholds for habitats described in the habitat matrix
 - Case studies

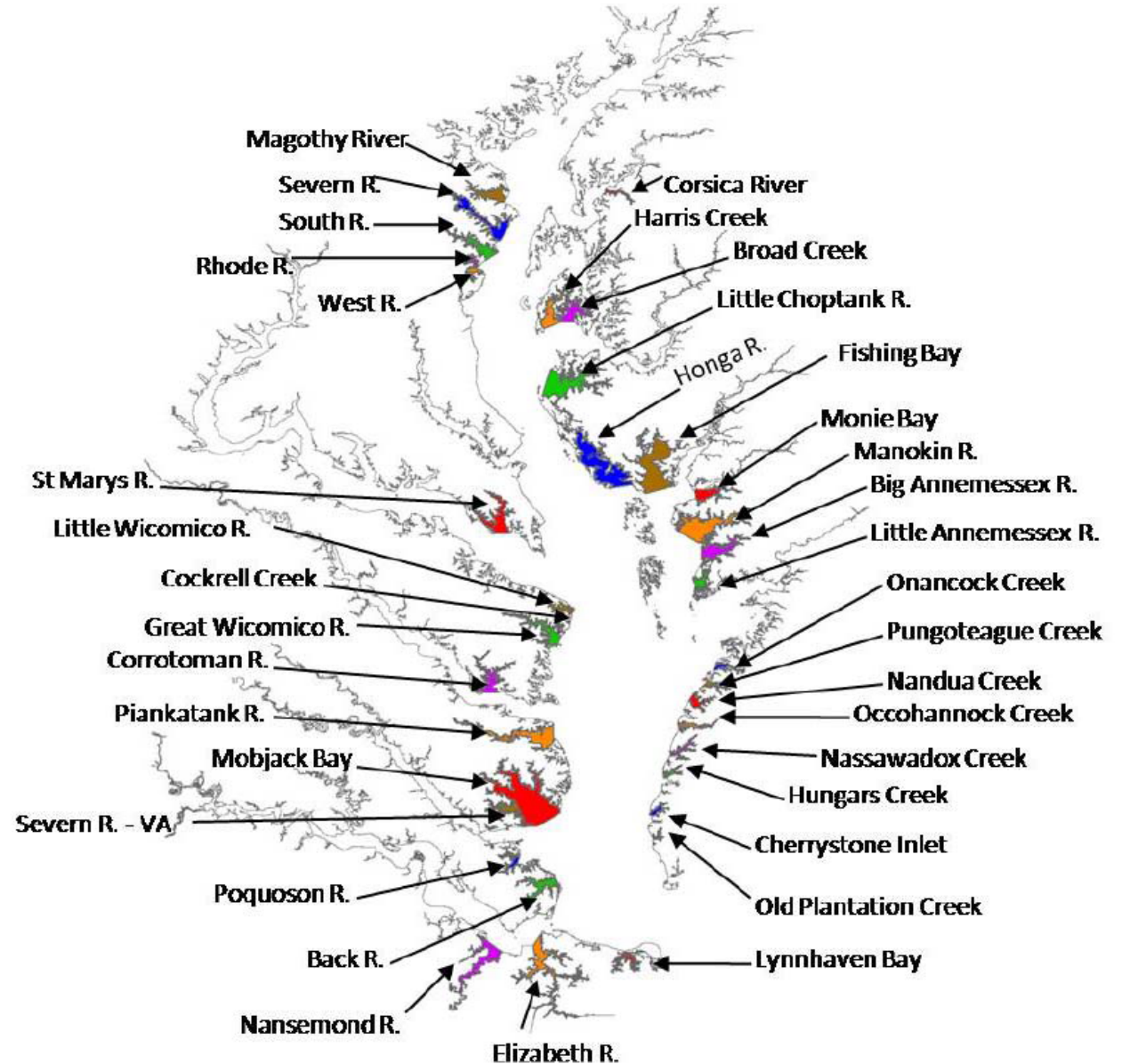


Options - Methods

- Wazniak, North, and Biocourt 2009
- Shen and Wang 2007
- Wainger et. al 2016
- Patrick and Weller (2014, etc) subestuaries

Wasniak, Boicourt, and North 2009

- Calculated and compared residence times for 36 small tributaries throughout the bay
- Limited analysis to “small tributaries without significant freshwater input or a well-defined gravitational circulation”



Wasniak, Boicourt, and North 2009

- Created three numerical indices to compare “retentiveness” of different basins in Chesapeake Bay
 - Percent intertidal volume (PIV)
 - Tidal prism flushing time (T_f)
 - Tidal prism flushing time adjusted by a return flow factor
- Required:
 - Chesapeake Bay shoreline shapefile
 - Bathymetry grid
 - Tidal flushing model to estimate return flow factor (Sanford et. al 1992)
 - Extensive manual processing to generate tributary polygons and depth grids

Wasniak, Boicourt, and North 2009

Result:

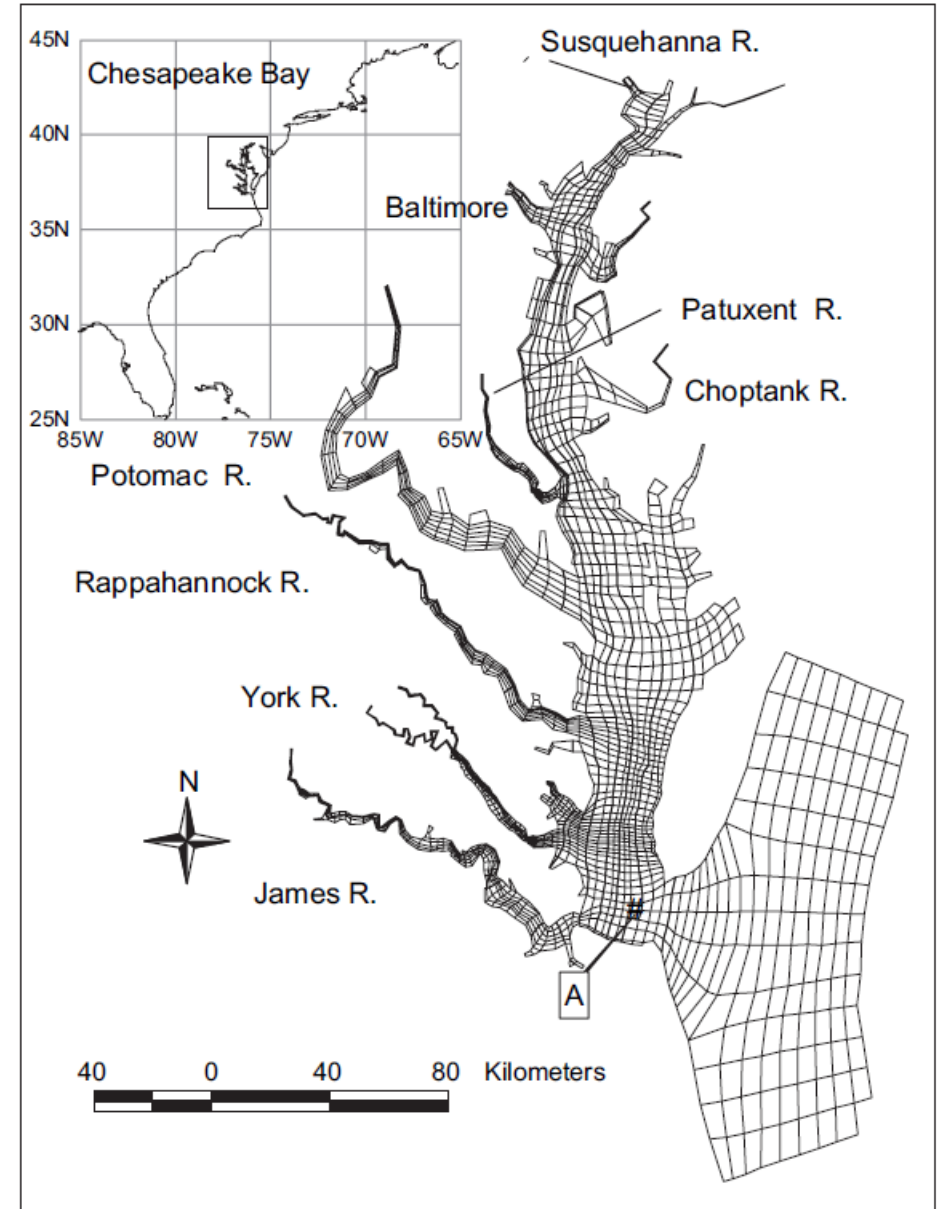
A ranking of tributaries by flushing time (“adjusted tidal prism flushing time”)

Table 6. Tributaries ranked by highest adjusted tidal prism flushing time (T_f).

Rank	Tributary	Adjusted T_f (days)
1	Severn River - MD	8.51
2	St Marys River	6.17
3	South River	5.98
4	Magothy River	5.95
5	Piankatank River	5.62
6	Great Wicomico River	5.56
7	Corrotoman River	5.3
8	Elizabeth River	4.98
9	Harris Creek	4.26
10	Broad Creek	4.1
11	Cockrell Creek	4.05
12	L. Choptank River	4.01
13	Corsica River	3.87
14	Rhode River	3.8
15	Mobjack Bay	3.73
16	West River	3.2
17	Honga River	3.01
18	L. Wicomico River	2.87
19	Fishing Bay	2.79
20	Severn River - VA	2.34
21	Monie Bay	2.05
22	Big Annemessex River	2.03
23	lower Manokin River	1.88
24	L. Annemessex River	1.71
25	Poquoson River	1.61
26	Onancock Creek	1.56
27	Nansemond River	1.54
28	Occohannock Creek	1.44
29	Nandua Creek	1.4
30	Pungoteague Creek	1.33
31	Back River	1.23
32	Nassawadox Creek	1.07
33	Cherrystone Inlet	1.06
34	Hungars Creek	0.87
35	Lynnhaven Bay	0.71
36	Old Plantation Creek	0.57

Shen and Wang 2007

- Calculated “age of water” (AW)
 - a function of tide, freshwater discharge, salinity, and wind
- Used a 3-dimensional hydrodynamic model (CH3D) of Chesapeake Bay
 - Conducted several simulations under a suite of flow, wind, tide, salinity, and temperature conditions



Shen and Wang 2007

- Can provide water age at one location over the course of the simulation

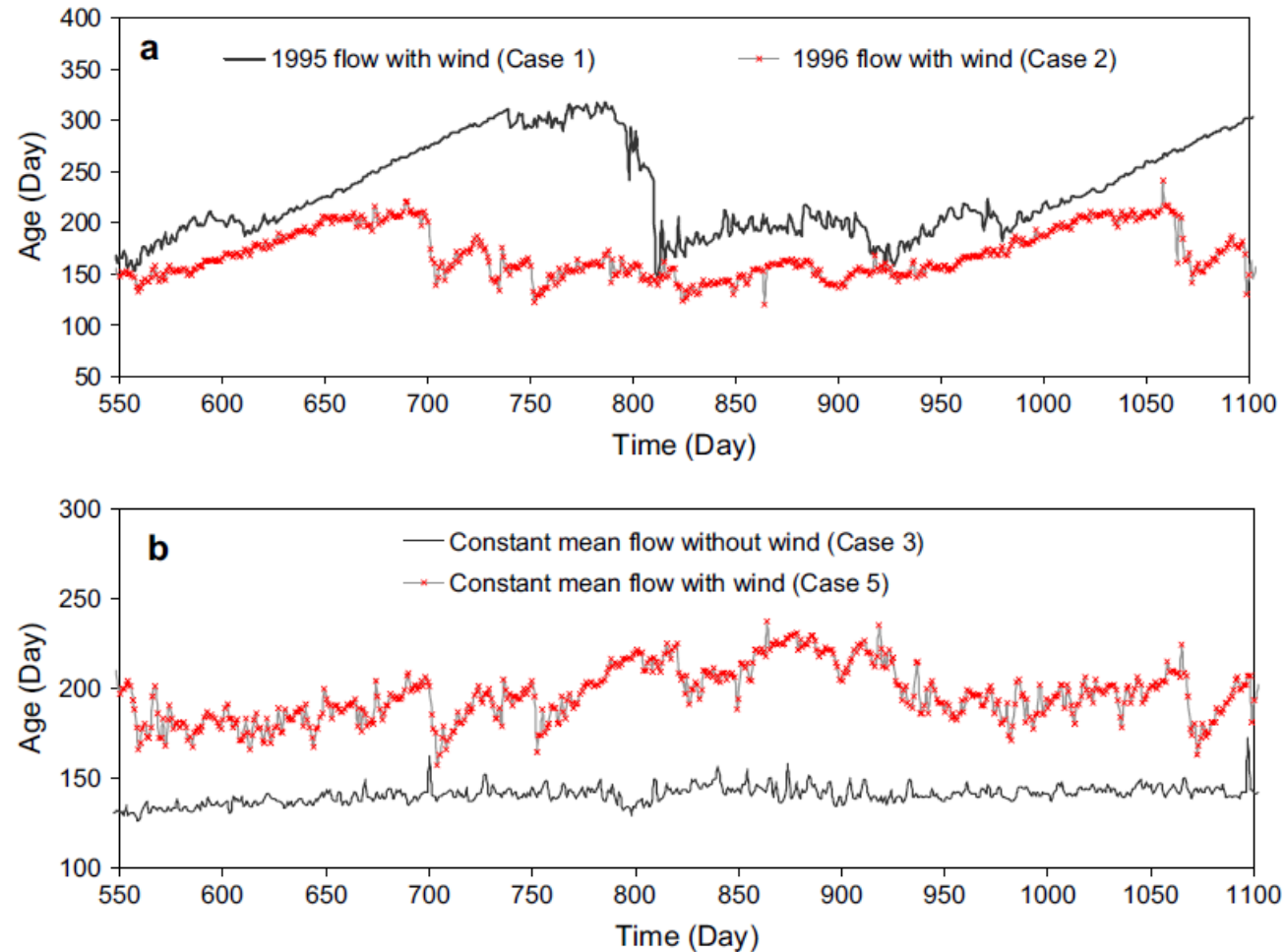


Fig. 3. Time series distribution of age of water near the Bay mouth at Station A. Top panel (a) is results of Cases 1 and 2. (Solid line is Case 1 with observed 1995 flow and wind, thin line with \times is Case 2 with observed 1996 flow and wind). Bottom panel (b) is results of Cases 3 and 5 (solid line is Case 3 with long-term mean flow and without wind, and thin line with \times is Case 5 with long-term mean flow and real-time 1996 wind).

Shen and Wang 2007

- Shows longitudinal patterns

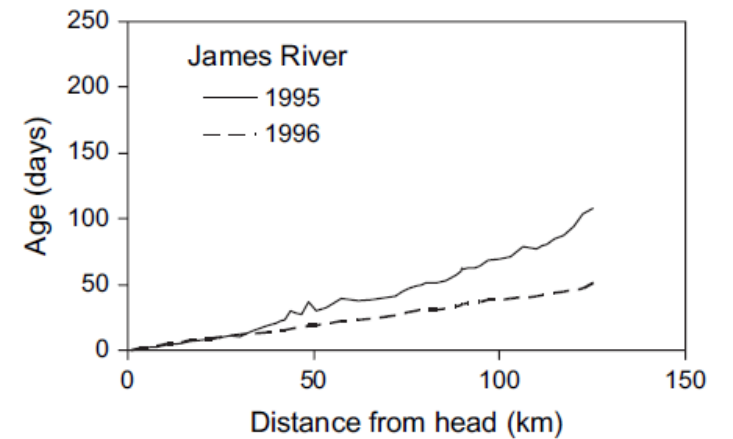
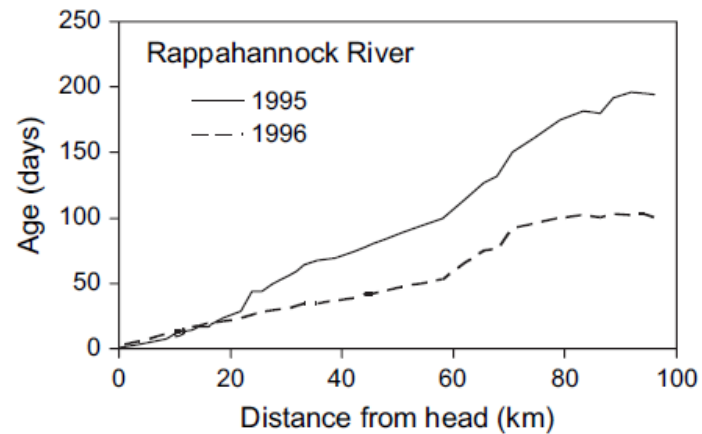
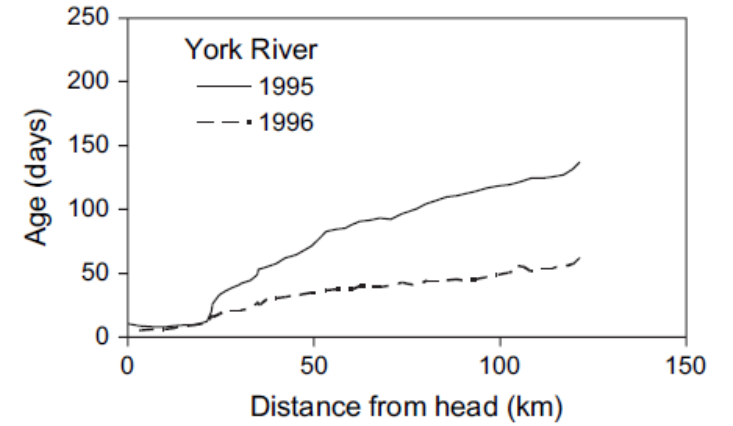
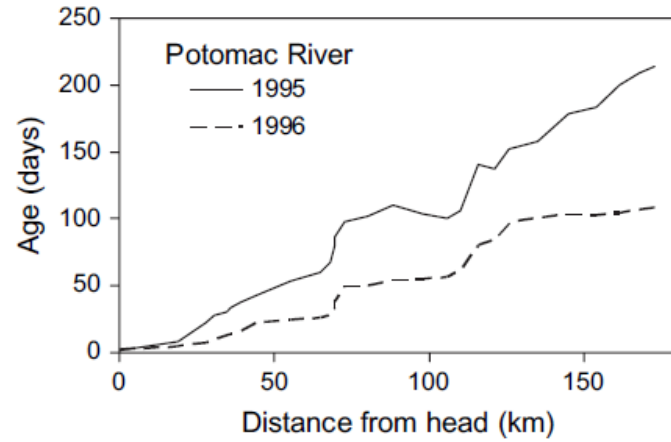
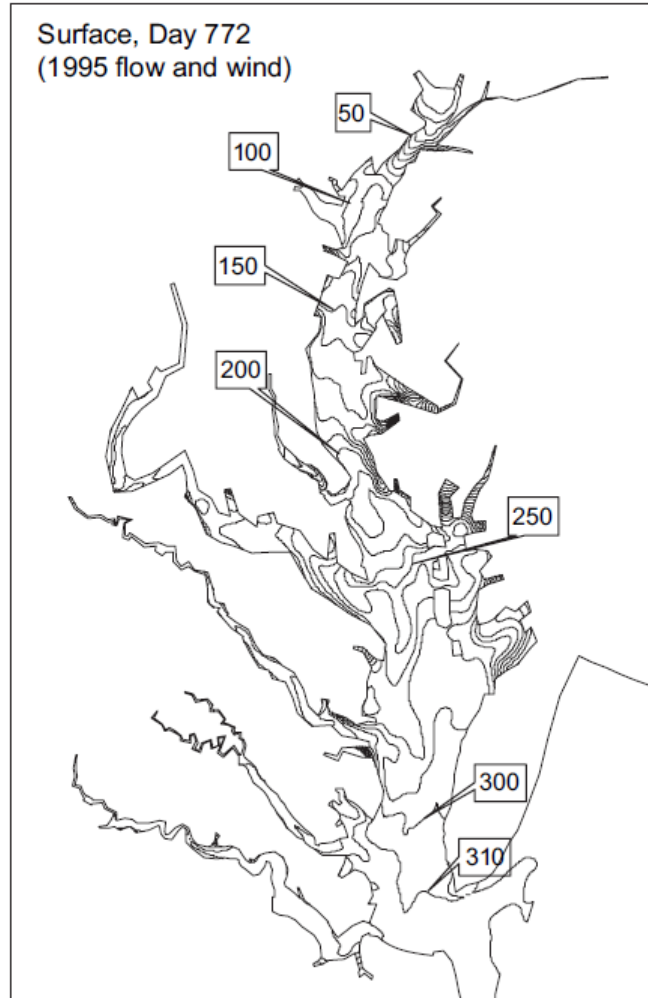


Fig. 6. Distribution of the vertical mean age of water of four major tributaries of the Chesapeake Bay in 1995 and 1996.

Shen and Wang 2007

Wasniak et al. 2009 on using CH3D models to obtain residence times:

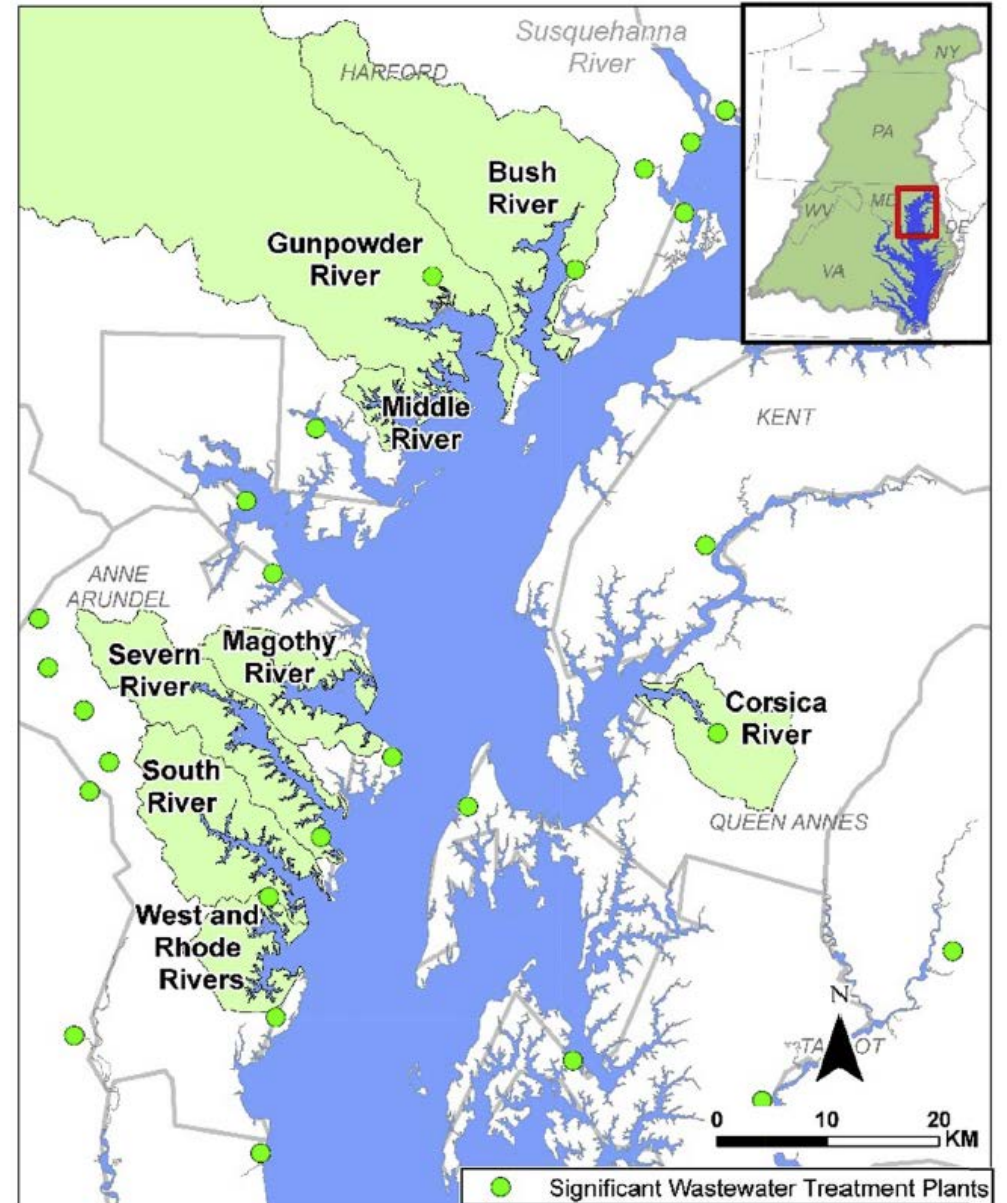
“Three dimensional numerical models are excellent tools to estimate the flushing time (e.g., Shen and Wang, 2007) because they can incorporate tidal, freshwater flow and wind forcing. But, these models are costly to implement in multiple systems, require high-resolution grids, and are not currently numerous enough to make comparisons of the flushing time among the many small tributaries in Chesapeake Bay that could serve as the site of oyster restoration projects.

Note from Harry Wang on current state of functionality:

- This can be used for calculating resident time for small sub-estuary, *if seasonally average flow rate of the basin is known.*
- They now have “an unstructured grid model SCHISM which can locally resolve sub-estuary with refined grid while coarse grid in the far field for the entire Chesapeake Bay.”

Wainger et al. 2016

- Analyzed eight “relatively small and shallow” subestuaries
- Calculated residence time as:
 - flow/volume ratio
 - watershed area/estuary volume ratio
 - median summer salinity
- Obtained flow from CBP WSM,
- Watershed area using USGS NHD, and
- Estuary volume from NOAA bathymetric DEM



Patrick and Weller 2014

- Analyzed 100 sub-estuaries within Chesapeake Bay and Atlantic Coastal Bays of MD, VA, DE
 - Evaluated 141, and dropped systems that had been categorized previously as SAV “no grow” zones and/or insufficient data
- Subestuaries and watershed boundaries are fully delineated
- Looking at residence times for these sub-estuaries could dovetail nicely with SAV work

