An annual pattern in water temperature differentials between adjacent regions of the Chesapeake Bay, Virginia

Thomas C. Mosca III
Dept of Mathematics, Rappahannock Community College
and
William C. Coles
Division of Fish and Wildlife – Department of Planning and Natural Resources

The R.V.Langley

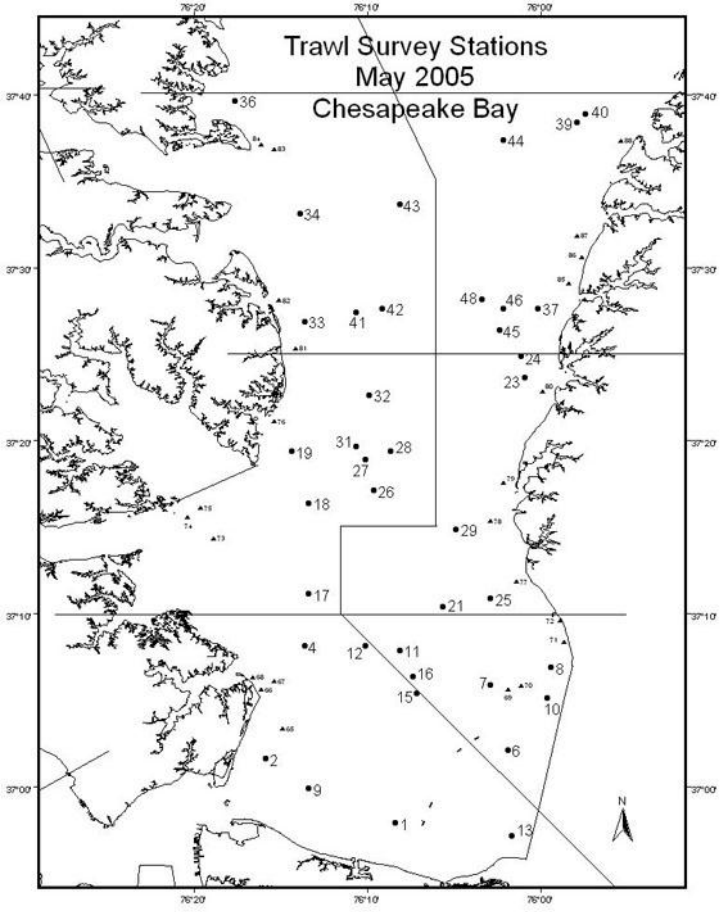
The temperature data were collected on research vessels that visited each region monthly as part of a juvenile finfish survey. People are seen here standing about the trawl net as R.V. Langley steams to the next collection station. Once on station the trawl net will be deployed by the overhead boom.

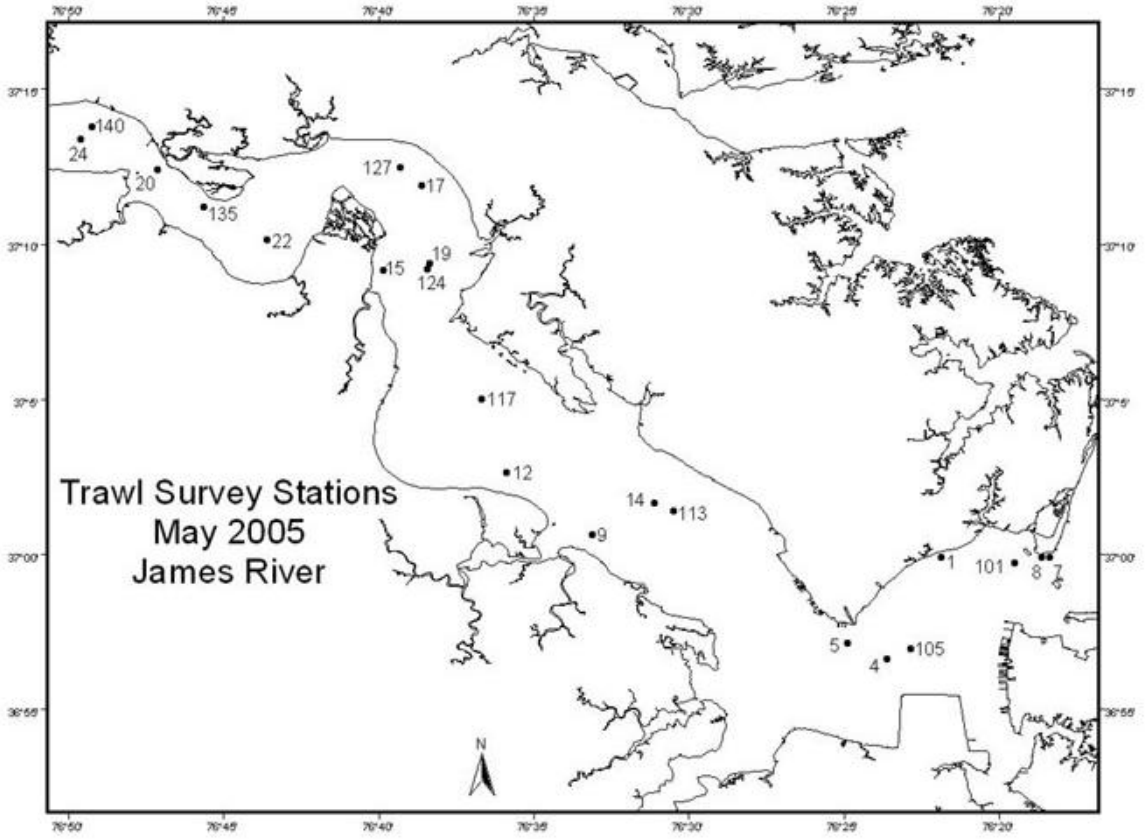
The cod end of the trawl net full of white perch

The purpose of the survey is to create monthly indices of abundance of the various species of fish inhabiting the Chesapeake Bay and its tributaries.

The data collection locations: Chesapeake Bay main stem

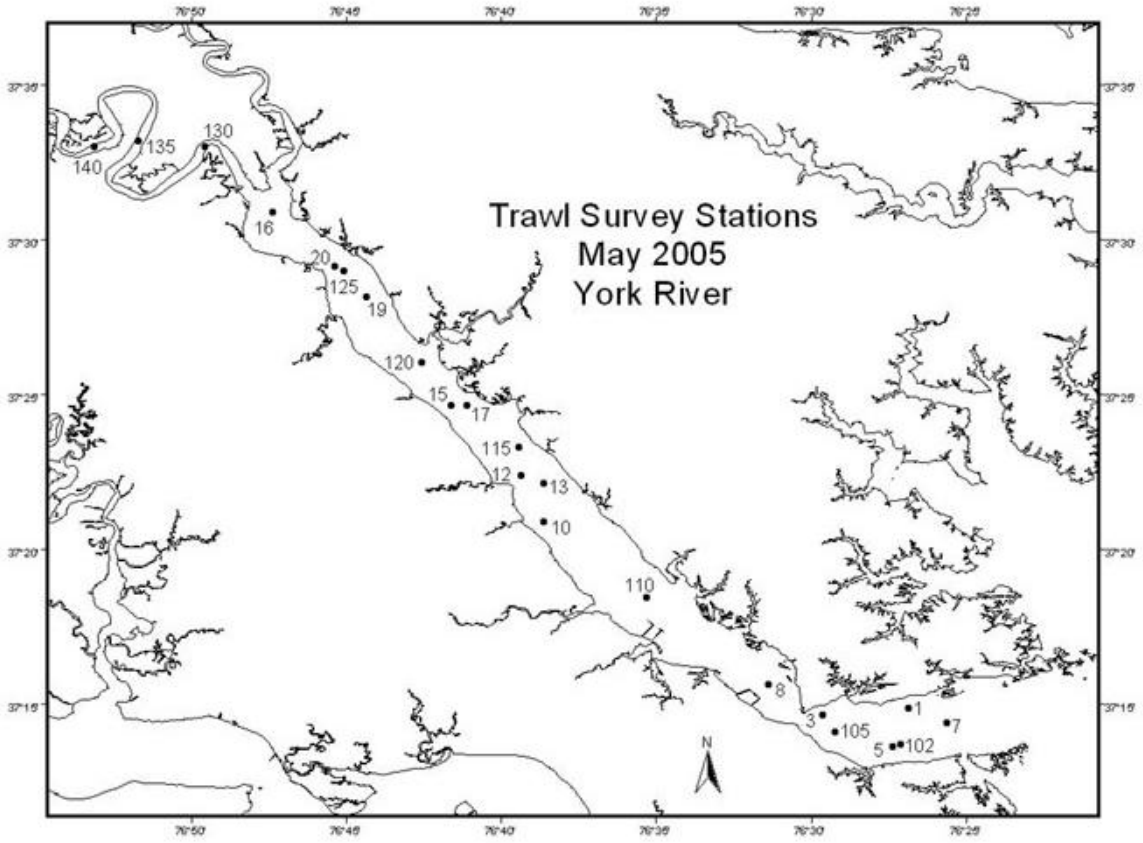
- Each major portion of the Chesapeake Bay system was divided into two regions, upper and lower.
- The division in the main stem of the Bay lies between the York and Rappahannock Rivers.





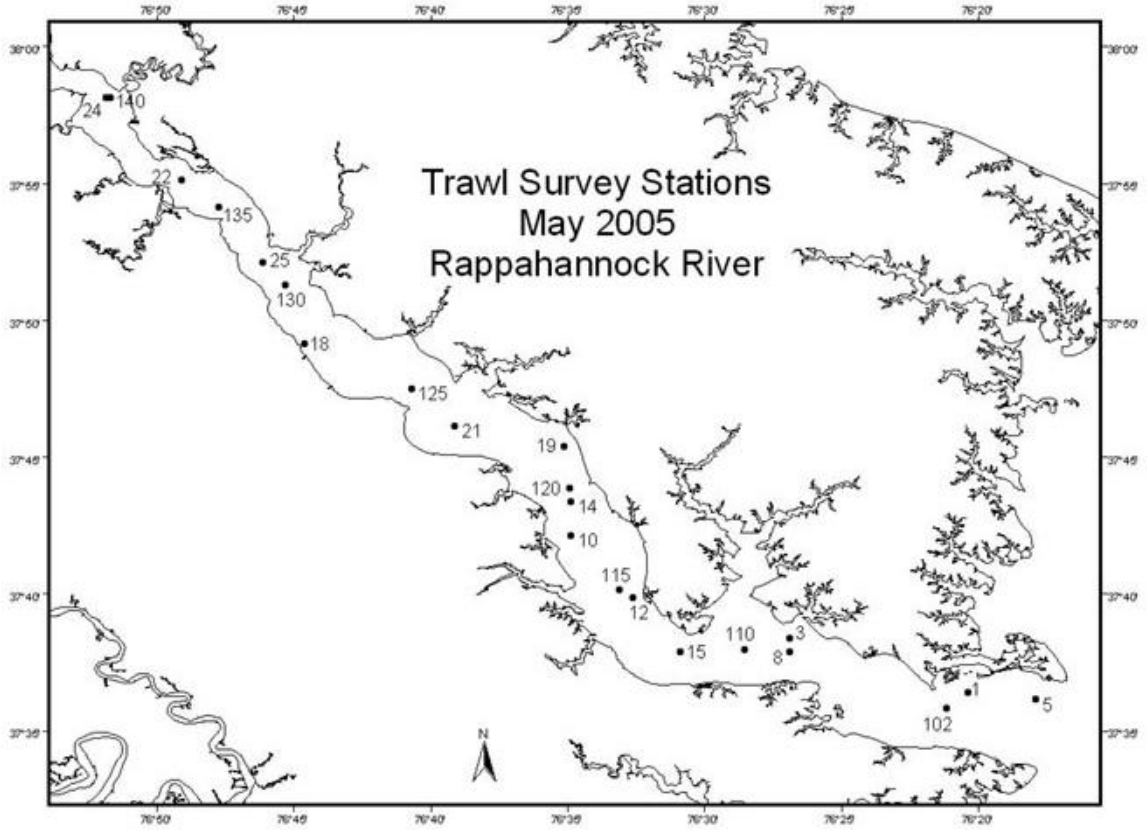
James River

The numbered dots indicate where data were collected in May of 2005, as do the other chart figures.



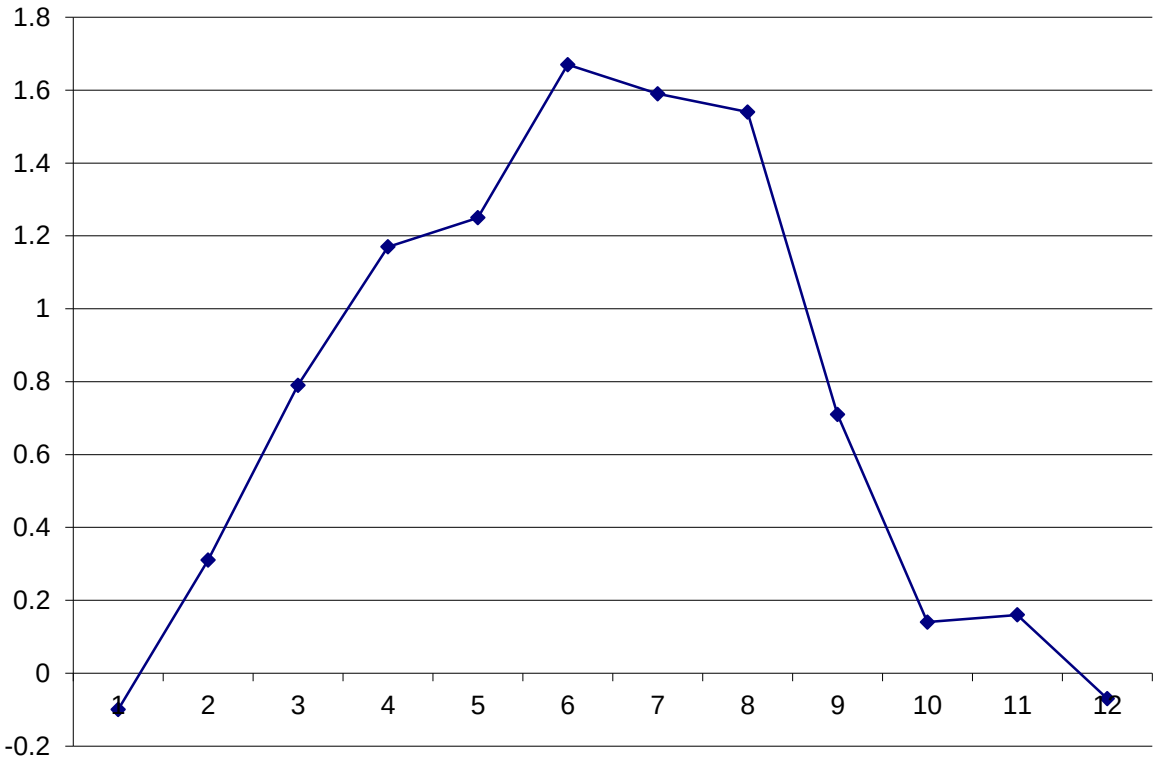
York River

All locations where it is possible to operate the collection vessel and the trawl gear are charted and assigned a number.



Rappahannock River

The choice of which stations to visit each month is made by random assignment.

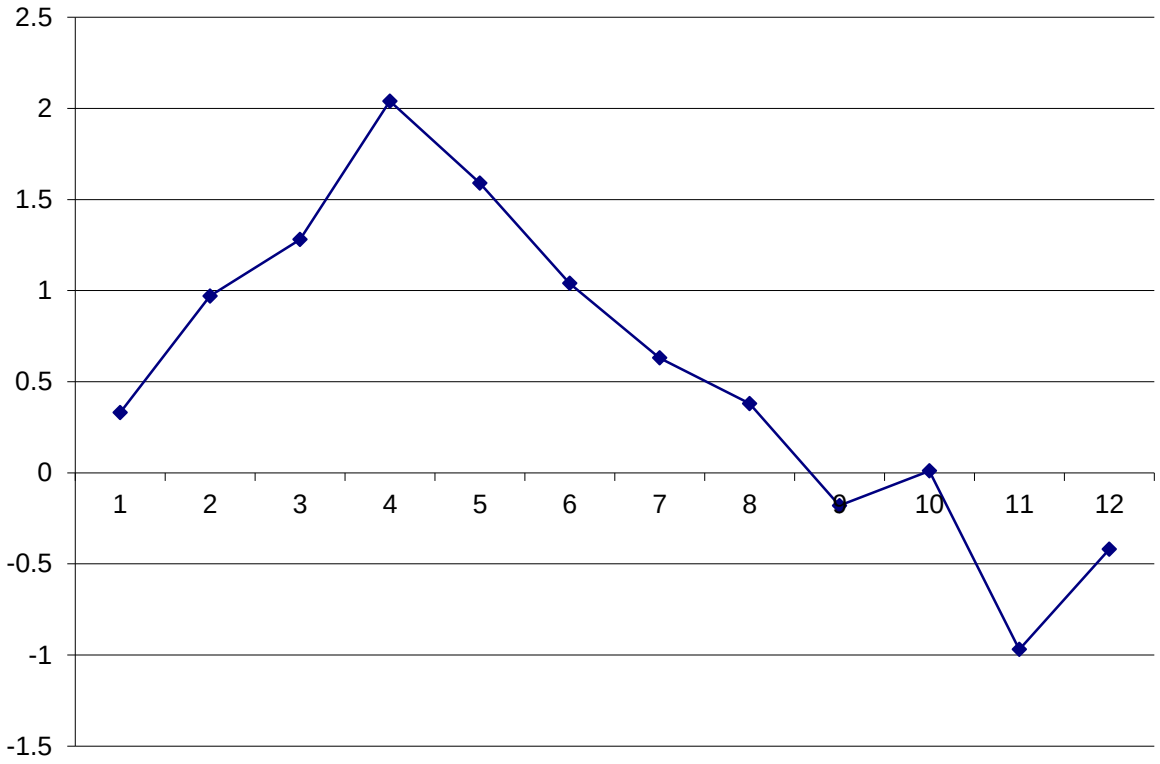


James River

The average monthly temperatures for January through December (1954-2001) from the adjacent up and down-stream regions of the James River are used to create an index of difference. The long term monthly average for the lower region is subtracted from the corresponding temperatures for the upper region.

At any two places in the Bay we expected the temperatures to be changing more or less in sync.

Instead of being in sync, it turns out that there is a lateral component.



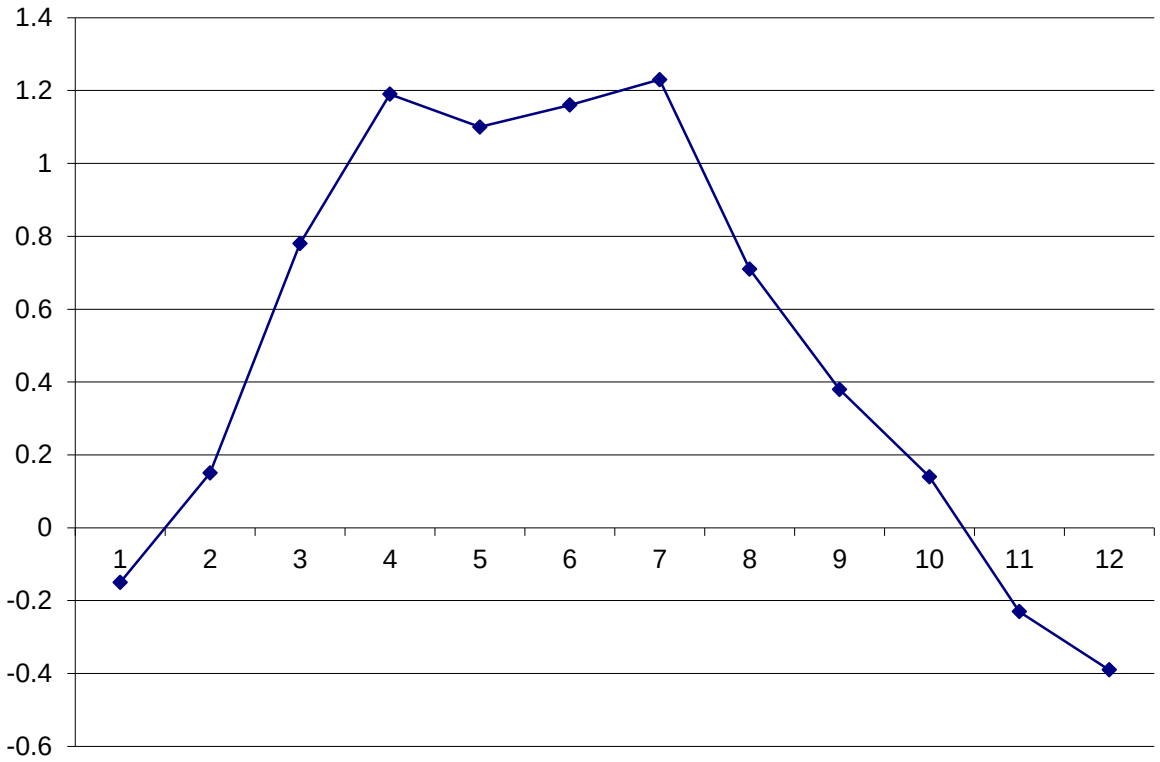
James River

Temperatures for the lower Bay are subtracted from those of the lower James River. The differences are somewhat more extreme than for the two regions of the river itself. The maximum difference also occurs earlier in the year than in the river.

- Each winter the lower Chesapeake Bay and the Atlantic Ocean cool to about the same temperature, as do the major tributaries to the Bay.

- As the water warms in the spring, water farther from the ocean warms faster, and the difference in temperature between the water bodies grows.

- There is also a net transport of water from upstream to the ocean.

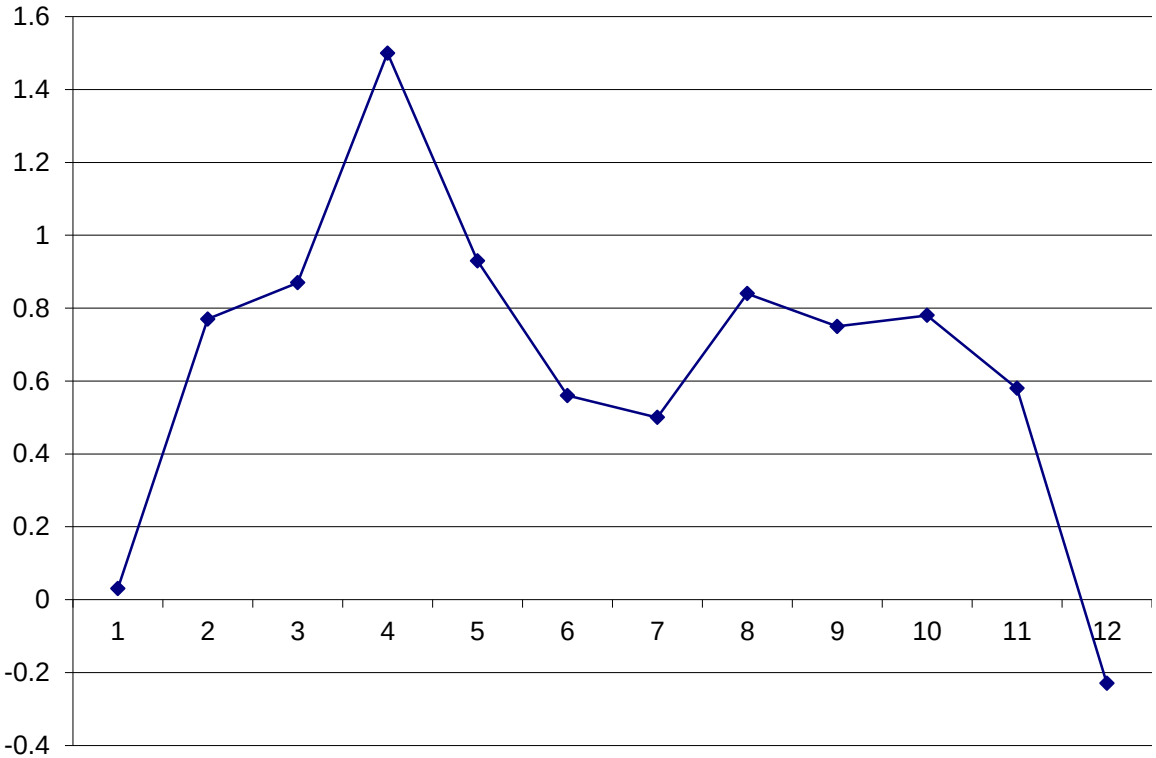


York River, Upper region minus lower region

The maximum difference is about one and one half degree C. The time of maximum difference is in the summer, within the rivers.

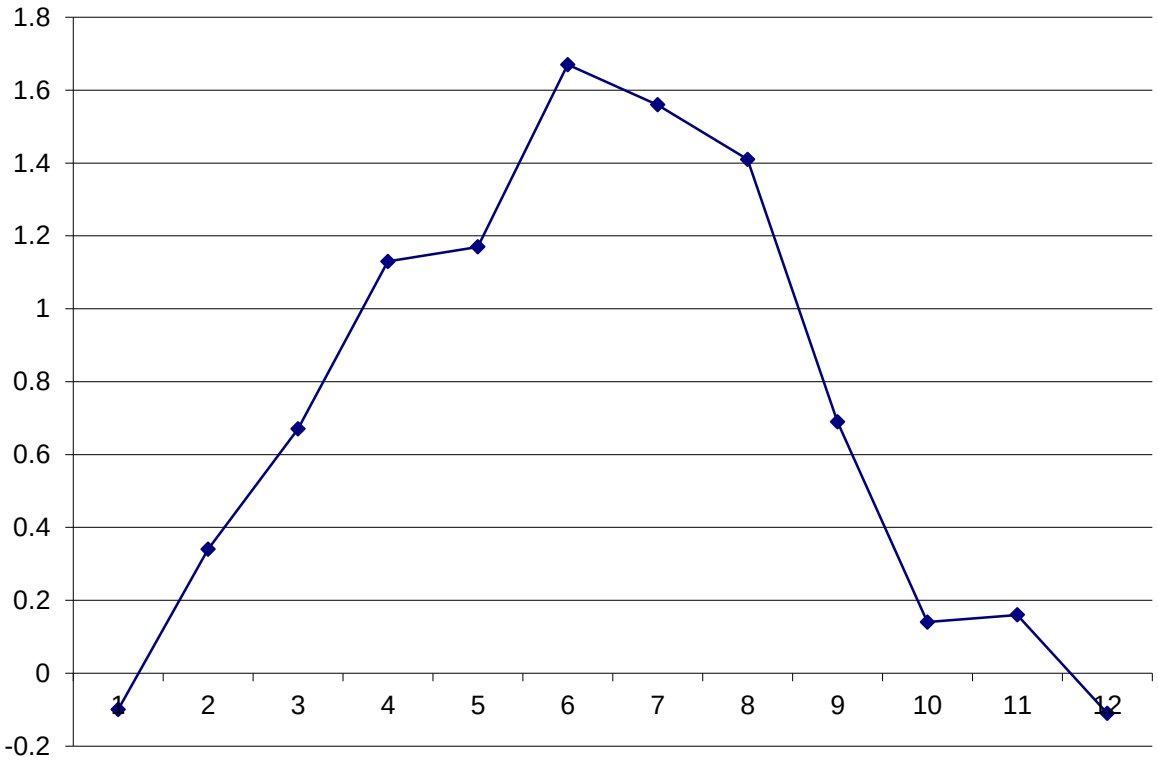
- For waters near the ocean, the maximum difference occurs early in spring, usually by March or April.
- Change continues later in the year farther upstream, with the maximum difference occurring around June or July.

- That a body of water in contact with the Atlantic Ocean would warm more slowly than another parcel farther away is not surprising.
- The ocean simply has more water per unit of surface area, and must warm more slowly.
- The lower stratum of Chesapeake Bay will warm more slowly than the upper stratum because cool ocean water circulates in this parcel .



York River, Lower River minus Lower Bay

Again, the timing of maximum difference has shifted to the spring, as in the James River.

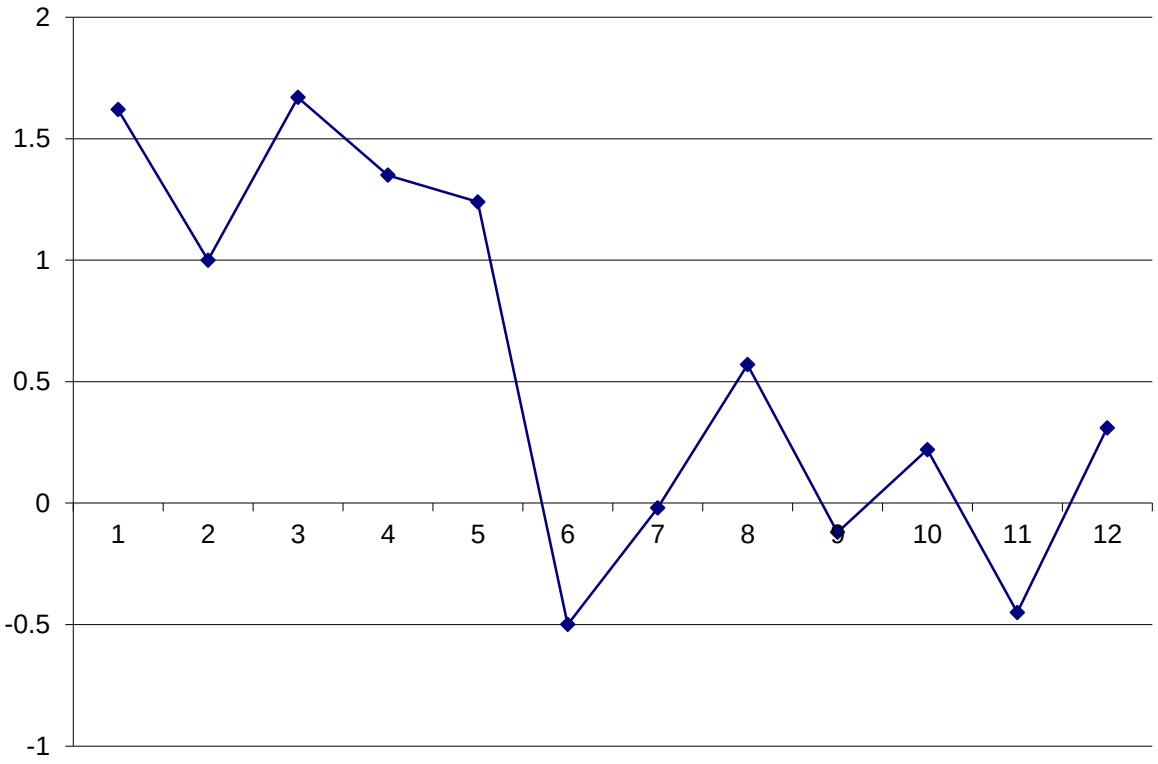


Rappahannock River, Upper region minus lower region

The maximum difference is only slightly greater (about 1.7 degrees), and the maximum again occurs in the summer.

- The three Virginia tributaries carry deep water to the fall lines.
- The Rappahannock is very deep in the first 10 nautical miles (nm) of the downstream region, with typical depths around 20m, while the next 30 nm carry depths of 6 – 10m.
- The York and James Rivers run around 10 – 12m deep throughout the first 40 nm.
- The downstream portions the rivers are wider, but not necessarily deeper.

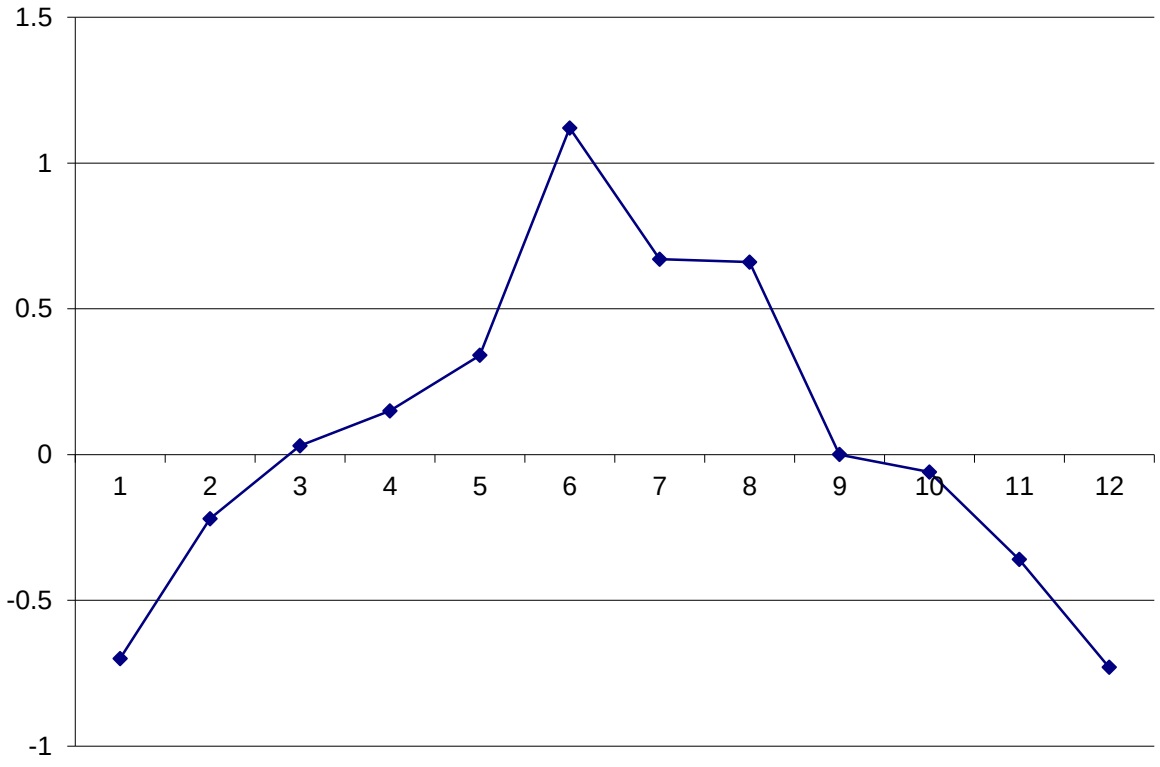
- The volume of water per unit of surface area exposed to the sun changes little, so there is no substantial change in solar warming rate across the transects of interest.
- The lag in warming must be attributable to the exchange of energy with the Atlantic Ocean, even at the farthest distances examined in this study.
- The different timing of the lags in the maximum temperature difference that occur in the upper reaches (June vs. April) is simply an artifact of distance from the ocean



Rappahannock River, Lower River minus Upper Bay

The one exception, in which the pattern fails to recur. Although differences exist, they are apparently randomly dispersed.

- The only area where this pattern changes is in the lower portion of the Rappahannock River.
- This is probably due to circulation, for the bathymetry of this river has an unusual feature when compared to the other two.
- In the first 10 nm it is very deep (often greater than 20m),
- but is partially cut off from Bay and ocean circulation by a ledge across the mouth of the river.
- Depths quickly become half that of the nearby deep zone.
- The disruption in circulation probably cuts off the energy exchange that we see in temperature lags.
- This feature is also responsible for regularly occurring periods of anoxia in the Rappahannock River



Chesapeake Bay, Upper Bay minus Lower Bay

Within the main stem of the Chesapeake Bay the pattern within the rivers is repeated. Maximum difference occurs in the summer.

- This feature of energy transfer is probably present in other estuaries, because a defining feature of an estuary is density driven circulation.
- If the change in water temperatures over time were examined in an inland sea, such as Pamlico Sound, NC, there would probably be no evidence of a similar temporal pattern.

We thank Virginia Institute of Marine Science for the data and images