Student Reading
Estuarine Tides — It's Not Just the Sun and Moon

What Affects Tides in Addition to the Sun and Moon?

The relative distances, positions, and movement of the sun, moon and Earth all affect the size and magnitude of the Earth's two tidal bulges. At a smaller scale, the magnitude of tides can be strongly influenced by the shape of the shoreline. When oceanic tidal bulges hit wide continental margins, the height of the tides can be magnified. Conversely, mid-oceanic islands not near continental margins typically experience very small tides of 1 meter or less. The shape of bays and estuaries also can magnify the intensity of tides. Funnel-shaped bays in particular can dramatically alter tidal magnitude. The Bay of Fundy in Nova Scotia is the classic example of this effect, and has the highest tides in the world—over 15 meters. Narrow inlets and shallow water also tend to dissipate incoming tides. Inland bays such as Laguna Madre, Texas, and Pamlico Sound, North Carolina, have areas classified as non-tidal even though they have ocean inlets. In estuaries with strong tidal rivers, such as the Delaware River and Columbia River, powerful seasonal river flows in the spring can severely alter or mask the incoming tide. Local wind and weather patterns also can affect tides. Strong offshore winds can move water away from coastlines, exaggerating low tide exposures. Onshore winds may act to pile up water onto the shoreline, virtually eliminating low tide exposures. High-pressure systems can depress sea levels, leading to clear sunny days with exceptionally low tides. Conversely, low-pressure systems that contribute to cloudy, rainy conditions typically are associated with tides that are much higher than predicted.

— Adapted from NOAA's National Ocean Service website, section on Tides &Water Levels.
URL:http://oceanservice.noaa.gov/education/kits/tides/tides08_othereffects.html.
Accessed: 2008-07-20. (Archived by WebCite® at http://www.webcitation.org/5ZS2dFx8h)

For a more thorough background on tides, see the NOS Tutorial on Tides and Water Levels:

oceanservice.noaa.gov/education/kits/tides/welcome.html

Student Worksheet
Salinity and Tides in York River

Part 1 — Tides in Chesapeake Bay

You might think of tides as the simple rising and lowering of the sea level based on the gravitational pull of the sun and moon. However, tides are much more dynamic and interesting, especially in estuaries. In Chesapeake Bay, it can take several hours for the high tide to move from the mouth of the bay to the northern tip. The rivers feeding into the bay add their own dynamics to the tidal variations. Here, you will study animations of tides in the Chesapeake Bay and York River to understand these tidal dynamics and their effect on salinity.

Tides in Chesapeake Bay

Go to the following web site, which has an animation that shows tides throughout the bay for the past day:

https://tidesandcurrents.noaa.gov/ofs/ofs_animation.shtml?ofsregion=cb&subdomain=0&model_type=wl_nowcast

Watch the animation and look for patterns in the tidal pulse as it works its way up the bay. Notice the scale on the right, with yellows and reds as high tide, greens and blues as low tides. Step through the animation, pressing the "Prev" and "Next" buttons, to watch the tide move up the bay.

1a. At what time is the tide highest at the mouth of the bay near Norfolk? How high is the tide?

1b. At what time did this tidal rise reach the northern tip of the bay near Baltimore? How high is the tide?

1c. How long did it take the tide to move this distance?

1d. Which location has higher tides? Why?

1e. Which location do you think has saltier water? Why?

Part 2 — Salinity as York River Flows into the Bay

Next, you take a closer look at York River to see how tides and the flowing river interact and affect salinity of the water.

The map below shows the York River where it empties into Chesapeake Bay. On the map, indicate how you think the salinity might differ throughout the river and into Chesapeake Bay. Label parts of the map "fresh," "nearly fresh," "fairly salty," "close to seawater," or "seawater."

Figure 1.

The location of York River with respect to Chesapeake Bay

Figure 2.

Yorktown, Virginia is situated at the mouth of the York River.

Part 2 — Interaction of Tides and River Flow

Go to this web site: https://coast.noaa.gov/estuaries/curriculum/salinity-and-tides-in-york-river.html

The animation shows salinity in York River, and how it changes with the incoming and outgoing tide, over 24 hours.

Use the slide bar to control the animation at your own pace. Watch the animation several times, looking for patterns in the salinity. Notice the time counter at the top, marking half-hour increments, and the scale bar on the left showing salinity in parts-per-thousand (ppt).

2a. At the mouth of the river (lower right), what are the highest and lowest salinity levels, in ppt, during this time frame?

2b. Now look up river at the upper left of the animation. What are the highest and lowest salinity levels there?

2c. Why is there such a difference between these two locations?

2d. Play the animation and study the full extent of the river. How often do the arrows change direction? How does that affect salinity throughout the river?

2e. At what point are there greatest changes in salinity throughout the day? Why do you think so?

2f. Does the freshest water (the darkest blue) ever appear on the image? Where and for how long? Does the saltiest water (red) ever appear on the image? Where and for how long?

2g. Now look at the cross-section views in the upper right of the animation, showing salinity with depth in the river, at the lines marked 1, 2 & 3. How does the water get mixed from top to bottom as the salinity changes from upstream to downstream?

Part 3— Salinity as Measured by Water Quality Stations in York River

The animations showed salinity distribution throughout a river based on a computer model. Now, you will observe actual salinity data for a specific day at five different sites along the York River. These sites use data buoys and other water quality stations to measure water depth, salinity, and other important data. These instruments support research at the Chesapeake Bay Virginia NERR and the affiliated Virginia Institute of Marine Science (VIMS).

If you use your computer, follow these instructions:

Open the Virginia Estuarine and Coastal Observing System site at: http://web2.vims.edu/vecos/
This will bring up a page showing a regional view with some of the York River stations.

Figure 3. Location of selected monitoring stations in the Chesapeake Bay region.

Whether you use computer to access data or the pre-printed graphs, answer the following question. Pay attention to the salinity ranges and their relationship to tide in the graphs .

3a. Describe the general pattern of salinity data for each site

Goodwin Islands

Gloucester Point

Yorktown (this station is not included in the data sheets provided for March 21-22, 2007)

Clay Bank

Taskinas Creek.

3b. Describe the differences in salinity among the five stations traveling up river from site to site.

Student Data Sheet
Salinity and Tides in York River

Salinity Data for March 21-22, 2007

Goodwin Islands Continuous Monitoring Station: CHE019.38

http://www3.vims.edu/vecos/StationDetail.aspx?param=CHE019.38&program=CMON

Location: N 37º 13' 01.2" W 76º 23' 19.2"

Tributary: York River

Salinity regime: Polyhaline

Mean tidal range: 0.79 meter

Mean water depth: 1.0 meter

Adjacent Water: located on the southern side of the York River, near the mouth of the River.

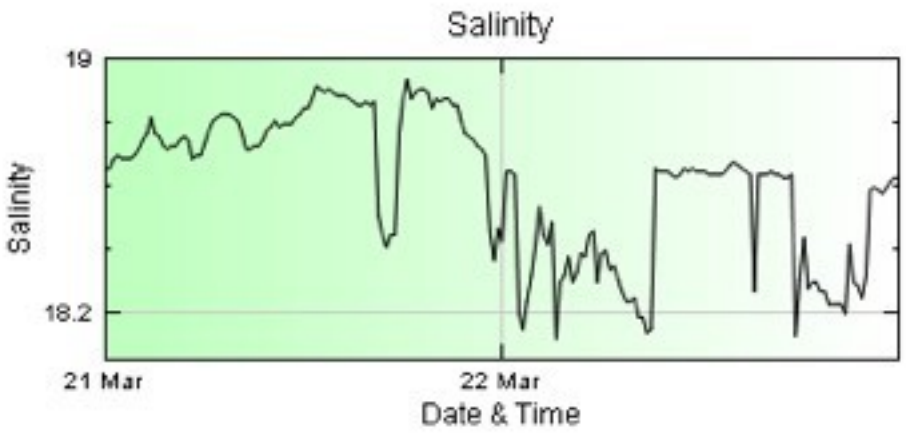

Figure 4. Salinity at Goodwin Islands Monitoring Station

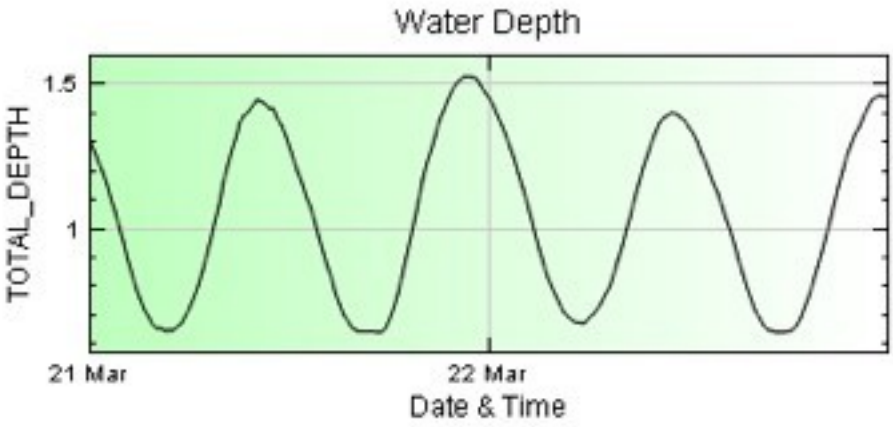

Figure 5. Water depth at Goodwin Islands Monitoring Station

Gloucester Point (GP) Continuous Monitoring Station: YRK005.40

Location: N 37º 14' 53.82" W 76º 29' 47.46" Tributary: York River

Salinity regime: Polyhaline

Mean tidal range: 0.73 meters

Mean water depth: 1.8 meters

Adjacent water: The Gloucester Point station is located north of the York River channel, approximately 5.4 nautical miles upstream from the River's mouth.

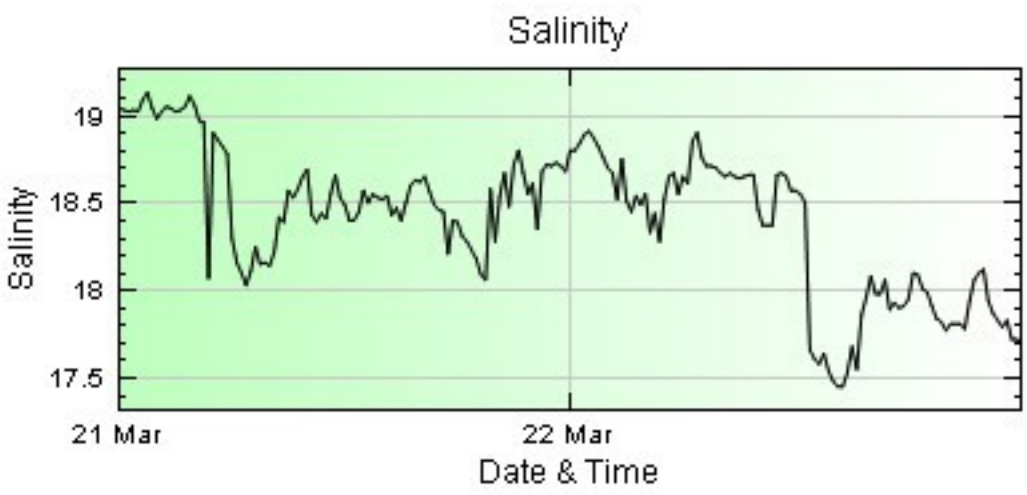

Figure 6. Salinity at Gloucester Point Monitoring Station

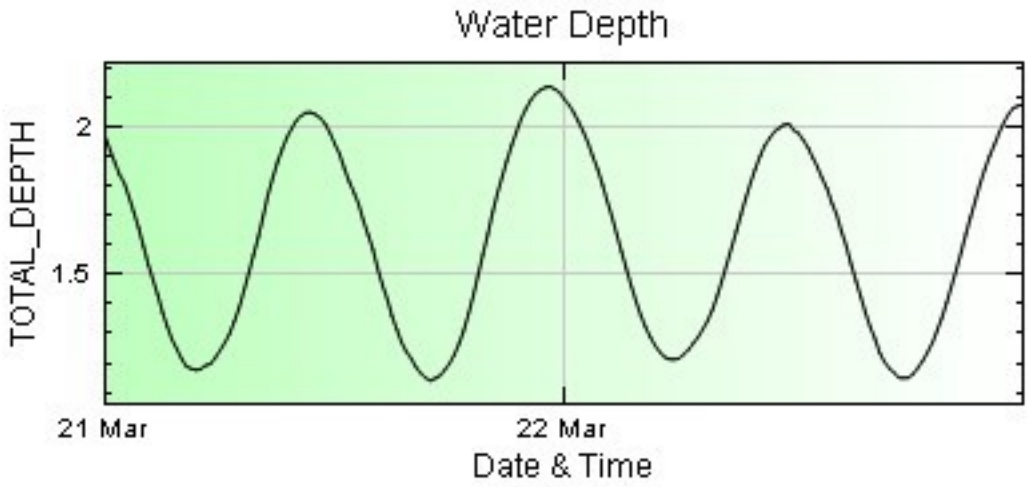

Figure 7. Water depth at Gloucester Point Monitoring Station

Claybank (CB) Continuous Monitoring Station: YRK015.09

Location: N 37º 20' 49.5" W76º 36' 41.94"

Tributary: York River

Salinity regime: Mesohaline

Mean tidal range: 0.85 meters

Mean water depth: 1.2 meters

Adjacent water: The Clay Bank station is located northeast of the York River channel, approximately 15.1 nautical miles upstream from the River's mouth.

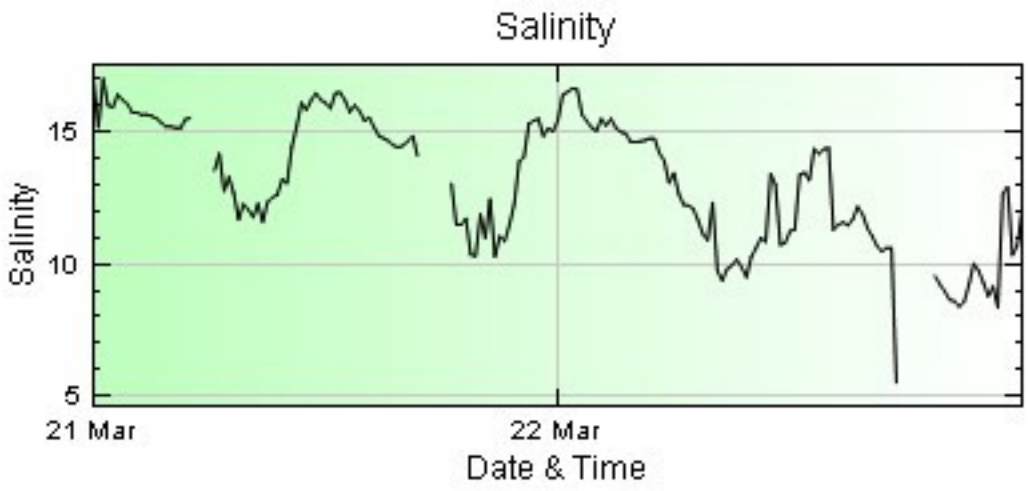

Figure 8. Salinity at Claybank Monitoring Station

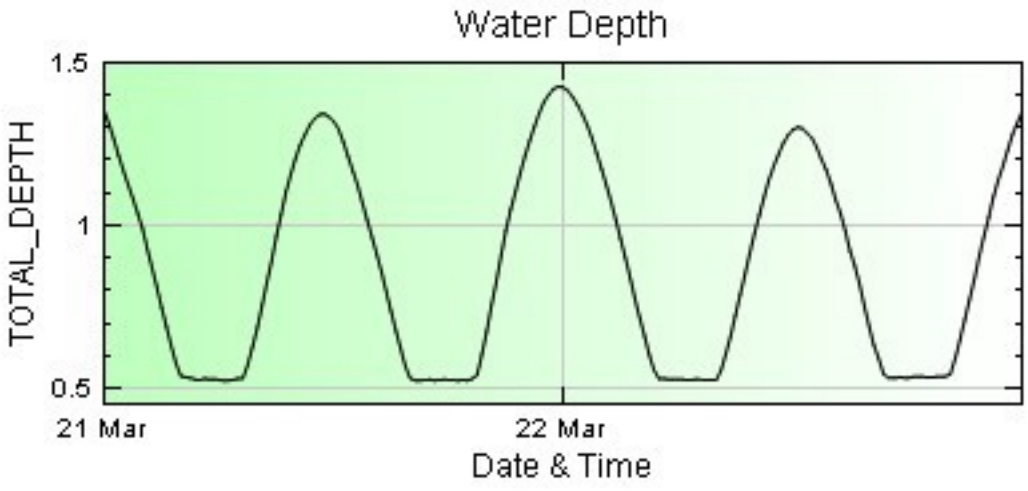

Figure 9. Water depth at Claybank Point Monitoring Station

Taskinas Creek (TC) Continuous Monitoring Station: TSK000.23

Location: N 37º 24' 54.79" W 76º 42' 52.74

Tributary: York River

Salinity regime: Mesohaline

Mean tidal range: 0.85 meters

Mean water depth: 1.5 meters

Adjacent water: The Taskinas Creek station is located southwest of the York River channel, approximately 23 miles upstream from the River's mouth.

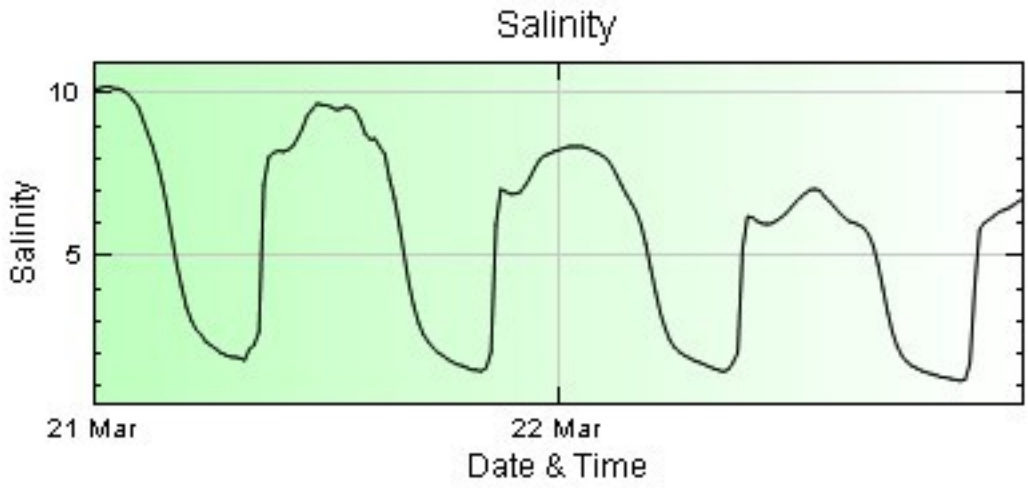

Figure 10. Salinity at Taskinas Creek Monitoring Station

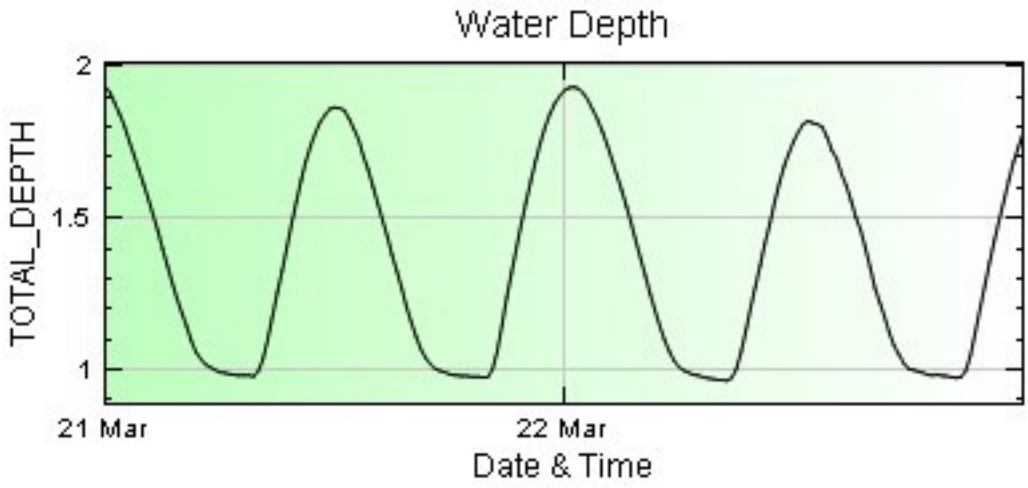

Figure 11. Water depth at Taskinas Creek Monitoring Station