An Educator's Guide to the CBF Water Quality Interactive Map

Student and adult groups that take part in field experiences with the Chesapeake Bay Foundation undertake authentic, hands-on scientific investigations.

Often, they measure the water chemistry to evaluate the health of a spot in the watershed at that specific point in time—you may have done this with your group in the field, or you may be doing it when you come out with us!

By compiling these points on a map using GIS software, we preserve this data to get a better view of the health of our waterways over time and throughout the Chesapeake Bay watershed. This also can serve as a classroom teaching tool and a place for students to explore or revisit topics we touched on in the field.

CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

CBF.ORG/EDUCATION/WATERQUALITY

IN THIS GUIDE:

What do I need to know about the data?

Under the supervision of CBF educators, participants collect water-quality data and store it using Collector for ArcGIS (a smartphone app). We typically measure seven different water-quality parameters that change throughout the year and across the watershed: Temperature, Salinity, Dissolved Oxygen (at the surface and at the bottom), Turbidity, pH, Nitrates, and Phosphates. Groups can also record water depth, general notes or comments, and pictures. Each specific point on the map may or may not have all of these fields filled in—it depends on what that group decided to measure at that time.

Field Names and Definitions

At any point on the map you may find:

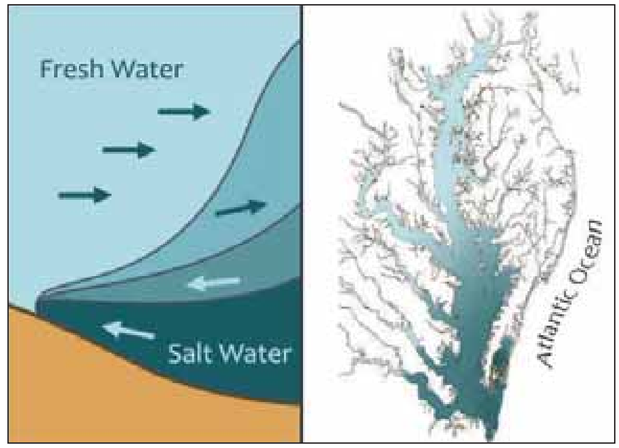
Date	Date of sample
Collected By	Name of school or group collecting the sample
Site Name	Site name, usually includes body of water
Water Temperature (°C)	Temperature at the surface, in degrees Celsius, taken with a thermometer or other temperature-measuring device (e.g. dissolved oxygen probe).
Turbidity (cm Secchi depth)	Measured in centimeters using a Secchi Disk
Dissolved Oxygen (mg/L)	Dissolved oxygen (milligrams/Liter) at the surface. Collected using the YSI Pro 2030 probe.
Dissolved Oxygen (mg/L)	Bottom: Dissolved oxygen (milligrams/Liter) at the bottom. Collected using the YSI Pro 2030.
Bottom Depth (m)	Bottom depth in meters
Salinity (ppt)	Salinity (parts per thousand), measured with YSI multi-parameter probe
pH	pH measured near the surface using pH color comparator
Nitrate (mg/L)	Total Nitrate-N (milligrams/Liter), measured using color comparator
Phosphate (mg/L)	Total orthophosphate (milligrams/Liter), measured using a Hach Pocket II colorimeter
Comments	Comments or notes about sample

Water-Quality Parameters and Methods

What are all those parameters again, and how did we measure them? Some of tools we used to measure water chemistry may be more familiar than others. Here is some information about what we measured and the procedures we might have used with your group.

SALINITY

The salt content (salinity) of a water body is one of the main factors determining what organisms will be found there. The density of water is related to the amount of salt dissolved in it, as well as its temperature. Salinity is also important because it affects dissolved oxygen solubility. Generally, the higher the salinity level, the lower the dissolved oxygen concentration. Oxygen is about 20 percent less soluble in seawater than in freshwater at the same temperature. That means, on average, seawater has a lower dissolved oxygen concentration than freshwater.



Left: A diagram of the salt wedge—denser salt water flowing into the Bay underneath less dense fresh water. Right: Brackish water in the Chesapeake Bay is generally saltier (shown as darker blue on this map) closer to the Atlantic Ocean and almost completely fresh at the northernmost points.

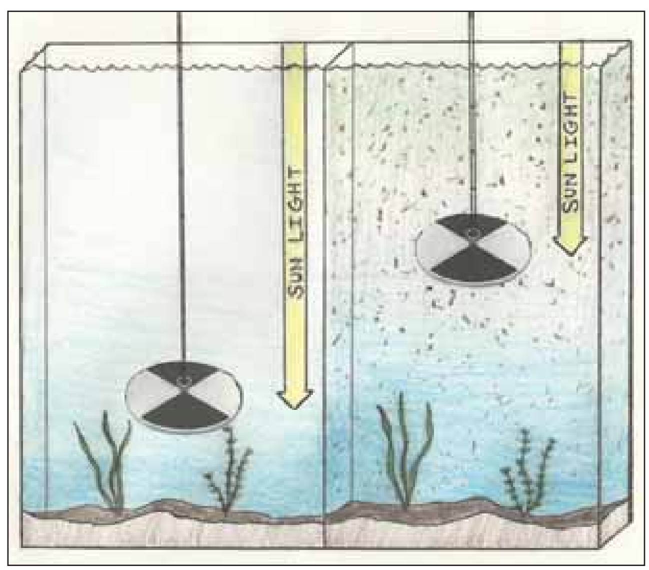
Range: Water in the Chesapeake Bay is brackish, a mixture of both fresh and saltwater. In the Bay proper it ranges from one ppt (parts per thousand) to 34 ppt. Salinity varies by season and location in the Chesapeake Bay and its tributaries.

Method: CBF uses a YSI Pro 2030 electric meter, often in addition to a refractometer, which measures the refractive index of a solution (in this case Bay water) and translates it to density.

TURBIDITY (WATER CLARITY)

Turbidity is the cloudiness or clarity of water. Visibility depends on the amount of suspended and colored materials in the water—material that comes from either sediment washed into a water body or biological activity in the water body (algae or plankton).

Students should think about what can affect how clear water is (things like sediment in polluted runoff, phytoplankton, and algae blooms are important considerations) and why this is important (light penetrating to submerged vegetation, visibility for predators, congestion for filter-feeders, sedimentation for bottom-dwellers).

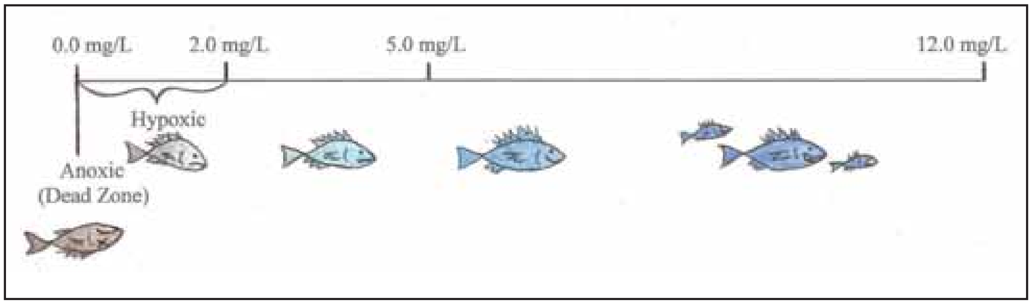


A Secchi Disk is used to measure turbidity. In clear water (left), the disk is visible deeper down in the water than in more turbid water (right).

Range: In tidal water, a good Secchi depth range is:
Less than 40 centimeters—Poor; 40-100 centimeters—Fair; 100-200 centimeters—Good; greater than 200 centimeters—Excellent

Method: The Secchi Disk is used to measure water clarity. A turbidity tube is used to measure transparency of flowing waters or where use of a Secchi Disk would be impractical.

DISSOLVED OXYGEN



Dissolved oxygen levels range from 0 milligrams per Liter (mg/L) to around 12 mg/L. Some organisms become stressed when levels fall below 5 mg/L, and almost all organisms need at least 2 mg/L to survive.

Dissolved oxygen is closely tied to the survival of plant and animal life in all bodies of water in the watershed. It is affected by natural processes and by human activities. The amount of oxygen in any water body varies naturally, both seasonally and over time. This occurs due to a balance between oxygen input from the atmosphere and certain biological and chemical processes, some of which produce oxygen while others consume it (photosynthesis and respiration, respectively).

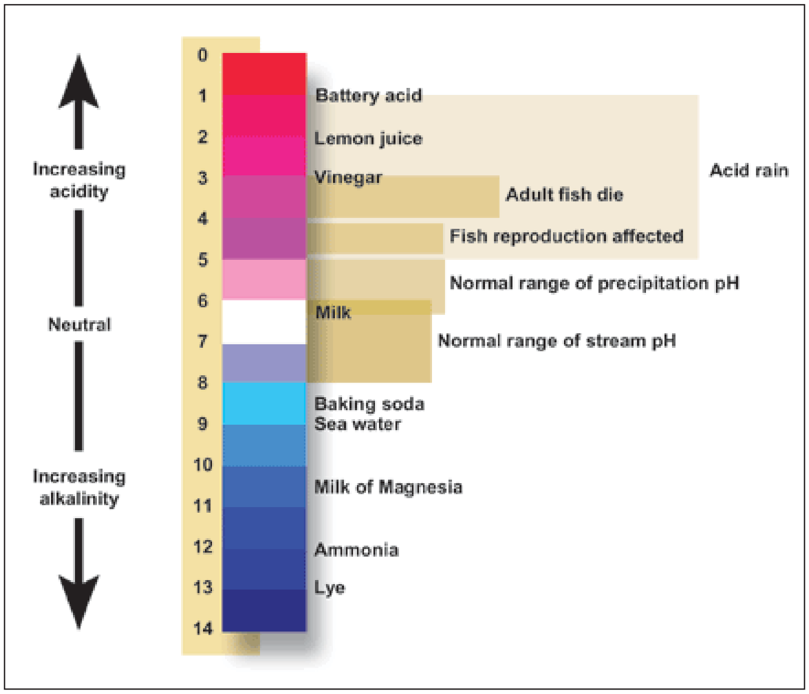
Stratification in the water column, which occurs when less dense freshwater from an estuary mixes with heavier seawater, is one natural cause of hypoxia—lack of dissolved oxygen. Limited vertical mixing between the water layers restricts the supply of oxygen from surface waters to more salty bottom waters. Hypoxia occurs most often, however, as a consequence of human-induced factors, especially nutrient pollution (also known as eutrophication). The causes of nutrient pollution, specifically of nitrogen and phosphorus nutrients, include polluted runoff from agricultural, urban, and suburban areas; fossil-fuel burning; and wastewater treatment effluent.

Range: Zero to 12 milligrams per Liter (mg/L) with 8 to 9 mg/L being very good quality water; 4 mg/L or below is considered a stressed environment and an impaired water. Three or below is stressful to most aquatic organisms. Two and below is considered hypoxic and a dead zone. And 0.2 mg/L indicates anoxic waters.

Method: CBF uses the YSI Pro 2030—an electronic Dissolved Oxygen Meter.

pH

The pH of water determines the solubility (amount of a substance that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical elements such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). For example, in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. In the case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble (like methyl-mercury in some acidic rivers of the Chesapeake Bay).



The pH scale, with some common substances and their pH levels, and effects of increasing acidity on aquatic life.

Range: As the diagram to the right shows, pH ranges from 0 to 14, with 7 being neutral.

Results less than 7 are acidic while pHs greater than 7 are alkaline (basic). Normal rainfall has a pH of about 5.6—slightly acidic due to carbon dioxide gas from the atmosphere reacting with rainwater to form carbonic acid. You can see that acid rain can be very acidic, and it can affect the environment in a negative way. The pH scale is 1 to 14 but the healthy range for most organisms is 6.5 to 8.2.

Method: CBF uses a color comparator kit—a chemical added to a water sample that changes color when reacting with hydrogen ions. Participants then assess the pH visually by comparing the color to a chart or samples with known pH.

NITRATE

Nitrates are a type of nutrient necessary for life and found in small amounts in all aquatic environments. Nitrates in excess of one part per million can become a form of pollution by overloading the nutrient supply, causing excess plant growth and decomposition, leading to depleted oxygen levels and eventually dead zones with no oxygen. This is a process known as eutrophication.

Nitrates are present in lawn and crop fertilizers, human and animal waste, air pollution, and organic material like dead leaves and detritus on land. When these things enter a water body through polluted runoff or wastewater, nitrate levels can become elevated.

Range:
0 to 1 milligram per Liter (mg/L): Natural levels of nitrogen needed for plant growth and aquatic life
> 1 mg/L: Excess nitrogen, possibly leading to accelerated plant growth and eutrophication

Method: CBF employs uses the VISOCOLOR ECO Nitrate color comparator. Added chemicals change the color of the water due to nitrate load, and students compare a blank sample to one that has an added chemical reagent.

PHOSPHATE

Phosphates are another type of limiting nutrient for living things—an excess in our waterways from commercial detergents, chemicals, waste, and fertilizer in runoff can lead to eutrophication, often in combination with excess nitrates. Phosphates enter waterways from human and animal waste, phosphorus-rich bedrock, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause increased eutrophication.

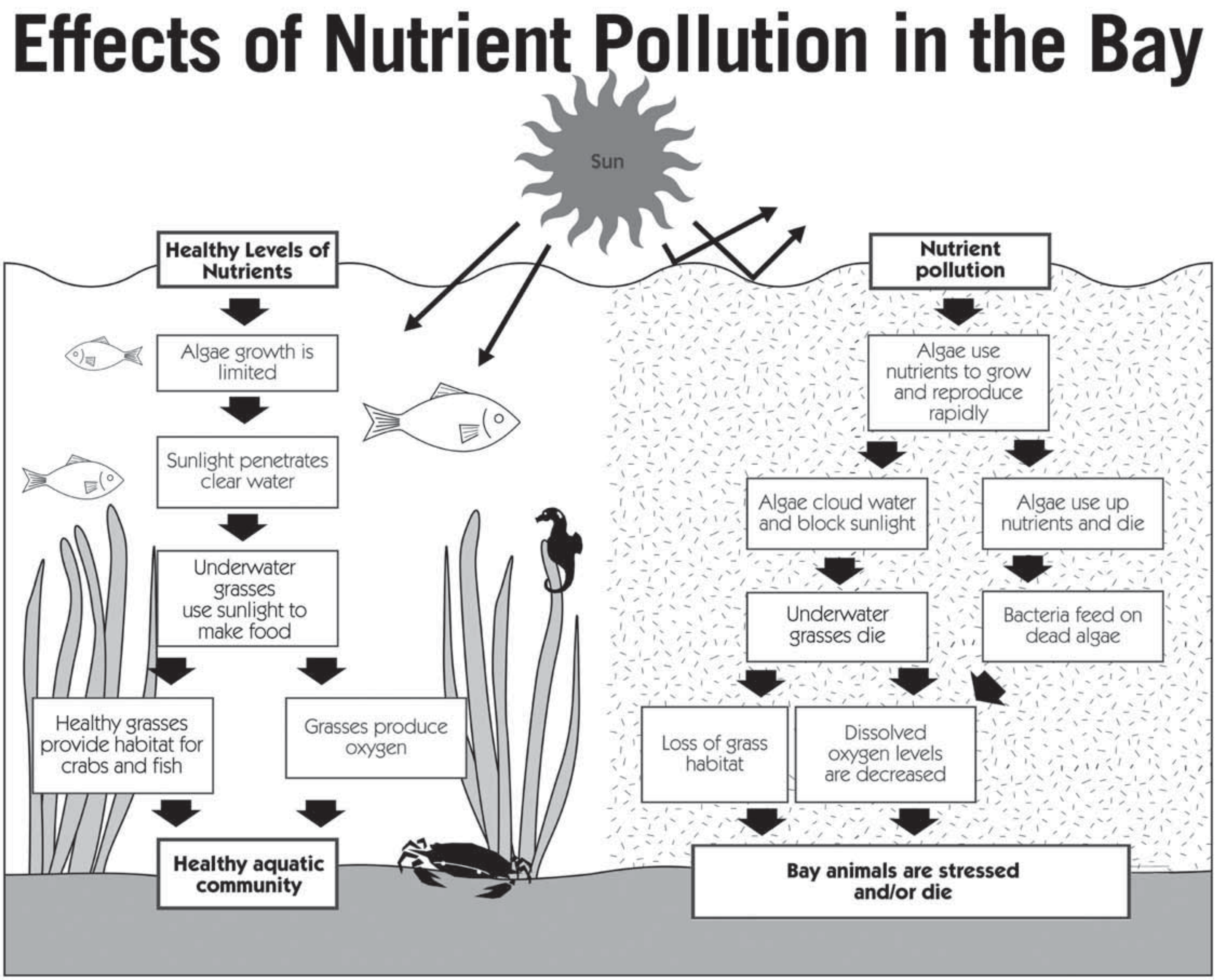
Range:
0.025 - 0.1 milligrams per Liter (mg/L): level at which plant growth is stimulated
0.1 mg/L: maximum acceptable to avoid accelerated eutrophication
> 0.1 mg/L: accelerated growth and consequent problems (cultural eutrophication)

Method: The equipment CBF employs is the Hach Pocket II single-parameter colorimeter. Colorimeters determine the concentration of a contaminant in a water sample by comparing a blank sample to one that has an added chemical reagent.

Eutrophication Process

Eutrophication is the natural aging process of a body of water such as a bay or lake. This process results from the increase of nutrients within the body of water which, in turn, create plant growth. The plants die more quickly than they can be decomposed. This dead plant matter builds up and together with sediment entering the water, fills in the bed of the bay or lake, making it more shallow. Normally this process takes thousands of years.

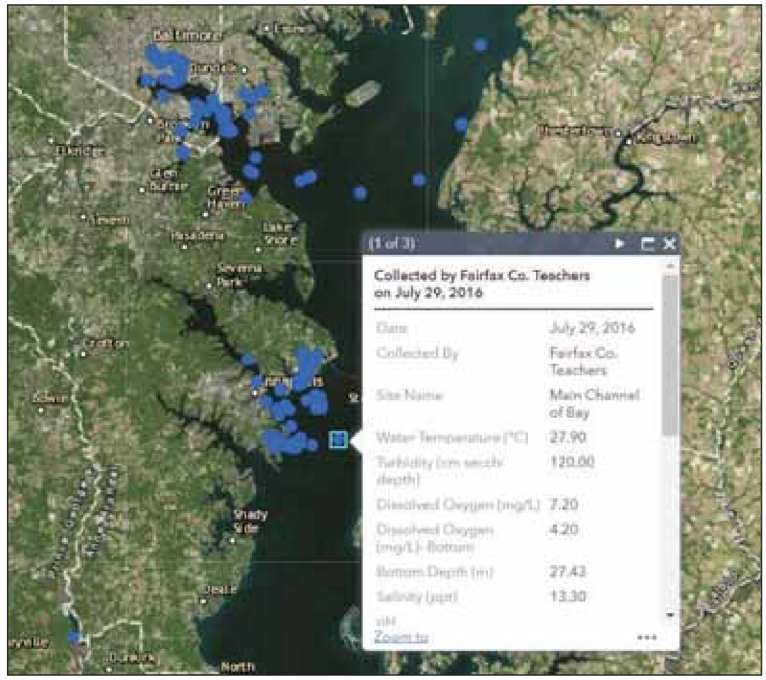
Cultural eutrophication is an unnatural speeding up of this process because of man's addition of phosphorus, nitrogen, and sediment to the water. Bodies of water are being aged at a much faster rate than geological forces can create new ones. In testing for cultural eutrophication, one would expect to find an algal bloom or scum on the water accompanied by a fishy smell and a low dissolved oxygen content (see graphic).



This diagram shows what a healthy level of nutrients does to water (left) and what excess can do (right).

What can my students and I do with the CBF online GIS app?

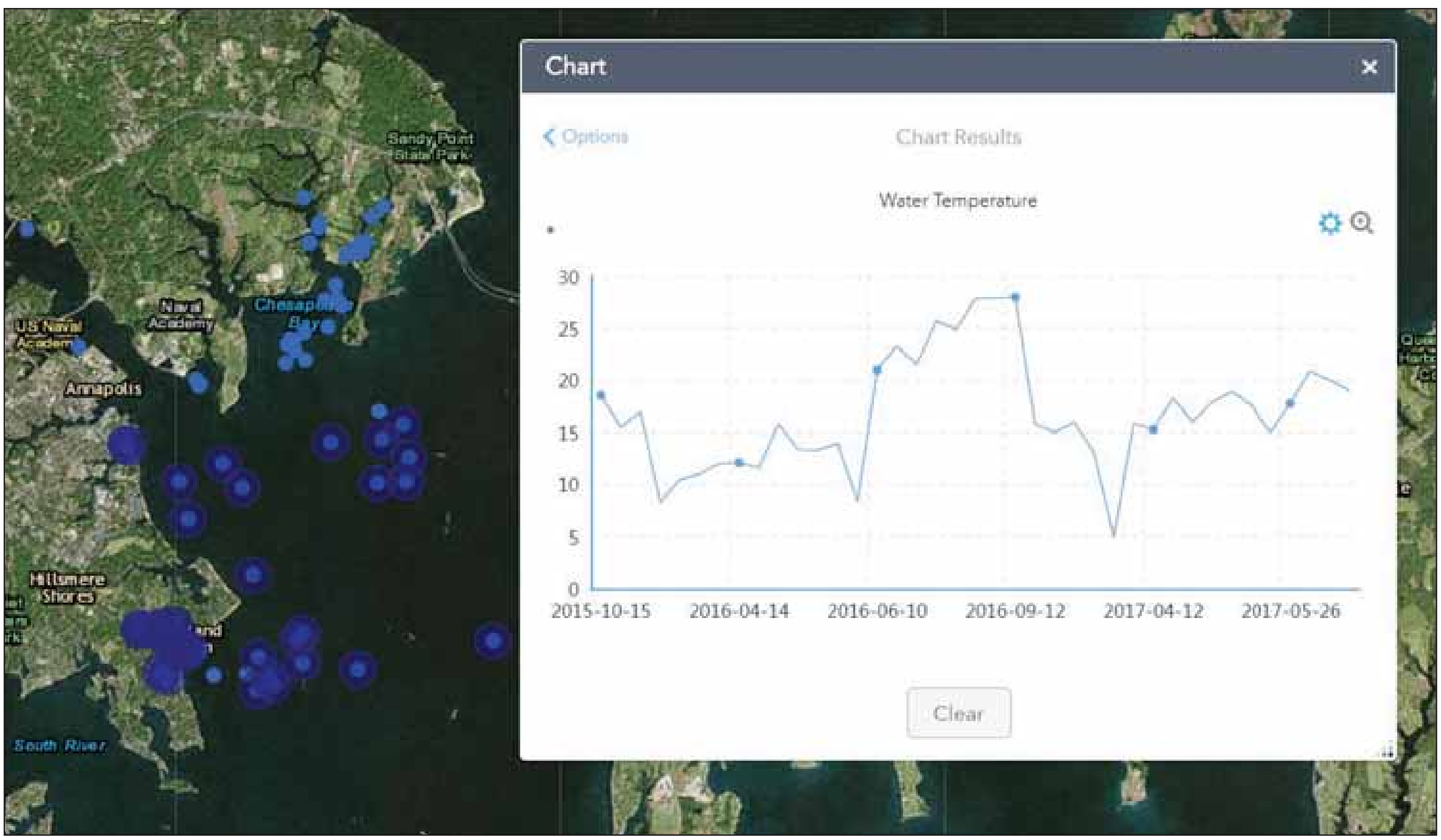
On the map to the right, each point represents data from a group collecting some or all the water-quality parameters above. Clicking on a point will display those specific results. Feel free to explore the Bay and click on any of the specific points.



Each blue point represents a group's data-collection results.

CREATE SIMPLE GRAPHS

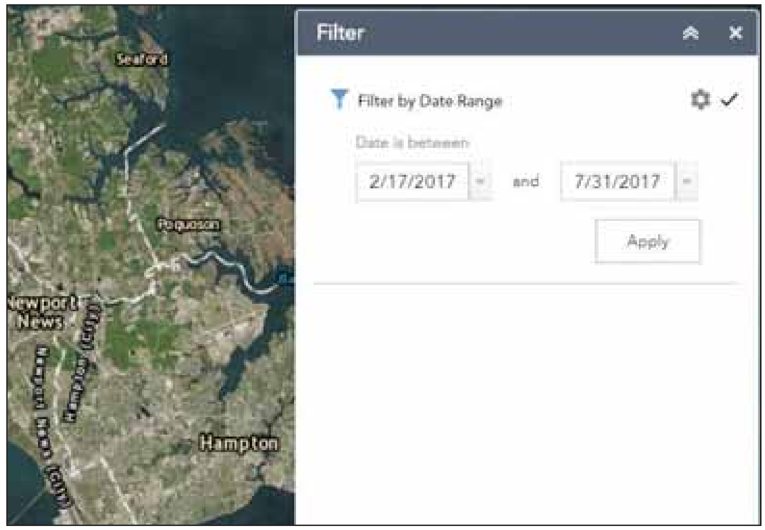
You can also create simple graphs of different parameters and locations through time in the web app: Click "Chart" at the top left and select a parameter to graph, then select "Only features intersecting a user-defined area," draw a shape (not a line) around the location you want, and click "Apply." You will get a graph for the entire timeline of data for the points you select.



The app allows you to create charts to show change over time.

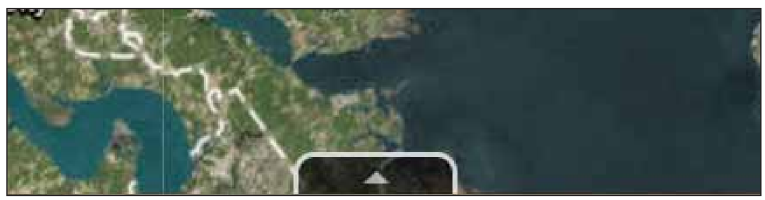
NARROW YOUR INVESTIGATION

You can narrow your investigation of the data by date, year, and specific location by clicking on a button on the top right of the map—scroll over them to see what each does. Click "View results by year," select the year you would like to see and "only return features that intersect with the shape drawn on the map." Then draw a shape around the area you are interested in, and click "Apply." To see an even narrower date range, click "Filter," and select the range you would like to see. Turn your filter on and off by selecting the checkmark in the top corner of the pop-up window. This could be useful for comparing a specific site in different years, graphing only a specific season, or comparing 2016 results from Baltimore Harbor with those from the Lynnhaven River, for example.



The filter tool in the app narrows the data down to specific criteria, such as data collected on a particular date.

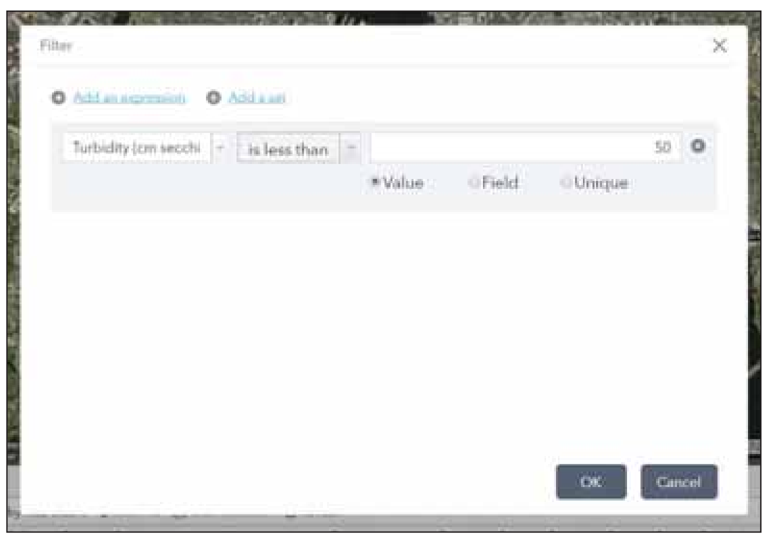
If you'd like to manipulate the data and narrow your investigation even further, you may use the data attribute table to filter or download data from a specific year and location: after filtering by year or date, open the attribute table by selecting the pop-up button at the bottom of the map pictured at right.



The pop-up button at the bottom of the map helps you narrow your investigation more.

FILTER THE DATA

To filter by water-quality parameter, select "Options" in the attribute table, and click "Filter." As in the example to the right, you can then add a filter expression to see where and when the Secchi depth was less than 50 centimeters.

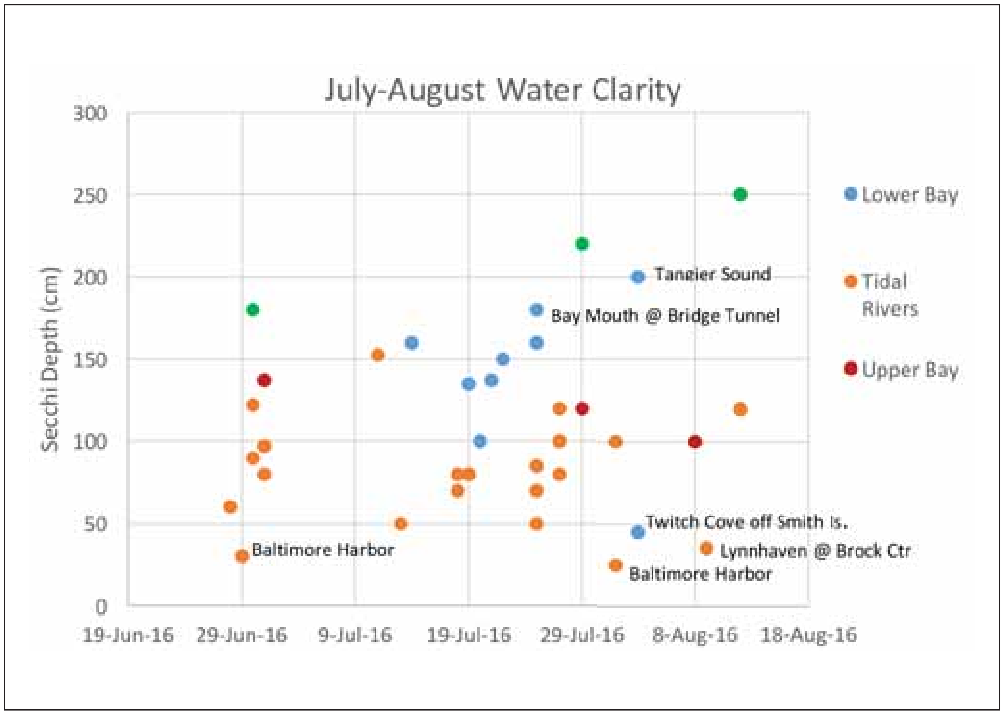


The filter also allows you to narrow your study to a particular field data category.

DOWNLOAD THE DATA

To download, select “Options” in the attribute table, and click “Export all to CSV”—you can open this file in Microsoft Excel. Make sure to pay attention to the “Filter by Map Extent” button in the table before downloading—you may or may not want this selected.

In Excel (or another graphing program), it is possible to analyze the data even more precisely, and fine tune the data set. For instance, you could use only the turbidity data from tidal waterways in the summer of 2016 and look for any trends in water clarity.



Once you’ve found the data you want to explore, you can export to a graphing program, like Excel.

Are there any lessons or specific activities I can do with my students using these online apps?

Hopefully—that’s where you come in! We are in the process of creating some lessons, so please reach out to us if you find this tool useful and/or would like to be involved in creating lessons and activities for students.

Note: Be careful to look out for data that are incorrectly entered—while rare, it can happen when entering data in the field. If something seems particularly abnormal about a specific result, contact Katie Leaverton at kleaverton@cbf.org.

Data are collected by students under the supervision of the Chesapeake Bay Foundation education staff and are to be used for education and outreach purposes only.

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