

Lake Waterford Fish Kill

Grade Level: Upper Elementary, Middle School

Subject Areas: Life science, environmental science

Duration: 45 minutes

Next Generation Science Standards:

- 3-LS4-3 – Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well and some cannot survive at all.
- 3-LS4-4 – Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
- 5-ESS3-1 – Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.
- 3-5- ETS1-2 – Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- MS-ESS3-3 – Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

Scientific and Engineering Practices

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts

- Cause and Effect
- Stability and Change

Reading and Writing

- CCSS.ELA/Lit.SL.4-5.1 - Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics and texts, building on others’ ideas and expressing their own clearly.
- CCSS.ELA/Lit.SL.6-8.1 - Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics, texts, and issues, building on others’ ideas and expressing their own clearly.
- CCSS.ELA/Lit.RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).



Lake Waterford Fish Kill

Environmental Literacy:

- 1.A.1 – Identify an environmental issue.
- 4.B.1 – Analyze the growth or decline of populations and identify a variety of responsible factors.
- 5.A.2 – Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes.
- 7.A.1 – Investigate factors that influence environmental quality.

Objectives:

- Students will be able to interpret authentic water quality data tables from the Eyes on the Bay website to determine causes of the fish kill event.
- Students will be able to discuss the importance of water quality monitoring stations in helping scientists determine the causes for changes in fish populations.
- Students will be able to identify and track connections of the direct and indirect causes of fish kill events.
- Students will create an action plan to eliminate or improve actions that have contributed to the fish kill event.

Vocabulary:

- Dissolved oxygen (DO) - the amount of oxygen in the water; it is measured as a concentration - mg/l (milligrams/liter)
- Impervious - not allowing something (for example, water) to pass through
- Necropsy - an examination and dissection of a dead body to determine the cause of death
- Nutrient - a substance that an organism needs to live and grow. In the case of water, usually refers to nitrogen (ammonia, nitrites, and nitrates) and phosphorus
- Toxicology - the study of the symptoms, treatments and detection of poisoning
- Saturated – holding as much water as possible
- Algal Bloom - rapid increase in algae organisms
- Dead Zone - an area where conditions are not suitable for life

Teacher Background:

This activity is based on an event that occurred in Lake Waterford in Anne Arundel County. Lake Waterford is a 12-acre, man-made lake, created by a dam near the headwaters of the Magothy River. The area around the lake is surrounded by development, mostly suburban homes, with a lot of impervious surface. On March 23, 2010, a day after DNR stocked the lake with 700 rainbow trout, approximately 500 dead fish, many of them trout, were found floating in the lake.

Scientists from the Maryland Department of the Environment were called in to investigate. They discovered that the dissolved oxygen levels in the lake were less than 1 mg/L. Most fish, but especially trout, which require high dissolved oxygen levels, cannot survive levels this low for more than a few hours. On March 25, water quality data from DNR's Monthly Monitoring Station downstream in the Magothy River showed that the dissolved oxygen level in the river was still very low (0.80 mg/L).



Lake Waterford Fish Kill

The scientists concluded that the immediate cause of death was low dissolved oxygen in the lake, which may have lasted for several days. The low oxygen level was probably triggered by an algae bloom fueled by nutrients washed off the land by the earlier heavy rains (over 3 inches of rain across much of Maryland) and was increased by the high amount of impervious surface in the area. When the algae ran out of nutrients, they died and the process of decomposition used up the oxygen.

This article is great at explaining most all answers in this activity:

http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/Magothy_monitoring_story2010.pdf

Materials:

- Student worksheet set
- Digital Resources Used:
 - Article Quoted on Student Worksheet:
<http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/March2010RunoffEvent.pdf>
 - Article referred to in Teacher Resources
http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/Magothy_monitoring_story2010.pdf

ENGAGE

- Ask students if any of them watch crime shows like CSI, NCIS, etc. How do the detectives or forensic experts solve a case? What sorts of things do they look for?
Answers may include physical clues like fingerprints, blood stains, autopsy reports, toxicology studies, etc.
- Suppose the “victims” were fish; why might scientists be concerned about a large number of dead fish? *Because whatever was causing the fish to die might cause serious damage to the environment, affect the commercial and recreational fisheries or be dangerous to humans.*
- In the case of a fish kill, what sorts of things might scientists do to determine the cause? *Look at water quality, do necropsies and toxicology studies on the fish, test the water for the presence of toxic chemicals, etc.*

EXPLORE

- Tell the students that there has been a fish kill in Lake Waterford in Anne Arundel County. This fish kill is an actual event that occurred in March 2010. Since they can't necropsy the fish, they are going to have to use water quality data to try to determine the direct cause, and then also identify the contributing factors or indirect causes.



Lake Waterford Fish Kill

- Distribute Student Worksheet.
 - Have students read first page (independently, in groups or as a class).
 - Discuss the charts for what information they hold and what each column means.
- (#1) In what ranges of the following water quality parameters can fish survive?
 - *Dissolved oxygen – greater than 5.0 mg/L*
 - *Water temperature – ideal temperature range is between 50° and 60° F, but rainbow trout can survive warmer water than other species of trout.*
 - *pH – 6.5-8.5*
- (#2) What is the direct cause of the fish death? What exact data show this?
 - *Cause: The dissolved oxygen level was too low for survival when compared to the range needed for fish survival: greater than 5.0 mg/L.*
 - *Data: Dissolved Oxygen was at .80mg/L for March 2010.*
- To answer #2, instruct students to analyze charts specifically for current 2010 data in the last column compared to the acceptable ranges in #1.

EXPLAIN

- (#3) List 3 (or more) contributing factors or indirect causes of the fish kill.
 - Remind students that the scientists and investigators from CSI-type shows will search for the direct cause of death, such as the specific injury, chemical toxicity, etc. Yet, they continue to investigate to find the factors and indirect causes of the mysterious death. We must do the same for the Lake Waterford fish kill. We know the direct cause, but what caused that to happen, and what actions, possibly by humans, led up to that deadly situation.
 - Have students list three contributing factors/indirect causes from the front page of worksheet.
(See many possible answers in a timeline below in Extension A)
 - When the students think they have figured out the “mystery,” have them read the following article:
http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/Magothy_monitoring_story2010.pdf



Lake Waterford Fish Kill

EXTEND

Extension Option A

- In groups, compare and contrast the individual student lists for question #3. Join all lists together to form one list for each group.
- From the group list, make a timeline or chain of actions for the direct causes, indirect causes and contributing factors for the fish kill. Use index cards or construction paper to make a physical representation of the timeline or chain of actions.
 - Sample cards for timeline steps of indirect causes are attached to this lesson, but allowing students to make their own is preferred so they can investigate and analyze the situation, using problem solving skills.
- Example of a student's list: Indirect causes: 1. Dead zone was found. 2. An increase in algae. 3. The heavy rainstorms of mid March.

Encourage this student/group to think about why the algal bloom actually happened (*extra nutrients in the water promotes algae growth*), and why the dead zone actually happen (*Dead zone is where no dissolved oxygen is in the water and occurs because the decomposition of the large quantity of algae uses all of the available oxygen in decomposition process*).
Ask students to figure out what the first thing was that happened in the process of the fish kill. (*Heavy rainstorms and snow melting.*)
- Brainstorm Next Steps: Have students brainstorm, based upon actions they determined caused the fish kill, what they could do to eliminate or reduce any of those steps or contributing factors for the fish kill in the Magothy River. Ideas for home, school and community are encouraged that will prevent storm water run-off, slow down water's path to rivers, reduce nutrients on land, reduce impervious surfaces, increase pervious surfaces, etc. Just a few of the many ideas are listed below.
 - Installing rain gardens and other features to slow water down so it has more time to soak into the ground naturally instead of running-off.
 - Reducing pet waste run off by picking up after their pets. Also, address the community with marketing campaigns to promote the benefits of picking up pet waste/proper disposal instead of leaving on the ground.
 - Designing signs for use at the location of previous fish kills for community awareness of steps they can take to help prevent fish kills.
 - Work with the school or community parks to install a no-mow zone or meadow space. These natural areas are allowed to grow as they desire instead of being cut to low turf standards, which allows for deeper and wider root growth from the plants. This in turn may increase the uptake of the plants, reducing a small amount of the run off that would have previously happened with a mowed lawn.



Lake Waterford Fish Kill

Chain of Actions and Contributing Factors for Lake Waterford Fish Kill

Rain – In this particular fish kill situation, over 3 inches of rain fell.



Run-off - The rain water does not soak into the land surface and flows to storm drains or rivers/streams/other water areas.



↙ Surrounding land area has high amount of impervious surfaces:
Roofs, driveways, roads and parking that increase volume and speed of water as run off.

Run-off water picks up materials from the land surface - Sediment, Litter,



Chemicals, Pet Wastes, Nutrients, etc.

Run-off water meets the larger bodies of water and deposits nutrients - Sediment, Litter,



Chemicals, Pet Wastes, Nutrients, etc.

Algae grow and “bloom” - Increased nutrients provide for increased growth.



Algae dies - Algae cannot survive after all extra nutrients used up.



Algae decomposes – Large amounts of Dissolved Oxygen are used in the process of plant decomposition.



Dissolved Oxygen Too Low - Fish Need DO Greater than 5.0 mg/L.



Large number of fish died in one area of the Magothy River - “Fish Kill.”



Next Steps: What Can YOU do to eliminate or alleviate any of these steps in a fish kill?



Lake Waterford Fish Kill

Rain!
Rain!
Rain!

**Run-off water picks
up materials from the
land surface**

Sediment, Litter, Chemicals,
Pet Wastes

Run-off

The rain water that does not soak into
the land surface and flows to storm
drains or rivers/streams/other water
areas.

**Extra Nutrients
deposited into water
by run-off**

Sediments, Litter, Chemicals,
Pet Wastes

**Surrounding Land
area has high amount
of impervious
surfaces**

Found in roofs, driveways,
roads and parking.

**Algae grow and
“Bloom”**

Because increased nutrients provide
for increased growth.



Lake Waterford Fish Kill

Algae Die

Algae die when all extra nutrients used up

Large Number of Fish Died

Algae Decomposes

Dissolved Oxygen is used in the process of plant decomposition.

Next Steps: What Can YOU Do?

Dissolved Oxygen Too Low for Fish Survival

Fish Need DO Greater than 5.0 mg/L



Lake Waterford Fish Kill

Extension Option B

- Review with students what climate change is (*a long-term change in the earth's climate, especially a change like an increase in the average atmospheric temperature*) and what the term climate means (*the usual weather of a particular place*).
- Use article links listed to gather information regarding climate change and situations like these.
 - <https://www.nwf.org/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Pollution>
 - <https://www.epa.gov/nutrientpollution/climate-change-and-harmful-algal-blooms>
 - <http://www.changingclimate.osu.edu/webinars/archives/2014-06-24/>
- Ask students what impact climate change may have on an event such as this?
Some ideas for answers:
 - Longer growing seasons will increase the opportunity that algae organisms can grow.
 - Longer growing seasons for land plants will also promote more frequent use of fertilizers over a longer period of time.
 - Wetter and stormier winters and springs can cause an increase in nutrient run off, which will increase the algae growth.
 - Harmful algal blooms may occur more often, in more water bodies and be more intense when they happen.
 - A slight temperature increase in the water can lead to lower Dissolved Oxygen. The higher temperature of the water will lower Dissolved Oxygen.
 - Warmer temperatures prevent water from mixing, allowing algae to grow thicker and faster.
 - Warmer water makes it easier for small organisms to float to the surface faster.



Lake Waterford Fish Kill

On March 23, 2010, 500 dead fish, including bluegill, trout and shad were found floating on the surface of the water in Lake Waterford in Anne Arundel County, Maryland. Lake Waterford is formed by a dam near the headwaters of the Magothy River and is a popular fishing lake. The area around the lake is surrounded by development, mostly suburban homes, with a lot of impervious surfaces (roads, driveways, rooftops, and parking lots).



The following statement was published in an article written by the *Eyes on The Bay* website:

“The heavy rainstorms of mid-March 2010 resulted in over 3 inches of rain across much of Maryland. In addition to the heavy rains, rapidly melting snow cover in western Maryland and Pennsylvania, and saturated soils caused the rain and snowmelt to run off streets, parking lots, buildings, residential yards and farm fields, filling neighborhood storm water facilities and downstream culverts, small creeks and wetlands. This surge of water carrying excessive nutrients, sediments and other pollutants continued downstream to rivers, and then eventually down to the Chesapeake Bay. Continued wet spring weather could extend these high freshwater flows that might result in less underwater grasses, an increase in algal blooms and an early onset of Bay “dead-zones.” <http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/March2010RunoffEvent.pdf>

The water in the lake has already been tested for toxic chemicals and the results came back negative. There are no water quality monitors in Lake Waterford itself, but there is a monthly monitoring station downstream in the Magothy River. Data from the downstream station is available on dissolved oxygen, water temperature, salinity, pH and many other water quality parameters. See the following charts.

Most fish found in this lake area, like gizzard shad, sunfish, rainbow trout, and others, require the following water quality parameters:

- Dissolved oxygen – greater than 5.0 mg/L
- Water temperature –
 - Trout: Ideal temperature range is between 50° and 60° F but rainbow trout can survive warmer water than other species of trout
 - Bluegill and most others native to this area: Can survive in temperatures from 32° F to 95° F
- pH – 6.5-8.5



Lake Waterford Fish Kill

Magothy River - Dissolved Oxygen (mg/L)				
Month	Minimum	Mean	Maximum	2010
January	4.10	8.91	14.00	8.10
February	1.70	9.34	13.60	7.20
March	4.90	10.06	13.00	0.80
April	2.30	7.48	10.80	
May	0.08	5.14	11.00	
June	0.00	1.97	6.70	
July	0.00	0.92	3.50	
August	0.00	1.54	6.10	
September	0.00	3.11	8.70	
October	0.70	5.96	11.60	
November	0.02	7.40	12.20	
December	1.60	8.49	13.30	

Magothy River - Water Temperature (° F)				
Month	Minimum	Mean	Maximum	2010
January	32.90	37.58	45.50	36.86
February	33.98	38.65	41.90	37.40
March	38.84	45.01	52.52	54.68
April	45.32	54.61	64.94	
May	60.62	66.33	76.64	
June	71.24	77.01	83.48	
July	77.72	81.21	86.72	
August	76.28	81.10	86.72	
September	67.64	75.03	80.42	
October	57.20	63.80	70.16	
November	43.16	51.51	60.80	
December	35.24	42.60	50.36	



Lake Waterford Fish Kill

Magothy River - Surface Water pH				
Month	Minimum	Mean	Maximum	2010
January	7.60	8.26	8.70	8.00
February	7.40	8.03	8.60	8.10
March	7.20	8.03	8.90	8.30
April	7.40	8.13	9.00	
May	7.90	8.71	9.60	
June	7.60	8.21	9.20	
July	7.20	8.05	8.90	
August	7.20	8.13	8.90	
September	7.40	8.08	9.50	
October	7.40	8.02	9.00	
November	7.50	8.41	10.00	
December	7.60	8.35	9.20	

Other Data Available: <http://eyesonthebay.dnr.maryland.gov/>



Lake Waterford Fish Kill

Lake Waterford Fish Kill – Student Worksheet

You work for the Maryland Department of the Environment and one of your duties is to investigate fish kills. Your job is to try to figure out what caused the fish to die, since you do not want people fishing or using the area for other recreational and commercial activities if there is a problem. Use the information and data given to answer the following questions and solve the mystery.

1. In what ranges of the following water quality parameters can most fish found in this lake survive?
 - Dissolved Oxygen (mg/L)
 - Water Temperature
 - Surface Water pH

2. What is the direct cause of the fishes' death? What data show this?

3. List 3 (or more) contributing factors or indirect causes of the fish kill.
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Lake Waterford Fish Kill

