Who Polluted the Water?

Using a model to represent the River, Bay or another local body of water, students participate in an interactive story dramatizing how, as populations increase and resource use changes, a water body becomes polluted. This activity demonstrates that we are all part of the pollution problem, and that we all must be a part of the solution. Students will discuss ways to conserve our valuable resources and how each of us can reduce pollution, trash and waste each day.

This lesson plan has been adapted from Population Education's "Who Polluted the River?"

Grade Level: can be scaled for different grade levels, see grade level options below

Time: 45-60 minutes

Objective: The students will be able to describe different types of water pollutants and their possible sources.

Optional Extension: There is an extension opportunity at the end of the lesson for students to investigate different ways of cleaning water pollution.

VA SOL: Scientific and Engineering Practices such as asking questions; defining problems; and constructing conclusions and explanations are also touched on throughout this activity

K 7a and 11c	1.5a, 1.8b	2.5a-c, 2.8c	3.3a, 3.5b, 3.8a	4.8a
6.6 a, 6.8d, 6.9a	LS 9a-c	BIO 2a, 8d	ENV 8, 9, 10, 11, 12	EC 11, 13

*SOL listed here do not include the optional extension activity

Background Information for the Educator:

Waterways such as rivers, lakes, and estuaries are important to humans and wildlife alike. Waterways are used for drinking water, transportation, recreation, and habitat for many wildlife species. However, many of our nation's rivers, lakes and estuaries are not swimmable, drinkable (potable), or provide healthy habitat for wildlife. Pollutants enter waterways from either point or nonpoint sources. **Point source pollution** are pollution sources that are clearly defined and localized, such as pipes, industrial plants, sewer systems, and oil spills. Federal and state governments monitor and regulate pollution from point sources as they are easier to detect and regulate. Unfortunately, nonpoint source pollution is harder to detect and control and therefore, they are the major source of water quality problems.

Nonpoint source pollution are pollution sources that are not distinct locations, they do not have a clearly defined source, for example, runoff of oil products from roadways and parking lots. Nonpoint source pollution occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into surface water or introduces them into groundwater. Septic systems, recreational activities such as boating and fishing, urban runoff, agriculture, construction, sedimentation can all cause nonpoint source pollution.

The most common nonpoint source pollutants are sediment and nutrients. These pollutants can enter waterways from agricultural land, animal-feeding operations, construction sites, and other areas of disturbance. Other common pollutants are pesticides, herbicides, pathogens, oil, toxic chemicals (such as PFAS), and heavy metals.

Pollutants can also be categorized into the following types:

- **Toxic pollution**: the introduction of toxic substances/chemicals into an ecosystem. Ex: pesticides, heavy metals, or PFAS
- **Thermal pollution**: varying temperatures above or below the normal condition. Ex: water heated by a power plant or rainwater heated when runoff an asphalt parking lot
- **Nutrient pollution**: oversupplying an ecosystem with nutrients, phosphorus and nitrogen compounds- this often leads to **eutrophication** or a suffocation of organisms, mainly fish, living in the waterbody. Ex: leaking septic systems or fertilizer runoff
- **Sediment pollution**: an increase of sediment in the waterbody above normal (construction sites, landslides)

Pollution in waterways may result in unsafe drinking water, toxins in fish, fish kills, destroyed habitat, beach closures, and many other environmental and human health problems. Pollutants can be human caused or naturally occurring. For example, the sulfur released into the atmosphere when burning fossil fuels does cause acid rain; however, acid rain can also be produced from the gases released during a volcanic eruption. Another example could be increased sediments due to a construction site or increased sedimentation due to a landslide.

State and Federal governments have made advances to protect water quality by regulating, monitoring, and enforcing clean water programs. Examples of federal programs are the updated 1987 Clean Water Act, the 1990 Coastal Zone Act Reauthorization, the Marine Protection, Research, and Sanctuaries Act of 1972, and the 1996 amendments to the Safe Drinking Water Act of 1974. Public and private businesses are using more pollution prevention and pollution reduction initiatives to control water pollution. More citizens are also practicing water conservation and participating in pollution reduction initiatives and clean up events.

This Background information has been adapted from Project WILD's Aquatic WILD "What's in the Water" lesson plan.

Lesson Plan for Lower Elementary Grade Levels:

**created by DWR staff*

Procedure:

1. Prepare and label the film canisters and the items in the chart below. Prepare enough canisters for each student to have at least one. There are 7 canisters, so unless your class is very small, you will need to double/triple some characters. (Some students will have identical canisters.)
    a. Note: Don't have more than one dog waste canister (coffee), it will make the water too dark

Label	**Fill container with**
Fishing line	Length of fishing line
Dog waste	1 tsp Instant coffee grounds
Trash and Garbage	Cut up pieces of paper and plastic bag
Oil	Vegetable oil
Bug Spray/Pesticide	Vinegar
Fertilizer	Baking soda
Cows	Dirt (to represent sediment) and chocolate syrup (cow manure)

2. Create a label for each student that will correspond to their container/character label and hand out to the student, activate prior knowledge by having a quick discussion about each container label
3. Fill a clear jar or bowl with water. Place the container in a location that can be seen by all students.
4. Set up the labeled canisters within easy reach of where you'll be facilitating the activity, lined up in the order they are to go into the water.
5. Explain that you will tell a story about the river, (insert the name of a river in your area, if you wish) and that each of the students will play a part in the story. The jar of water represents the river. When they hear the name of the container you've given them, they should come up to you and get the matching canister, open it, and empty its contents into the container.
    a. Note: If you feel the students will have trouble opening the canisters without spilling the contents, remove the lids for them, or leave the lids off altogether.
6. Read the story Who Polluted the Water? aloud. Add emphasis as you read each bolded character name and pause after each question to give the students time to think and respond.

Who Polluted the Water? Story- Lower Elementary version:

Black type: Story lines
Green Type: Questions to ask the students along the way- includes answers in parentheses.
Bold Type: characters, when called need to pour their container contents into the water

Early explorers canoed up the Shenandoah and James Rivers and wrote in their journals of the beautiful forests they could see from their boats. They also noticed an abundance of wildlife such as foxes, groundhogs, deer, raccoons, squirrels; they had only to drop their fishing lines in to catch plenty of fish to eat.

Gesture to the water container. Do you think the early explores drank the water from the river? Do you think they swam in the river? What about the water makes you think they could drink or swim in it? (Clean, clear)

Today, Jenny and Mike are fishing in the river. They have been trying for quite a while to catch some fish. They are getting thirsty. Do you think they will drink water from the river? Mike's **fishing line** gets tangled, so he cuts it off and throws the tangled fishing line mess into the river.

Do you think Mike did the right thing with his fishing line? (No) What can fishing line do to animals that live in the river? (Wrap around organisms, make it hard for them to swim) What should have Mike done with his fishing line? (throw it away properly in the trash)

Andy is walking his dog right along the riverbank so he can look for rocks as he walks along. As soon as it starts raining, Andy runs home and doesn't see his **dog's waste** get washed into the river.

Do you think that it's good that the dog waste ended up in the river? Do you have a dog? What happens to your dog waste? (May need to prompt if anyone ever cleans it up using the bags)…don't talk about nutrients, yet

A family is picnicking nearby. When it starts to rain, the family is in a hurry to get to the car and leave some **trash and garbage** behind. It gets blown around and washed into the river.

Oops, do you think the family meant for their garbage to end up in the river? What should you do with trash

and garbage? (Trash can/Recycle/Reusable containers) What do you think can happen if too much garbage ends up in the river? (It covers the surface or animals start eating it)

The family's car leaked some **oil** onto the parking lot while they were picnicking, which soon gets washed into a nearby ditch that leads to the river.

Uh-oh, oil from the car made it into the river. Cars need oil to work…how do you think it got into the river? (Hole in oil pan) A little oil from one car may not be harmful to the river but think of how many cars you see on the road every day!!

In a subdivision nearby, Mr. and Mrs. Hall have been busy working in their garden. They have worked very hard planting and then weeding their vegetables and don't want to lose any of their crops to insects, so they spray the garden with **bug spray or pesticide**. When it starts raining, they run inside as the rain washes the bug spray into a little creek by their house which leads to the river.

Bug spray? Why is Mr. and Mrs. Hall using bug spray? (so the bugs don't eat their crops) Sometimes though, the bug spray also kills bugs that you don't want it to…. like lightening bugs or insects that live in the river!

Mr. Green, a farmer down the road, is busy putting **fertilizer** on his fields so that his crops will grow better. The rain catches him by surprise, so he heads his tractor home as the rain washes the fertilizer into a ditch, which leads to a creek, which leads to the river.

Why does Farmer Green use fertilizer? (to help his crops grow because the soil doesn't grow plants well anymore…kind of like taking a vitamin or eating your veggies so you grow big and strong) What do you think Farmer Green's fertilizer is made of? (Manure from cows or chickens)

Here's the problem with the fertilizer going into the river…remember how we said that the fertilizer is used because the soil isn't good anymore? Well, a river doesn't have soil….the river has enough nutrients. So when the extra nutrients from lots of farms or lawns enter the river it can make the river sick. What does a river look like when it's sick? (dead fish, green slime/algae on top)

Mr. and Mrs. Holstein have a new herd of cows that they are so proud of. They didn't repair the fence by the river before they put them in their pasture, and the cows like to cool off in the river. The **cows** are depositing lots of manure in the river every day.

Have you ever swam in a river or lake? It feels good on a hot summer day, right? So you can't really blame a hot cow for going swimming! But having cows in streams isn't good. Can anyone think of reasons why having cows in streams isn't good? (they go to the bathroom in the water and they are big animals-they push dirt from the stream bank into the river…which makes the river muddy and adds dirt to the water)

Now let's take a look at our river, remember all the things that the community accidently put into the river? (fishing line, dog waste, trash, oil, bug spray, fertilizer, cow manure, dirt) Keeping all that in mind, would you want to drink this water now? Why not?!?!? (dirty, could make you sick)

Why do rivers get dirty? (People accidently put stuff into the river, like in our story, or people are not throwing things away properly) Do you think it's good to have dirty rivers everywhere? Would you want all of our rivers to look like this?

Could any of this pollution in our river have been prevents from going into the river? (Almost everything that

made our river dirty could have been preventing from entering the river if the people were a bit more careful)

But our river is already polluted! So, how can we clean it up? (write down the student ideas of how to clean the water) (If possible, extend the activity, gather materials to allow students to "test" their ideas of removing the pollution from the water- this would be the extension)

- Example filter materials: buy a couple cheap plants in soil, fish net, container of sand, sponges, etc.
- Allow the water to filter through these materials into a different container and you can compare the filtered sample with the original. Use a scale of 1-5 on how clean the water got using the filter method.

Lesson Plan Upper Elementary Grade Levels

The following lesson plan was created and published by Population Connection, please visit their site for more lesson plans and resources: https://populationeducation.org/

The included lesson plan here can be found at:
https://populationeducation.org/sites/default/files/who_polluted_the_river.pdf

UNIT 7 | PEOPLE AND WASTE

WHO POLLUTED THE RIVER?

COUNTING ON PEOPLE
K-5 Activities for Global Citizenship

METHOD

Through an interactive story, K-2 students experience the pollution of a local river over time and propose methods to protect the river from current and future pollution.

MATERIALS

- 1 clear gallon jar or bowl of water
- 1 plastic film canister for each student (canisters are often available for free at film processing stores—if you can't find film canisters, any small condiment container with a lid will work)
- Canister labels (provided)
- Character nametags (provided)
- Story: *Who Polluted the River?* (provided)
- Canister ingredients
- Plastic fish toy (optional)

INTRODUCTION

Rivers have always been an important resource. They provide water for drinking, a means of transportation, a home for wildlife, and more. As human populations have increased, so has our impact on the water system and many rivers have changed as a result. In this activity, students participate in an interactive story about the changes humans have made to a river over time and learn how many of our rivers have become **polluted**. This example demonstrates that just as we each contribute to the problem, we can also each be part of the solution.

PROCEDURE

1. Prepare and label the film canisters using the provided Canister Labels and the items in the chart below. Prepare enough canisters for each student to have at least one. There are 10 canisters, so unless your class is very small, you will need to double some characters. (Some students will have identical canisters.)

   Note: Don't have more than one barnyard canister (coffee), as two doses of it will make the water too dark to notice the progression of pollution afterwards.

CONCEPT

Over time, individual actions have impacted our rivers in both negative and positive ways, causing many rivers to change.

GRADE LEVEL

Lower elementary

SUBJECTS

Science, Social Studies, Language Arts

OBJECTIVES

Students will be able to:

- Discuss ways people can pollute a water source.
- Propose methods for preventing and cleaning up water pollution.
- Explain why it is more effective to prevent pollution than to clean it up after the fact.

SKILLS

Critical thinking, listening and observing, role playing, understanding cause and effect, describing

CHARACTER	INGREDIENTS
Trees	Dry leaves
Building sites	Soil (dry)
Farmers	Baking soda
Family picnics	Litter, assorted (shreds of paper, pieces of plastic, etc.)
Person fishing	Tangle of fishing line or dental floss
Barnyards	Water + instant coffee
Factories	Water + one drop red food coloring
Drivers	Vegetable oil + one drop red and green food coloring
Washing the car	Soapy water
Motorboats	Vegetable oil + one drop red and green food coloring

2. Cut out the Character Nametags. Make sure that there is a Character Nametag for each canister you've made (ex. if there are two "Driver" canisters, there should be two "Driver" character cards).

3. Fill a clear jar or bowl with water. Place the container in a location that can be seen by all students. If using a fish toy, put it in the water now and when asking the questions within the story, point to the fish and include the question "How do you think the fish feels?"

4. Distribute one Character Nametag to each student. To activate background knowledge, ask students to share one thing they already know about the Character they are given (the sound it makes, what color it is, etc.).

5. Set up the labeled canisters within easy reach of where you'll be facilitating the activity, lined up in the order they are to go into the water.

6. Explain that you will tell a story about the river, (insert the name of a river in your area, if you wish) and that each of the students will play a part in the story. The jar of water represents the river. When they hear the name of the item pictured on the Character Nametag you've given them, they should come up to you and get the matching canister, open it, and empty its contents into the container.

Note: If you feel the students will have trouble opening the canisters without spilling the contents, remove the lids for them, or leave the lids off altogether.

7. Read the story *Who Polluted the River?* aloud. Add emphasis as you read each bolded character name and pause after each question to give the students time to think and respond.

DISCUSSION QUESTIONS

1. Who polluted the river?

Everyone played a role.

2. What effect did the increasing population have on the health of the river? What are some examples?

In this situation, population growth led to increases in pollution. Examples include: factories that make things for people leaking paint and chemicals, cars leaking oil, families leaving trash on the beach, etc.

3. Think about the pollution contained in your canister. What could each of us do to keep the river clean by making sure these kinds of pollution don't get into it in the first place?

Answers will vary but may include: biking or walking instead of driving, using water carefully, picking up litter so it doesn't end up in our fresh water supply, etc.

4. Challenge students to come up with ways to clean up the water in the bowl—after all, everything has to go somewhere. Can water be cleaned up in the real world?

Solids can be strained using a kitchen strainer or netting. Students may also find coffee filters or absorbent cotton helpful. In reality, people clean up rivers in many ways – using nets to pull out large items, treating the water with chemicals, etc.

5. Is it easier to prevent pollution, or to clean it up later? Have students explain their ideas.

Preventing pollution is known to be a more effective approach for ensuring clean waterways.

MEASURING LEARNING

Ask students to pick a pollutant from the story and illustrate:

1. an action that would cause that pollutant to go into the river.
2. an action that would prevent that pollutant from entering the river.

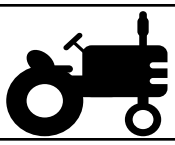
FOLLOW-UP ACTIVITY

Arrange a class field trip to your local waste water treatment plant. Prior to your visit, have each student write down one question they have about polluted water and/or the cleaning process. At the plant, ask that an employee provide a tour of the facility and provide information such as how the water is cleaned, how much water goes through the plant, and why the plant is an important part of the local community. Be sure to leave time for student questions!

WHO POLLUTED THE RIVER?
CANISTER LABELS

Trees

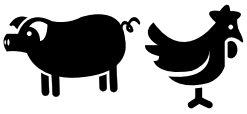
Building sites



Farmers

Person fishing

Family picnics



Barnyards

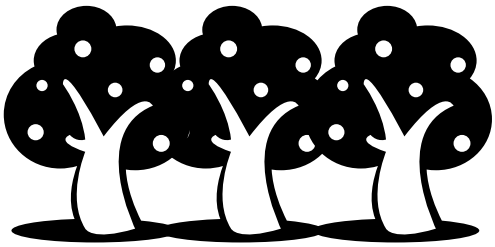
Factories

Drivers

Washing the Car

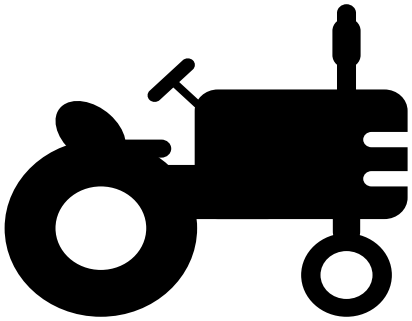
Motorboats

WHO POLLUTED THE RIVER?
CHARACTER NAMETAGS



Trees

Building sites

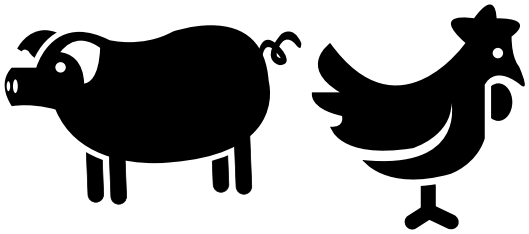


Farmers

Person fishing

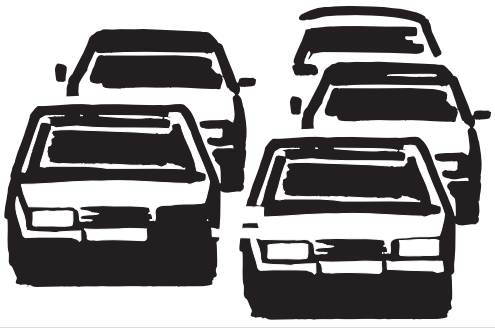
Family picnics

WHO POLLUTED THE RIVER?
CHARACTER NAMETAGS



Barnyards

Factories



Drivers

Washing the car

Motorboats

STORY: WHO POLLUTED THE RIVER

There was a time many years ago when our land was very wild. This was a time before roads and cars. Only a small number of people lived here then. These native people depended on nature for many of the things they needed to survive, but they lived simply and didn't change the natural surroundings too much. The people hunted in the forests, found food in the swamps, and caught fish in the river. *[Insert the name of a local river.]* The beautiful and sparkling river was home to fish and other wildlife. Imagine that the container of water in front of you was taken from the river a long, long time ago.

- Describe how the water looks to you. Would you drink this water? Eat fish that came from it? Swim in it?

Eventually, more people traveled to this land from across the ocean. They found rich soil for farming, forests full of wildlife, and a river that provided plenty of food and water. It was a perfect place to live.

- How do you think the new people used the river? *(Answers will vary but may include: for water to drink, cook with, bathe and wash clothes in; to catch fish from; to go boating on; to move supplies from place to place)*
- Do we use the river the same way today? *(Answers will vary.)*

The river has changed a lot since that time long ago. This is the story of those changes. Listen for the name of what's pictured on your Character Nametag. When you hear your picture named, walk up to the teacher, get the matching container, and dump what's inside into the river. Be sure to stand to the side, so the whole class can see the bowl.

Years went by, and once in a while there were big storms. Strong winds whipped through the **TREES** and blew leaves into the water. More and more people moved to the area. Gradually, a city grew up around the river. People drained swamps and cut down forests to build houses, schools, churches, stores, roads, hospitals and many other buildings. Rains washed loose soil from these **BUILDING SITES** into the river.

- Is this water safe to drink? *(If the response is "no," ask if the river had leaves or soil in it when people long ago drank from it.)*
- Would you swim in it? Is it safe for animals to drink and fish to swim in?

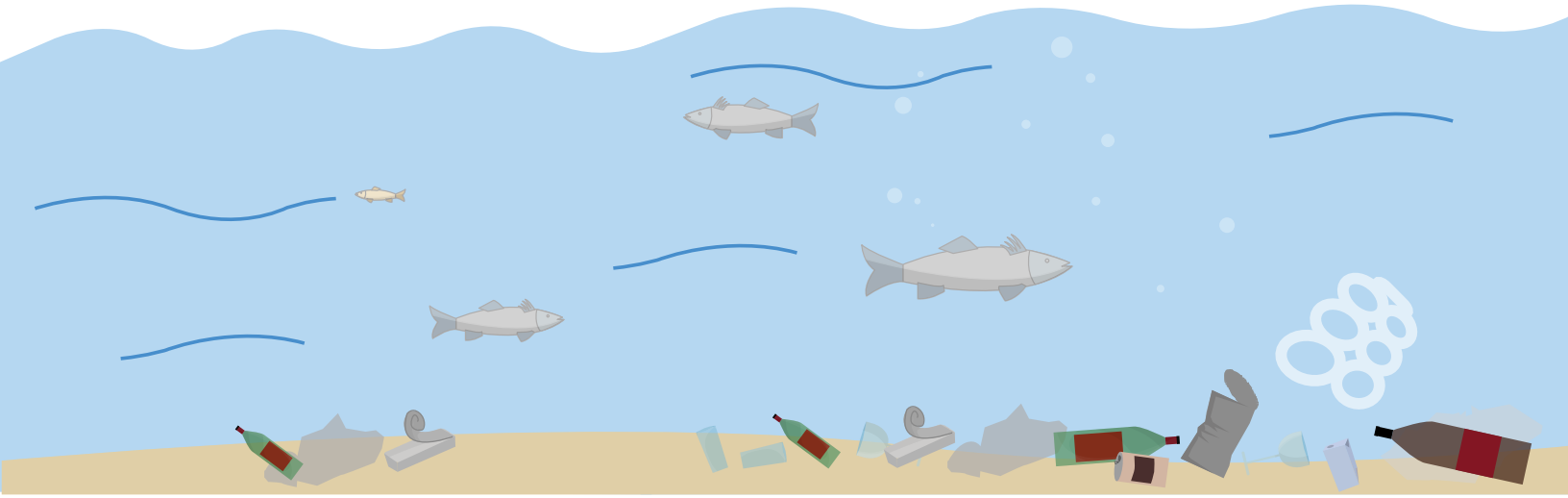
At first, the city was small. Upstream, **FARMERS** planted crops to feed all the people as the city grew. They used chemicals called fertilizers to make their crops grow faster. Some farmers kept pigs and other animals in **BARNYARDS**. As rainwater drained out of the fields and barnyard, it carried some of the fertilizers and manure into a little creek behind the farm. The creek flows into the river.

- Would you drink this water now? Would you swim in it? Go boating on it?
- Is it safe for fish and animals?

Now, the city along the river has grown to be one of the largest cities in the country. Many people live and work in and around the city. Many businesses provide services for the people. Several **FACTORIES** make things that people want, like cars and furniture, but the factories leak paint and other chemicals into the river. These pollutants cause the fish to become sick. As people move about their busy days, they often drive from place to place. Traffic jams are a big problem for **DRIVERS** who take their cars to and from work. If a car is not taken good care of, it might also leak oil or other fluids, which will be washed off the roads and into the river with the next rain.

A boy in the city is out **WASHING THE CAR**. The soapy water rushes down the driveway into the storm drain by the curb; the storm drain empties into the river. The grease and grime on a car contains tar from the roads, very tiny bits of rubber from the wearing of the tires, and rust. If the boy had gone to a local car wash instead, the water would have been cleaned before it went back into the river or was recycled.

On nice days, many people head down to the river. Some zoom up and down the river in **MOTORBOATS** and don't notice that a little engine oil leaks into the water. The oil will not mix with the river water, but will float on the surface. It will coat the feathers of ducks or other birds that paddle around on the water looking for food, making it harder for them to stay afloat or fly. Lots of people are having **FAMILY PICNICS** in the parks along the river, too. Some of these people have left trash on the shore. With the next storm, that trash will wash into the river. On the shore a **PERSON FISHING** snags a hook on a log. Instead of untangling it, the person fishing simply breaks off the snagged piece of the nylon fishing line and lets it fall into the river. The land is no longer wild, and the river has changed a lot over the years.



Lesson Plan High School Level

The following lesson plan was created and published by Population Connection, please visit their site for more lesson plans and resources: https://populationeducation.org/

The included lesson plan here can be found at: https://earthmatters.populationeducation.org/wp-content/uploads/2018/06/Code-Blue-Endangered-Oceans.pdf

CODE BLUE: ENDANGERED OCEANS

EARTH matters
Studies For Our Global Future

introduction

As human population has increased and land uses have changed, our oceans have been negatively altered. For centuries, people have regarded the ocean as an inexhaustible source of resources and a convenient dumping ground that could absorb the residues of human activity with little negative impact. Mounting evidence now shows that human activities – **overfishing**, pollution, and carbon dioxide emissions – are stressing the ocean's health, leading to the progressive deterioration of marine habitats and species.

Vocabulary: overfishing

materials

- Clear plastic container or bowl of water
- Opaque film canisters or other small lidded containers
- Canister Labels (provided)
- Extraction Cards (provided)
- Extraction Items (provided)
- Plastic drinking cup
- Masking tape
- Canister ingredients (see chart)
- Water
- Salt
- 16 clothespins or binder clips
- Story: "Code Blue" (provided)

procedure

1. Before class:

    a. Fill a large, clear container with water until it is approximately half full.
    b. Print the Canister Labels and tape one to each canister. Fill each canister with the appropriate material from the chart. The canisters represent things that are added to the ocean.
    c. Print the six Extraction Items, laminate them if desired, and tape them to the side of the bowl. The Extraction Items represent something currently found in the ocean.

concept

The impacts of humans on the ocean provide insight into the effect that a population of almost 8 billion has on natural resources and the difficulties of managing an international commodity.

objectives

Students will be able to:

- List the principal pollutants in our world's oceans.
- Describe how humans have altered the ocean ecosystem over time.
- Discuss ways to preserve ocean health.

subjects

Environmental Science (General and AP), AP Human Geography, Geography, English Language Arts

skills

Listening comprehension, observing, understanding cause and effect

method

As the instructor reads a story about the history of the world's oceans, students act as characters adding and removing items based on real-world events.

d. Print the six Extraction Cards and laminate them if desired. These will be passed out to students.
e. Tape the "Sea Level Rise" Canister Label onto the plastic drinking cup and fill with water.

Note: There are 17 different characters between the Canister Labels and Extraction Cards. For classes of more than 17 students, create two of some characters so all students can participate.

CANISTERS	
Character (Canister Label)	**Canister Ingredients**
Algal blooms	Green yarn
Abandoned nets	Fishing line, dental floss, or hair net
Antibiotics	Baking soda
Litter	Cut-up pieces of plastic
Natural disasters	Broken up toothpicks or craft sticks
Chemical fertilizers	Vinegar + green food coloring
Coal	Water + red food coloring
Off-shore Oil Wells	Cooking oil + red and green food coloring
Ocean acidification	Vinegar
Sewage	Water + instant coffee

2. Distribute the canisters and Extraction Cards so each student has one or the other.

3. Explain that you will be reading a story about the history and health of our oceans. Instruct the students to listen for the name of the character printed on their canister or Extraction Card. When they hear the name in the story, they should come to the front of the class and pour the contents of their canister into the bowl. If they have an Extraction Card, they should find the matching Extraction Item from the side of the bowl and remove it. After removing their item, they should hold it up for the class to see and say what they have removed.

4. Tell the students that the clothespins or binder clips represent the world population and that each clip represents 500 million people. You will begin the demonstration with one clip on the side of the bowl and end with 16 (representing 8 billion people). You may decide to have a few students be the "population monitors" and add clips throughout the story so that you do not have to pause.

5. Read the story, adding emphasis and pausing on the bolded words in all-caps so that students have a cue to either add their pollutant or make an extraction.

discussion questions

1. Who polluted the ocean?

   Everyone played a part. Students should mention that each person had an impact and everyone shares the oceans.

2. What effect did increasing population have on the health of the ocean? Can you think of any ways that population increase helped the ocean?

   In this situation, population growth led to increases in pollution sources and decreases in open space and in available wetlands, which filter water. However, the increase in population also led to stronger environmental laws, more efficient uses of resources, and public services like sewage treatment plants.

3. Think about the pollution held in the canisters. What are some things individuals can do to prevent some of those materials from entering the water? What are some actions businesses (especially industry and farms), communities, and governments can take to reduce and prevent some of this pollution?

   Answers may include: as individuals, we can use less chemical fertilizers on our property, be selective with what types of products we purchase and eat, recycle, participate in beach and park clean-up projects, use alternative transportation, etc. Farms (land-based and aquaculture) could reduce their use of chemical fertilizers and pesticides and better manage animal waste, as all can be foul watersheds. Industries can reduce their use of fossil fuels. Regulations on the fishing industry could prioritize sustainable fishing practices that do the least harm to marine ecosystems.

4. Think about the organisms that were removed or destroyed due to human activities. They aren't confined to just one area of the world, but swim freely. Who owns these animals? Who should manage how many of these creatures people are allowed to remove? How can these management systems be enforced internationally?

   Answers will vary. Guide students to understand that there are international management groups that sign treaties to protect international interests (ICCAT, IPCC, IWC) but that these treaties are difficult to enforce.

5. Were all of the impacts on the ocean caused by humans? Which ones were? Which ones weren't?

   Many were human caused, but natural disasters like tsunamis and mudslides can't be prevented. However, human activities can affect how devastating these natural disasters are by destroying natural buffers to storms, like mangrove forests, coral reefs, or cutting down trees that are meant to stop erosion and nutrient depletion. We also increase the intensity and frequency of these storms through global warming.

6. Think about the impacts of sea level rise in coastal communities. Where will these impacts be the worst?

   Areas with high population density living in very low-lying areas. The poorer, tropical regions will be the most impacted.

7. Is it easier to prevent pollution by managing ocean resources beforehand, or to clean it up and restore it later?

   To prevent it in the first place. Because preventing pollution typically requires cooperation among many stakeholders, people often rely on ocean restoration as the main way to maintain the health of the oceans. Most forms of pollution are nevertheless impossible to entirely remove from a body of water, making prevention always a better option when possible.

8. What could each of us do to help improve the health of the oceans?

   Answers may include: using alternative transportation besides just cars, conserving water, eating organic foods or foods produced with natural fertilizers, only eating sustainably harvested seafood, etc.

assessment

Students complete an exit ticket identifying three ways humans impact oceans and two ways these impacts can be mitigated.

follow-up activities

1. Have students research a piece of the story that seemed the most interesting or relevant to them. For example, they could research overfishing, ocean acidification, whaling, the Plastic Gyres, or sea level rise and climate change. Then, have students write a short essay with more specific details and examples of how their research topic impacts the oceans. Students can also research impacts that were not included in this story.

2. Discuss international policymaking. What are the difficulties of getting countries to solve problems together? What is the best method of solving these problems? Have students research an international policy or regulatory body of their choice (Montreal Protocol, Kyoto Protocol, Paris Agreement, International Panel on Climate Change, International Whaling Commission, or the Convention in the Trade of Endangered Species). Ask them to write a short paper on the history of the policy, which countries were major players in the debate, and why it was important or controversial. Alternatively, they could work in groups and give a short presentation to the rest of the class on their treaty or commission.

3. Have students explore some of the following sources to learn more about ocean health:

    - FAO, The State of World Fisheries and Aquaculture 2020
    - Monterey Bay Aquarium, Seafood Watch Program
    - NOAA, Oceans & Coasts
    - Pew Charitable Trusts , Ocean Conservation
    - Ocean Conservancy
    - Joint Ocean Commission Initiative
    - UN Atlas of the Ocean

    Information on various international organizations that are working on these issues:

    - Intergovernmental Panel on Climate Change
    - International Whaling Commission
    - International Commission for the Conservation of Atlantic Tunas
    - International Coral Reef Initiative

Story: Code Blue

Throughout humans' existence on Earth, we have made our home on the coasts of the ocean, depending on its resources for food and transportation. The ocean makes up over 70 percent of the Earth's surface, making it the primary reservoir of water on Earth's surface. It is the largest of the three marine biomes, is teeming with wildlife, and is responsible for much of our climate patterns. Imagine that this container of water represents the ocean 500 years ago (*pour salt into the container*). Back then, our world population was 500 million, or about 1/16 of what it is now (*place one clothespin on the side of the bowl*). The oceans were filled with diverse ecosystems of corals, invertebrates, fish and mammals, all relying on each other in interconnected food webs.

However, the ocean has changed a lot since 1500 and this is a story of those changes.

One hundred years passed by and people turned to the ocean as a resource to improve their lives. During this "Age of Discovery," the popularity of ocean transit exploded. People and goods embarked on ambitious new oceanic trade routes that interconnected Europe, Africa, and Asia. Additionally, people began to recognize the ocean's wealth as harvestable. Though people had been hunting whales for thousands of years, new technologies like faster ships and large harpoons now entered the scene and made **COMMERCIAL WHALING** more lucrative in Europe and North America. Whale blubber was converted to lamp oil, and baleen ("whalebone") was used in ladies' corsets. By the mid-1700s, it became difficult to find whales near the Atlantic coast, leading fleets to expand their hunting to other parts of the globe, decimating whale populations worldwide. Currently, there is an international moratorium on commercial whaling; however, some countries such as Norway, Iceland, and Japan continue the practice.

In the early 1800s, world population had reached 1 billion (*place another clothespin on the bowl*) and scientists and farmers were looking for ways to increase crop yields to feed the population. Scientists began creating **CHEMICAL FERTILIZERS** with high levels of nitrogen, phosphorous, and potassium. Nitrogen is highly soluble and when used in large amounts, can run off into large bodies of water. Increases in nutrient pollution in the ocean cause **ALGAL BLOOMS** that consume all of the oxygen in an area and create a dead zone where no other organism can live. Dead zones occur in many areas, including the East Coast of the U.S. and the Gulf of Mexico, which has the second largest dead zone in the world. Worldwide, there are now some 700 coastal dead zones. However, the small amounts of chemical fertilizers used in the early 1800s weren't enough to cause these troubles, and people probably never anticipated how widespread their use would become or that, in large quantities, their use could harm marine ecosystems.

The Industrial Revolution in the mid-19th century ushered in a new era of technologies and jump-started a fossil-fuel based economy. **COAL** was the new main energy supply, but it caused a large amount of air pollution. Burning coal was also a source of mercury poisoning in our ocean system. Trace amounts of mercury found in coal were released as coal was burned, and it moved into our atmosphere and our oceans. Fish ingest the mercury and humans are susceptible to illness if they eat fish with high mercury content.

- *What has changed about the oceans from 1500 to 1850?*
- *How have humans been helped/hurt by these changes? Possible answers: Helped – more access to food due to fertilizer use and whaling; better transportation systems. Hurt – less biodiversity because of the algal blooms and whaling; water has high levels of mercury.*

In the early 1900s, the first **OFF-SHORE OIL WELLS** were installed off the coast of California to try to keep up with growing demand for oil. These early wells, dug close to the shoreline, blackened beaches but produced only modest amounts of oil. The first major oil spill was in California in 1910 and dumped 378 million gallons of oil into the Pacific, devastating the ecosystem. By 1930, when world population reached 2 billion *(place two more clothespins on the bowl)*, oil companies began constructing platforms in the Gulf of Mexico. Today there are over 1,300 offshore oil rigs around the world. One of the largest spills occurred as a result of an oil rig explosion on April 20, 2010. It took nearly three months to stop the flow of oil into the Gulf of Mexico, which had devastating effects on the environment but also for the Gulf Coast community and economy.

In the 1950s, much of the maritime technology that was developed during World War II was converted into new **FISHING TECHNOLOGIES** to help feed the 3 billion people on the planet (*place two more clothespins on the bowl*). However, these technologies caused severe overfishing, as fishermen could now catch thousands of pounds of fish in one outing. These new technologies, including trawling, a technique the scrapes the seafloor with large nets, would catch anything and everything. Additionally **BYCATCH**, or the accidental catch of marine life, was becoming a problem as turtles, dolphins, and other fish were often caught and killed in fishing gear that was meant for other animals. **ABANDONED NETS,** fishing lines, and traps can also continue to kill animals for weeks after they have been deployed if fishermen forget to retrieve them. As of 2017, two-thirds of the world's fisheries were being fished at maximally sustainable levels, while one-third were being overfished, depleting fish stocks. The cod fishery in the Northeastern United States and Canada had record high catches in the 1960s but later collapsed due to overfishing.

Even with the fishing boom, we weren't producing enough fish to provide for our growing population. In the 1970s when world population reached 4 billion, *(place two more clothespins on the bowl)* **AQUACULTURE**, or raising fish in pens as you would cows or chickens, became a growing industry, especially in Asian countries such as Indonesia and Thailand. In many rural areas, coastal ecosystems were decimated as fish farmers cleared mangrove forests to create room for more aquaculture. These mangroves were home to hundreds of species of birds and fish but were converted into large feeding pens of shrimp and salmon. Due to the density in which the fish are grown, they must put large quantities of **ANTIBIOTICS** in the water to stop the spread of disease. Unfortunately, these antibiotics seep into the oceans and pollute our water, endangering our public health as well as our food sources.

By 1987, world population was at 5 billion people (*place two more clothespins on the bowl*) who were together producing millions of pounds of trash. This **LITTER** from land sources, commercial ships, and cruise vessels entered the ocean system as pollution. By 1997, with population nearing 6 billion (*place two more clothespins on the bowl*), scientists discovered two "Plastic Gyres" in the Pacific and Atlantic Oceans. These massive swirling mounds of plastic, created by water currents, seep toxic substances into the water and kill **MARINE BIRDS** who choke on or consume the plastic.

Litter isn't the only pollution we have to worry about. In many countries, sewage treatment facilities are not available, and **SEWAGE** from cities and households runs directly into our rivers and oceans.

Recognizing the global nature of the problems our oceans were facing, international bodies have been created to monitor pollution, climate, and fishing industries. However, it was and still is difficult to get countries to agree on an action plan, and, without an enforcing body, many countries still do not comply with the agreements. As the world population reached 7 billion people in 2011 (*place two more clothespins on the bowl*) all of the detrimental human impacts on the ocean were accumulating. Increased concentrations of carbon dioxide, or CO_2, in the air from burning oil and coal led to Arctic ice melting and **SEA LEVEL RISE**. Low lying countries such as Bangladesh, Papua New Guinea, and islands in the Pacific Northwest have already had to evacuate some communities due to permanent sea level rise.

Similarly, as more CO_2 is absorbed by ocean waters, the pH level of the water decreases and causes **OCEAN ACIDIFICATION**. Many organisms can only handle a narrow range of pH in their environment and maintain homeostasis. This acidification makes it difficult for **CORAL REEFS** to form shells, leading to the death of the coral and the rich biodiversity that relies on it. Both coral reefs and the mangrove forests normally act as natural buffer zones against storms for coastal communities. With increases in global temperatures, storms, like hurricanes, are increasing in intensity, and without these natural protective structures, **NATURAL DISASTERS** wipe out entire towns and wash them into the water. Mangrove forests are also a "carbon sink," sequestering – or soaking up – carbon dioxide from our atmosphere. Without them, the cycle of global warming and ocean acidification continues.

Now, as our population approaches 8 billion (*place the last two clothespins on the bowl*), our accumulated activities are threatening ocean health and all it provides to us and the global ecosystem. Our oceans are essential for nutrition, transportation and recreation, but also for making the Earth habitable for humankind by regulating temperatures and atmospheric moisture, and storing carbon. The UN has recognized the need for protecting ocean health by including the goal "to conserve and sustainably use the world's ocean, seas and marine resources" (SDG#14) in the Sustainable Development Goals, hoping to ensure healthy oceans exist for generations to come. It is important for all countries to work together to achieve this goal.

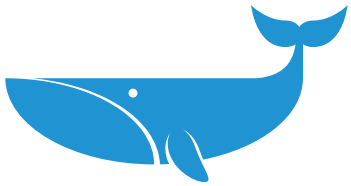
CODE BLUE: ENDANGERED OCEANS | canister labels

Print and tape each label to a canister.

CHEMICAL FERTILIZERS	ALGAL BLOOMS	COAL
OFF-SHORE OIL WELLS	ABANDONED NETS	ANTIBIOTICS
LITTER	SEWAGE	OCEAN ACIDIFICATION
NATURAL DISASTERS	SEA LEVEL RISE	

CODE BLUE: ENDANGERED OCEANS | extraction cards & items

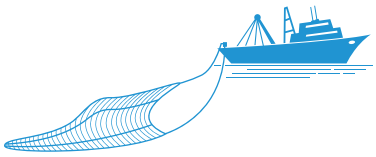
Extraction Cards: Print and give one to six students in the class instead of a canister.



COMMERCIAL WHALING

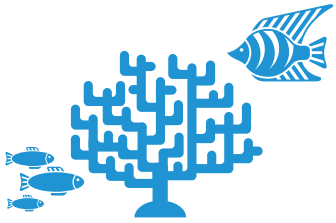
MARINE BIRDS

BYCATCH



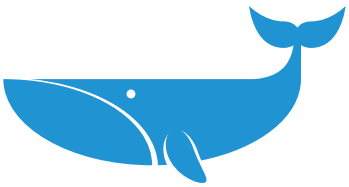
FISHING TECHNOLOGIES

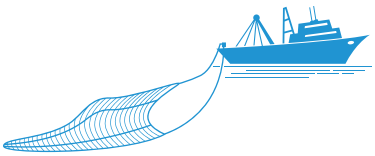
AQUACULTURE

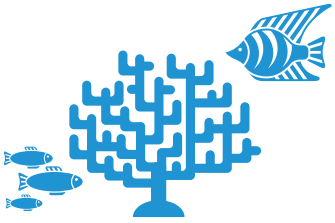


CORAL REEFS

Extraction Items: Print and tape to the side of the clear bowl of water.







Extension Activity- Inquiry Lab- How to Clean Up This Pollution?

Objective: Now that the class has their polluted water, have students brainstorm with ways to clean the water and provide them the materials to construct and test various filters to see how clean students can get the water.

Procedure: As the teacher, compile various materials for them to create different types of filters or other cleaning methods and oversee construction and testing for safety.

Suggested filter materials, but it is important to have the students come up with many on their own too!

- Plants rooted in various soils
- Sponges
- Cheesecloth
- Various soil/dirt: sand, clay, loam, etc
- Activated charcoal
- Fish net
- Cotton balls
- Various size screen
- Various types of fabric

Possible additional materials:

- Cups with holes in the bottom
  - Could be filled with the soil and the drain holes allow the water to pass through
- A water collection bin for when students test their filters
- Creation of a qualitative scale for how clean the water got when filtered
- Rubber bands
- Duct tape
- Zip ties
- PH strips- could test pH before and after filtering
- Paper towels
- Funnels