THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 1: Getting to Know Aquatic Animals

Topic: Youth will be introduced to aquatic animals that are related to fisheries in Maine.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1. List some of the aquatic animals found in Maine.
2. Explain where some of Maine's aquatic animals are found using a map.
3. Defend their reasoning of where they put animals using evidence.

Background Information for Facilitator

Because Maine has a large coastline (we have more coastline than California!), we have access to a lot of fish, like salmon and cod, as well as other aquatic species, such as lobster and clams. It is no surprise that Maine is a big contributor to fisheries and fish markets. Not all the fish and aquatic animals fished in Maine are found in the same spot. For example, clams are found in the intertidal zone (covered in water at high tide and exposed at low tide), whereas cod and haddock are ground-dwelling fish in the ocean.

The intertidal zone is an important part of the coastal ecosystem. Picture Maine's rocky coastline; close to the water the rocks are getting splashed with water, which sometimes flows over them, and as the terrain reaches land, the rocks increase in elevation. At high tide, the spaces between the rocks fill with water creating pools of water, called tide pools. At low tide the water recedes back into the ocean, leaving the tide pools, a habitat for different creatures: crabs, sea urchins, starfish, and lobsters. To learn more about the different zones within the intertidal zone and what creatures live there, check out the **Additional Resources** section.

On the information sheet, you may notice that it states that both cod and haddock populations off the coast of Maine are decreasing. Cod populations began decreasing in the early 1980s due to overfishing. Although quota limits and catch limits were put in place, the populations continued to decline, meaning that other factors were contributing to this trend. Researchers found that the quick warming of coastal Maine ocean temperatures was the leading cause, making the habitat less liveable for the cod. The warming temperatures decreased the number of spawning cod and the probability of them living through adulthood. For more information visit the **Warming waters a major factor in Gulf of Maine cod collapse page** (NOAA Research News website): research.noaa.gov/article/ArtMID/587/ArticleID/597/Warming-waters-a-major-factor-in-Gulf-of-Maine-cod-collapse

As another ground-dwelling species, haddock has a similar history of being overfished. However, haddock populations don't seem to be hit as hard from warming temperatures in the Gulf of Maine.

Materials

- Fish Memory Game Cards
- Fish Memory Game Information Sheets
- Zone map
- Whiteboard
- Paper
- Pencils
- Colored pencils

Vocabulary

- **Aquatic =** relating to water
- **Intertidal zone =** the shore area that is covered by water at high tide and exposed at low tide (i.e. sand beaches or muddy flats)
- **Diadromous =** fish that migrate between fresh and saltwater (i.e. alewife)
- **Landlocked salmon =** a species of salmon that live in lakes and ponds in eastern North America (they are related to Atlantic salmon, which you may be more familiar with.

Methods

Engage

1 Explain to youth what they will be doing today, then lead them through a brainstorming exercise. "Today we're going to be exploring the types of aquatic animals that are fished for in Maine. Before we start, I want to know what types of fish or other aquatic animals you know are fished for in Maine."
   - Have youth share as a whole group what they know and record their ideas on the whiteboard (or they can come up to the board and record themselves!).
   - If needed, here are a couple of prompts you can share to get youth thinking: "Have you ever gone fishing? Do you remember what you caught?" "Consider the types of water we can fish in: lakes, ponds, rivers, and the ocean." "If you have ever gone to a grocery store that has a fish or seafood section, what have you seen?".

Explore

1 Split youth up into groups of 3.

2 Give each group a set of cards, an information sheet, and a zone map.

3 Explain to the youth that this is a game of matching. In each set of cards, there are several aquatic animals that are fished for in the state of Maine. There are two cards for each animal. Their goal is to find the matches.
   - Have youth shuffle the cards so they can't see the animals.
   - Have them organize the cards face down in a grid formation, so they are in straight lines and do not touch (see right).
     - You can use the whiteboard to show youth what this looks like.
   - Each person in the group will get a turn to flip over TWO cards. If the cards match, that person gets to (1) keep those cards, (2) find the animal on the information sheet, and (3) read it out loud to the rest of the group.
     - Then, have youth collaborate as a group and place the animal on the zone map where it would most likely be found. For example, on the information sheet it says "[clams] are found in the intertidal zone," so youth should place the clam card(s) on the intertidal zone on the map. If youth have trouble here, point them to the information sheet where it speaks to where they are found. Looking at the sheet and map side by side can be helpful.
   - If you don't get a match, you flip the cards over and the next person goes.
   - Whether you get a match or not, it's the next player's turn.
   - Have youth continue to play until all the cards are matched.

- Some groups may finish quicker than others. If a group is quick and is done early, they can begin to play again (first shuffling their cards to mix them up! Facilitators should walk around and try to give 'time left' updates (1 minute left/the last turn), even if some groups aren't completely finished).

4 Once youth are done playing, ask them to collect the cards in a pile so you can go around and collect them.

5 Compare the aquatic animals brainstormed before this activity and the animals that were used in the game.

- "What new animals were you introduced to? What animals surprised you?"
- "Looking at the animals and where they are found, do you see any patterns?" Below there are a few listed. They can be used to prompt youth if they are confused about what you are asking or having trouble seeing them. Patterns can be about anything, what the animal looks like, where they are found or how they are caught!
  - Clams and lobsters have unique ways of being caught (dug with a clam rake and caught with a trap, rather than a net or line).
  - Cod and haddock populations are both declining.
  - Besides the lobsters, the fish don't seem to have very bright colors.

Explain

1 All of the aquatic animals we explored and learned about are caught or fished for in the state of Maine and are used for either bait to catch other fish or for food.

2 Youth may have noticed reading the information sheet that aquatic animals are not all found in the same place. Some of them, like haddock and cod, are found near the ocean floor. Clams, on the other hand, are found in the intertidal zone, a shore zone that is covered by water at high tide and exposed at low tide.

- Use the map to point out these various places and have youth notice the differences between them.
  - Identify the three different places on the map: a stream, the intertidal zone, and the ocean.
  - "How are the ocean and stream similar?" They are both water and they are both blue on the map. "How are the ocean and stream dissimilar?" Youth may know that the stream contains freshwater and the ocean contains saltwater. "How is the intertidal zone dissimilar from the stream and ocean?" It's not always covered by water, you can walk on it and you can see it (hard to see underneath the water).
- If the youth are less familiar with the ocean or coast, it may help to explain that the end of the intertidal zone is where the seaweed, shells, and wood debris ends up (this ocean debris is where the water is at high tide, so the tide pushes it all up). If the youth have ever been to the beach the intertidal zone and is usually more wet and firm. The really soft and light sand usually sits above the intertidal zone.

Elaborate

1 Allow youth to choose one of the aquatic species that is fished for in the state of Maine to draw.

2 Hand out paper, pencils, and coloring materials.

3 Give youth time to draw their creature and color it in. Using the information in the sheet, youth can also draw where they would be able to find this creature (ocean, intertidal zone, river/freshwater). The zone map can be used to reference where the animals are found as well.

- **Option:** You may choose to share the video in the Additional Resources section (#4) from the Marine Stewardship Council to highlight the importance of fisheries, as well as some of the obstacles and solutions.

4 Allow youth to share some of their drawings with the group.

- You can start this as soon as youth start to finish, this will allow some youth to share and listen while others are continuing to draw.
- Keep the sharing time to a minute or two, this will allow most all youth to share. If you cannot get to everyone, allow youth to leave the picture with you so you can appreciate it and give it back at the next meeting.
- To engage with youth about their drawings you can ask questions or make observations: "Why did you include __?" "I notice you included a lot of detail about __ (colors, scales, habitat)." "Can you explain your thought process while drawing?"

Evaluate

Discuss the following questions as a whole group.

1 "What was it like to work in a group?"
   - "What was it like to have to collaborate and agree upon a spot to put the animals on the map?"

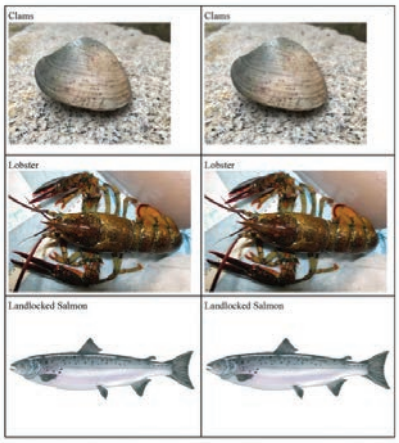
2 "Do you have any new thoughts or feelings about aquatic animals?"
   - "How about when you were drawing them?"

Additional Resources

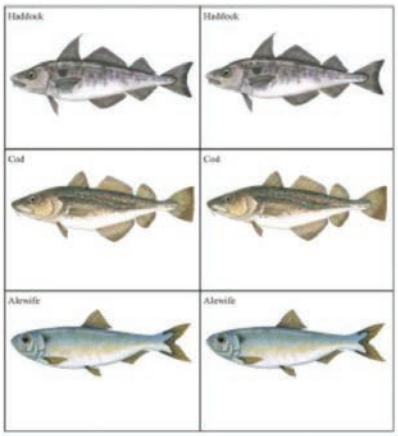
- Article on declining cod populations from NOAA: *Warming waters a major factor in Gulf of Maine cod collapse* (NOAA Research News website)
- This virtual storyboard paints a picture of what the intertidal zone is, what lives there, and why it is important: *The Rocky Intertidal Zone of the Gulf of Maine* (Research in Ecology, Evolution and Marine Biology, Bowdoin College, 2019 website)
- Interactive webpage that allows youth to explore the different zones, the creatures that live there and answer some questions about them: Life in the Intertidal Zone (Ocean Explorer NOAA website)
- *Commercial Fisheries State of the Gulf of Maine Report* (PDF), includes the history of fisheries in Maine, which types of fish and organisms are commercially fished in Maine, as well as the threats, impacts, and actions of fisheries. This may be useful for specific facts and information, and for more background on commercial fishing, specifically in Maine.
- An educational short film on fisheries, "My dad the fisherman," on the Film and clips page (Marine Stewardship Council). This video inspired the flow of this lesson, incorporating both factual information and socio-cultural connections to commercial fisheries.

Supported by National Science Foundation award #OIA-1849227 to Maine EPSCoR at the University of Maine.

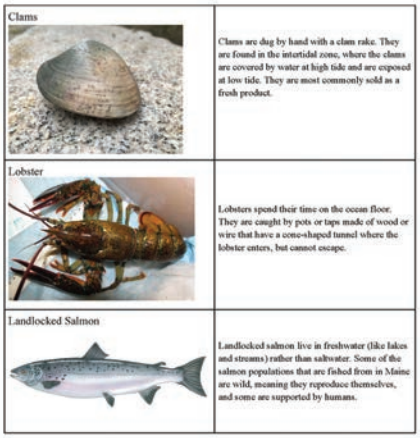
This project is part of the RII Track-1: Molecule to Ecosystem: Environmental DNA as a Nexus of Coastal Ecosystem Sustainability for Maine (Maine-eDNA) at the University of Maine.



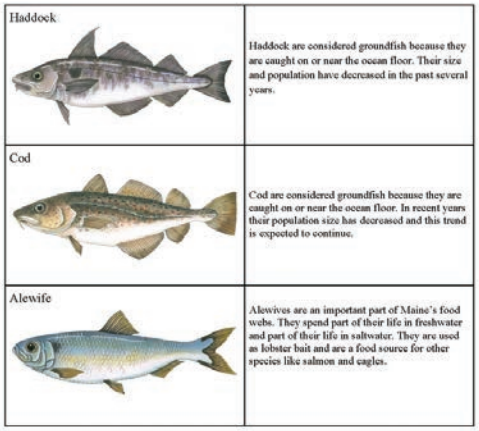
Fish Memory Game Cards Layout #1



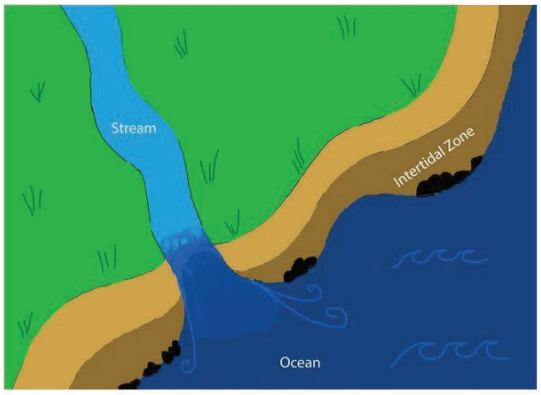
Fish Memory Game Cards Layout #2



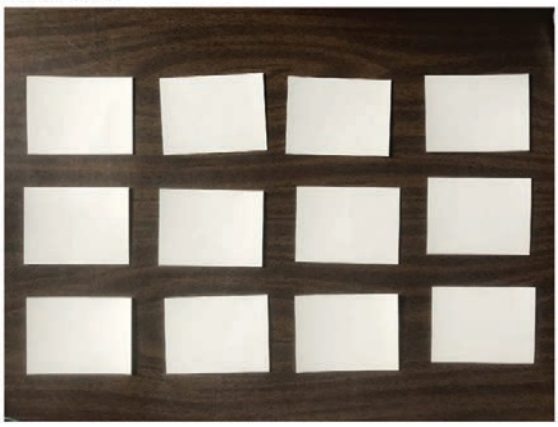
Information Sheet #1 for Fish Memory Game.



Information sheet #2 for Fish Memory Game.



Zone Map. Drawing provided courtesy of the Maine Department of Marine Resources Recreational Fisheries program and the Maine Outdoor Heritage Fund.



Grid formation for organizing cards.

THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 2: Species Range

Topic: Youth will learn that where fish and aquatic animals live depends on what they need to survive.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1 Explain some of the habitat factors that are involved in a species range.
2 Discuss how knowing species ranges can be beneficial as a fisherman, individual, and scientist.
3 Defend their reasoning of where they put animals using evidence.

Background Information for Facilitator

In particular environments or habitats, some animals survive well, some less well, and some cannot survive at all. Factors that influence this are temperature, humidity, accessibility to water, or saltwater versus freshwater. These are classified as **abiotic** factors, non-living factors, or things in an ecosystem. When looking at these factors on a map, you can start to understand areas in which species are able to live. This is called species range, the range in which a species can survive, grow and reproduce. By looking at a species range, fishermen are able to narrow where the animals they are looking for might be. For example, clams are found in the intertidal zone, so there is no need to look for them in the middle of the ocean. Certain fish also live within temperature ranges, so looking for those fish in the right temperature waters narrows where you can find them. In other words, due to the data scientists have collected, they have narrowed down the areas in which species can survive and therefore be found.

There are also **biotic** factors, living factors, that influence whether a species can live within a certain area, which includes things like food, predators, other animals competing for survival, and plants. This isn't a key focus in the lesson and activities below, but feel free to include it in your discussions!

Materials

- Map
- Species Range Table
- Stick-able fish species
- Whiteboard and marker

Vocabulary

- **Species =** iving animals (or plants) that are closely related
- **Habitat =** the natural home or environment for a living animal (or plant)
- **Species range =** where a specific species will be found during its lifetime
- **Depth =** distance from the top to the bottom of something; how deep something is
- **Freshwater =** water that is not salty, can be found in lakes, ponds, streams, and rivers, but not the ocean.
- **Saltwater =** water that has salt in it, which includes all seawater
- **Abiotic =** non-living things or factors in an ecosystem (ex. rocks, temperature, weather)
- **Biotic =** living things or factors in an ecosystem (ex. plants, animals)

Methods

Engage

Ask youth the following questions:

1 "What do you think determines if a species can live within a certain environment or habitat?"
   - If needed, define what a species and habitat are.
   - Record these ideas on a whiteboard or poster board.

2 "What about fish and aquatic species? What factors limit where they can live?"
   - If youth need some help here, they can look at the different habitats on the map and ask them what similarities and differences they notice between habitats.
   - Add these to the list of ideas.

3 Take a moment to explain the difference between abiotic and biotic factors to youth. Then, categorize some of the examples youth gave as either abiotic or biotic.

Explore

1 Split youth up into groups of 2 or 3, each group representing a group of fishermen that are working together to figure out where they should fish.

2 Give each group a map, a set of stick-able fish, and species ranges.

3 Encourage youth to work together to map out where they are going to fish for the day depending on where their species are most likely to live, according to the species ranges given.

4 Do one together as a group. Pick one aquatic species and talk through your reasoning for placing it where you did, taking into consideration all three abiotic habitat factors (temperature, depth, and type of water) that go into determining a species range.
   - For example, the alewife could live in the uppermost lake on the map. The temperature of the lake falls within the alewife's range, as well as the depth. Because alewife can be found in both saltwater and freshwater, they could be found in a lake.

5 Give youth time to work through the rest in their groups.

6 Check-in with groups to see how they are constructing explanations on where to place species based on evidence: "Why did you put the [species name] there?" "What evidence supports your explanation?"

7 Come back together as a large group and allow youth to share their explanations of species placement using their maps and evidence.
   - "Using your map, can you explain where we might find a [species name]? What evidence do you have to support your explanation?"
   - "Do you agree or disagree with this explanation?" "If you disagree, can you share your explanation with evidence?"

1 Factors that limit where a species can live are salinity (saltiness of the water), temperature, and depth. The data scientists collect about this helps us understand where to find species.

   - Have youth think about deer populations. "Do any of you take walks in the woods or play in the woods?", "Do any of you hunt deer or know someone who does?"

2 Knowing where deer populations are is very helpful! Based on the data collected about the habitat they live in and their range helps us hunt in areas where deer are and populations are high. For example, we know deer don't live in deserts, so we wouldn't try to hunt in that habitat.

3 Check-in with youth to see if they understand this concept. "How does this model (map and species ranges) represent an ecosystem?", "How does this model represent what happens in real life?", "Why do you think this information would be helpful/useful?"

   - In relation to fish and aquatic species, this information about where species live helps fishermen decide where to fish. Knowing where deer are found can help hunters, knowing where fish are can help fishermen. For example, you wouldn't try to catch tuna, a saltwater fish, in a pond.
   - The area where a species can live during its lifetime is called a species range. It's an area that meets the requirements for all the species' habitat factors (temperature, type of water, depth, etc.).

Evaluate

Discuss the following questions as a whole group:

1 "What was your goal for this activity?"

   - "How did you get to your goal?"

2 "Acknowledging a growth mindset, did you find anything challenging today?"

   - "How did getting through that challenge help you? Make you feel?"

Extension

1 Share with youth maps of aquatic species distributions. Here is one example, located on page 4 of **Climate Change Indicators in the United States: Marine Species Distribution, August 2016** (EPA) website at extension.umaine.edu/4h/stem-toolkits/sustainable-fishing/activity-2-species-range/

2 Have youth consider how a species range would shift or change with climate change.

   - "As water temperatures warm, where do you think these species will go?"
   - "How do you think this impacts fishermen and fisheries?"
   - For a story about how the Gulf of Maine Research Institute (GMRI) has used ecosystem modeling to predict where species will go, visit the **Following Fish on the Move** website (GMRI) at www.gmri.org/stories/following-fish-move-ar2018/

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Species	Location	Temperature	Depth
Alewife 	Ocean, rivers, stream and lakes	39 - 77 °F	56 - 100m
Tuna 	Ocean (come to Maine coast seasonally)	66 - 75 °F	20 - 120m
Landlocked Salmon 	Deep, cold large lakes and ponds that have rocky shores and bottoms	50 - 75 °F	20 - 40m
Cod 	Ocean	32 - 55 °F	20 - 200m
Lobster 	Ocean floor on rocky, sandy or muddy bottoms	64 - 73 °F	4 - 50m
Key: °F = degrees fahrenheit m = meters			

Species Range Table

Species Ranges

Note: These ranges are restricted to the open water fishing season between August and October.

Species	Location	Temperature	Depth
Alewife 	Ocean, rivers, streams, lakes and ponds	4 - 25 °C	56 - 100m
Tuna 	Ocean (come to Maine coast seasonally)	19 - 24 °C	20 - 120m
Landlocked Salmon 	Deep, cold large lakes and ponds that have rocky shores and bottoms	10 - 24 °C	20 - 40m
Cod 	Ocean	0 - 13 °C	20 - 200m
Lobster 	Ocean floor on rocky, sandy or muddy bottoms	17 - 28 °C	4 - 50m
Key: °C = degrees Celsius (Fahrenheit to Celsius conversion is subtract 32 then multiply by 5/9) m = meters			

Species Range Table with fields in the first row for Alewife circled.

Map

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4-H STEM Toolkit

Activity 3: Finding Fish

Topic: Youth will be introduced to what a fishery is and will explore various fishing techniques.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1 Explain why it's hard to find fish.
2 Explain how sonar technology works to help find fish using observations from the demonstrations and models.
3 Carry out a scientific investigation.

Background Information for Facilitator

A fishery is an area where fish are caught for commercial purposes (i.e. catching, processing, and selling fish). Fisheries can be a defined area of the sea or it can be an area where a collection of fishing boats have agreed upon. Most of the time there are different fisheries for each kind of fish, so one fisherman's boat could be just for lobster and another one could be just for salmon. A big question: how do fishermen find fish in bodies of water that are so large? Fishermen use the knowledge that has been passed down from generations (and/or mentors) through story and song, they take from their experiences (ex. this is where the salmon have been at this time of the month in the past few years), and they utilize technology. One example of that technology is the sonar technology onboard boats that send sonar sound waves into the water. When the sound waves hit objects, such as fish, those waves are reflected back to the boat, allowing the fishermen to 'see' where fish are underwater. This is one way to get a sense of where fish populations are in bodies of water. Searching for fish and collecting them is only one step in the process of a fishery. Other steps include the process or mechanisms of the vessel, techniques to catching fish, sorting them, and selling them. However, those all depend on collecting enough fish to sustain the operation and the people involved financially.

Materials

- Aluminum pie plates
- Water
- Eyedroppers
- Rubber ball for demonstration
- Paper towels

Vocabulary

- **Fishery =** an area where fish are caught for commercial purposes, usually including the catching, processing, and selling of fish
- **Sonar technology =** fish-finding technology that sends and receives sound waves multiple times a second. When the waves hit something that is different than water, they are sent back to the boat, appearing as 'echos'
- **Echolocation =** the location of objects using sound wave reflection
- **Population =** a group of the same animal in a certain area

Methods

Engage

1 "During the last lesson, we learned that knowing an animal's species range helps us know where to find them, where they could be. How do we know they are actually there?"
   - Provide an example or give an analogy. For example, say you work as a fisherman for a place that sells fish. They tell you they have a demand (need) for landlocked salmon. You know their species range (based on what we learned last class we know they live in large, deep cold lakes and ponds with rocky bottoms, which tend to be the depth and temperature they like). This means you know where to look, where they likely could be. How do you know for sure that they're there? What evidence tells you they are present?"
      - Another example could be a school, students being the species. We know that classrooms are a part of a student's range, that students could be in the classroom. What evidence could you use to make the claim that students are present?"

2 Ask youth how they know when an animal is present. "What evidence tells us an animal is there?"
   - For example, a deer can leave behind fur, tracks, scat, and antlers.
   - We can hear squirrels 'chipping', they also leave behind tracks and acorn scraps.

3 Ask youth to consider what aquatic animals leave behind. "How do you know that a fish is present?" "What evidence do you think they leave behind?"
   - "What makes it hard to find fish?"
   - It's harder to tell when aquatic animals are present because we can't see underneath the water, the body of water can be really deep, they can swim away or could be hiding.

Explore

1 Let's take a moment to imagine what that is like.
   - Set the scene. You are going to be a fish under the surface of the water. The youth are going to be fishermen, trying to pinpoint exactly where to cast their nets to catch you.
   - Have all youth close their eyes. Ask one person (could be a youth or another facilitator) to count to 10. When the counting is happening, move to another location in the room as quietly as possible. Once the counting is finished, have youth, with their eyes still closed, point to where they think you are in the room.
   - Have the youth open their eyes. Were they correct?
   - You may have to try this a few times for (1) youth to understand when to open and close their eyes and (2) to drive home the concept that when you can't see where things (fish or people) are moving it's hard to know where they are! This is similar to fishermen trying to find fish underneath the water.

2 Try this activity again, but this time clap as you walk around and have the youth point to where they think you are, with their eyes closed.

- Discuss with youth how the first couple rounds (without sound) compared to the round(s) with sound.
- "Why was it easier to locate with sound?"

Explain

1 Some fishing boats have sonar technology on them that helps find fish. The technology sends sound waves to the water's floor and they bounce back to the boat. This happens multiple times a second. From the waves that are received or echoed back, a picture forms on a screen, showing some idea of what is underneath the water.
   - Ask youth if any of them have seen or used this before. It can also be called a 'Fish Finder'. If so, ask them to tell the group about their experience and what the picture looked like.

2 Below are two analogies to help drive home the concept of sonar technology. You can also share the video in the Additional Resources section if you have access to technology.
   - Analogy 1: Sonar technology is similar to how bats find their food using echolocation. Bats send out sound waves, which they receive back. These sound waves communicate to the bat the size and structure of objects around them. The sound waves bouncing off a tree are going to sound different than those bouncing off a moth.
     - Once again, if youth are familiar with echolocation, you can ask them to share what they know and make any clarifications.
   - Analogy 2: Bounce a rubber ball on the ground. Tell youth to imagine the ball as the sound waves. They are released from the boat's technology (your hand) and bounce back when they hit an object. Just like the ball, the sound waves communicate if an object (the floor) is closer or far away.
     - You can show this by bouncing the ball off the floor and then a table. If you bounced the ball off of every surface in the room you could map out the whole room!

Elaborate

1 Split youth up into small groups.

2 Hand out aluminum pie plates to each youth.

3 Fill each tray with some water (enough to cover the bottom, about halfway full).

4 Give every youth an eyedropper and allow them to use the water in their tray to fill the eyedropper.
   - Demonstrate how to use an eyedropper: place the opening of the dropper in the water so it is completely submerged. Then, squeeze the end of the dropper and take it out of the water.

5 Have the youth drop one drop of water into the tray. Ask them to make some observations and share them with their group.

6 Ask youth if they have any questions they are wondering about or "what-ifs" about this phenomenon they are observing.
   - If needed, share some of your own! Here are some examples: "What determines how the ripples move?" "Can you make the ripple effect different" "What happens if I change the height of the dropper?"

7 Explain to the youth that together you will be carrying out an investigation. Have them choose one question to investigate (either one of theirs or yours).
   - Share what you know so far. "What do we know from our initial observations?" (option to write these out on the whiteboard).
   - "How should we change what we are doing to answer the question?"
     - Make sure you're only changing one variable at a time (just the height of the dropper or the volume of water in the plate, putting an object in the water and leaving the other variables the same, etc.).

- Have youth make predictions of what they think is going to happen.
- Observe what happens when you change the variable.
- Have youth share observations.
  - "What happened?" "What was the effect?"
  - "What was the cause of that effect?" "What did you do?"
  - "Were your predictions correct?" "Did the effect surprise you?"

8 Allow youth to carry out an investigation of cause and effect in their groups, coming up with a question they can investigate collaboratively.
- Have them choose another variable to test. You may want to have them check with you before they get the go-ahead to investigate.
  - Have them make predictions of what they think will happen.

9 Allow groups to share what happened. Encourage youth to ask each other questions!
- "What happened?" "What was the effect?"
- "What was the cause of that effect?" "What did you do?"
- "Were your predictions correct?" "Did the effect surprise you?"

10 Clean up before coming back to discuss as a group.

Evaluate

Have youth turn to someone next to them to discuss the following questions.

1 "How would you explain to someone else how sonar technology works?"

2 "How could sonar technology help fishermen?"

Additional Resources

The Gulf of Maine Research Institute (GMRI) website hosts a video, Visit the **Gulf of Maine, Explained: Fisheries Acoustics** gmri.org/stories/gulf-maine-explained-fisheries-acoustics/?play=true (Gulf of Maine, Explained, May 30, 2018), which describes how sound can be used to tell us how deep fish are in the water, how many there are, and what they are.

Aluminum pie plate with eyedropper.

Supported by National Science Foundation award #OIA-1849227 to Maine EPSCoR at the University of Maine.

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4-H STEM Toolkit

Activity 4: Battle for Fish

Topic: Youth will play a coordinate grid game to simulate the act of attempting to find fish and then 'catching' a population once it is found.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1. Simulate the process of catching fish once they are found.
2. Define what bycatch is.

Background Information for Facilitator

Before fish are caught, they have to be found. One way fish are found is by using sonar technology, a technology that was explored in the previous lesson. Finding one fish can mean there is a whole population (one fish → many fish). When catching large amounts of fish, there is a potential consequence of bycatch. Bycatch are the organisms caught while fishing that were not intended to be caught. Anything can be bycatch, whether it's dolphins or sea turtles that have accidentally been caught or the hundreds of fish thrown back after quotas have been reached. Bycatch is one factor that can make fisheries and fishing unsustainable, but efforts can be made to combat bycatch.

Materials

- Pony beads (10 per youth)
- Coordinate grids
- Bycatch grids
- Whiteboard or poster paper
- Folders (1 per youth)
- Dry erase markers

Vocabulary

- **Bycatch =** the unwanted fish or other marine species that are caught unintentionally while trying to catch another type of fish.

Methods

Engage

1. It is difficult to find fish and other aquatic species in water because bodies of water are so big! Not only do they stretch far but they can also be very deep.
2. Draw a grid on the board. Then mark one of the squares.

- Ask youth how they would communicate where the mark is. "How would you describe its location?"

3 Add numbers to the top of the grid and letters to the side of the grid.

- "This time can you use the letters and numbers to describe the square with the location of the mark?"

4 Practice. Change the location of the mark and ask again.

5 If youth understand the concept of using a grid, let them know they'll be using this skill for the next activity. If they are not understanding the concept, explicitly explain how to use the letters first and then the numbers (ex. E6) to describe a mark's location.

Explore

1 Split youth into pairs.

2 Distribute the plain coordinate grid, folder, and 10 beads to each youth. The folders are to create a barrier so their partner can't see their sheet.

3 Explain to the youth that they are going to be playing a coordinate game where they are going to be looking for fish. Youth may notice that this game is similar to another popular game they have played.

- First, youth use the beads provided to create 3 different fish populations on their sheet, a population of 5, 3, and 2. The populations of fish have to be 'connected', going either vertically or horizontally. See the example at the end of this toolkit.

- Have youth play rock paper scissors to decide who goes first. Note: If you have an odd number of students, this game still works (youth A asks youth B, youth B asks youth C, youth C asks youth A).

- The first person to go will call out a number and letter that correspond to the grid. If the partner has a bead (or fish) on that space, they take it off, symbolizing that the fish was caught. If the person whose turn it is catches a fish, they are able to take another turn. If they do not catch a fish, it's the other person's turn.

- Explain to the youth that they can use the dry erase marker to record where they have guessed (putting an X) and which guesses they caught a fish (putting an O). This will help ensure they don't guess the same spot more than once. See the example to the right (or share slide 5 in the slideshow with youth).

- Continue to play.

4 Bring the group back together to discuss.

- "What emotions or feelings did you experience during this activity?"

- "How did you feel when you caught the 5 fish population compared to the smaller populations?"

- "How did you feel when you guessed and it was not a catch?"

- "What was easy about this activity?"

- "What was challenging about this activity? Why? How did you solve it?"

- "What strategies did you use to find fish?"

- For example, if youth caught fish in one spot did they continue to guess around that spot? Why not guess somewhere random?

Explain

1 What event does this activity model?" "How does this activity relate to real life?"

- Youth are modeling catching fish. Facilitators should be sure to explain this if it does not emerge from youth, the concept of modeling for scientific practice is important.

2 "What is the cause and effect of this event?"

- "What is a cause that would make you fish?" Maybe it's your job, you're hungry, feeding your family, or maybe it's for fun.
- "What is the effect of the event?". The effect is that you are catching fish, removing them from their habitat and aquatic system. Reasons that you may catch fish are feeding for your family, income, or pleasure.

3 Depending on what youth bring up in their answers above, you may want to explain in detail what the activity models: This activity simulates what happens when we, or fishermen, fish. If we cast a line or net into an area and don't catch any fish (blank space on the grid), we try another spot. Once we find fish somewhere we continue to fish in that spot, hoping it's a big population.

Elaborate

1 Explain to the youth that they are going to battle for fish again, but this time you're going to slide a bycatch grid behind the original grid. Don't look!

2 Have youth play the game using the same rules as before.

3 After they have completed the game, have the youth take the 'bycatch' grid out from behind the one they used to play with.

- Explain that the squares with animals in them that correspond to the ones with marks on them (where they attempted to catch fish) symbolize bycatch.
- Explain various forms of bycatch: (1) species that were not intended to be caught, but were on accident, (2) fish that were thrown back because quotas have been filled, are too small or too big, and (3) protected species that have to be thrown back.
    - When fishermen cast their nets into fish populations that they have found, depending on the nets and methods they use, sometimes they collect species they don't want. For example, casting a big net with small holes may cause you to collect an endangered sea turtle or fish that are too small to be sold, but cannot escape through the small holes in the net. You can also share the Marine Stewardship Council video on bycatch in the **Additional Resources** section.
    - The bycatch grids youth have in front of them actually simulate the bycatch that occurs in real life. About 20% of fish caught by fisheries are discarded before they reach the port. The bycatch on the grids is on ~20% of the squares (10 out of 50).
    - The animals on the bycatch grid are some examples of species that are impacted by bycatch. For example, about 150 sea turtles are caught every day.
    - "Did any of you have bycatch?"
    - "How does that make you feel?" "What might play into your fishing strategy as a result of this experience?"
    - Have youth think about cause and effect again: "What is the cause and effect of the model now?". The cause of the event, fishing, maybe the same as before, but now the effects are larger. Not only are targeted fish being caught but also bycatch.

Evaluate

1 "What did you learn about life through this activity?"

2 "Why would it be important to have strategies, or familiarity with fishing practices, when catching fish? Can you think of other instances where this might be helpful?"

3 "Can you think of any ways fishermen could reduce bycatch?"

- The Marine Stewardship Council video shares two ideas: (1) modifying the size of the holes in the nets and (2) using bright colors on the nets to ward off seabirds.

Extension

1 Species range connection: If youth completed the 'Species Range' lesson, discuss with them how including temperatures or areas of freshwater and saltwater on the map would change the game.
   - Including a species range on the grids would limit where you could put a species and would narrow down your search for that species.

2 Bycatch: Explore ways in which fishermen could reduce bycatch.
   - Think about the way nets are created and the size of the holes. "Can they be individualized for the type of species being caught?"
   - "Besides nets, what other ways could we reduce bycatch?"

Additional Resources

1 This is a 1-minute video (good one to show students) from the Marine Stewardship Council – Sustainable seafood which quickly explains what bycatch is, why it happens, and how some fishermen are changing their techniques to help solve the problem: **What is bycatch and how can it be managed?** www.youtube.com/watch?reload=9&v=_3od7CqoQfs&feature=youtu.be.

2 This is a PDF document produced by Oceana, March 2014 (Authors: Amanda Keledjian, Gib Brogan, Beth Lowell, Jon Warrenchuk, Ben Enticknap, Geoff Shester, Michael Hirshfield, and Dominique Cano-Stocco) explains what bycatch is and why it's a problem in U.S. fisheries: **Wasted Catch: Unsolved Problems in U.S. Fisheries (PDF)**

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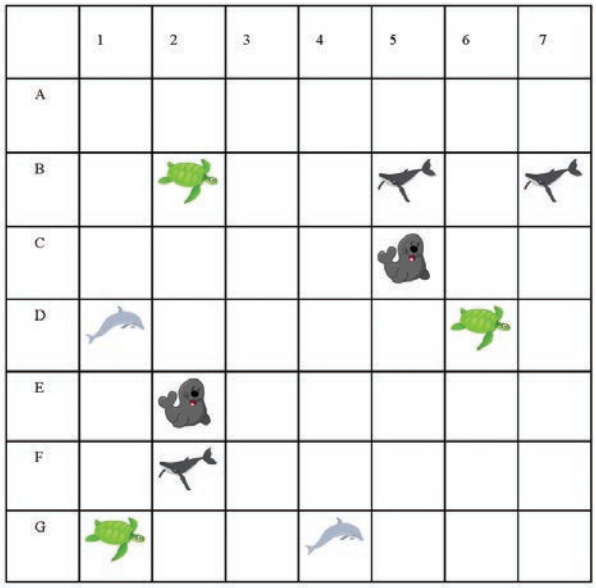
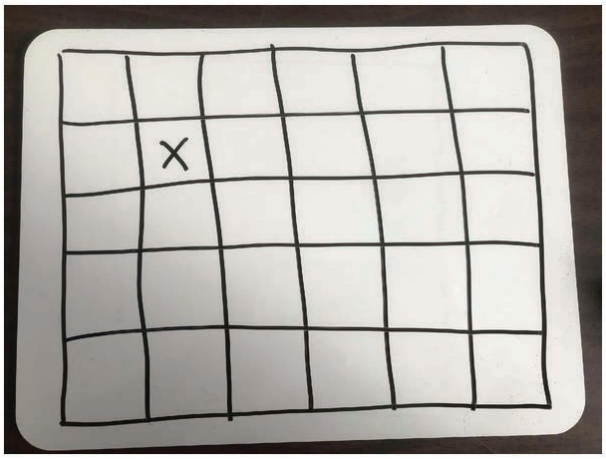
	1	2	3	4	5	6	7
A							
B							
C							
D							
E							
F							
G							

Create 3 different fish populations:
One with 5 fish
One with 3 fish
One with 2 fish

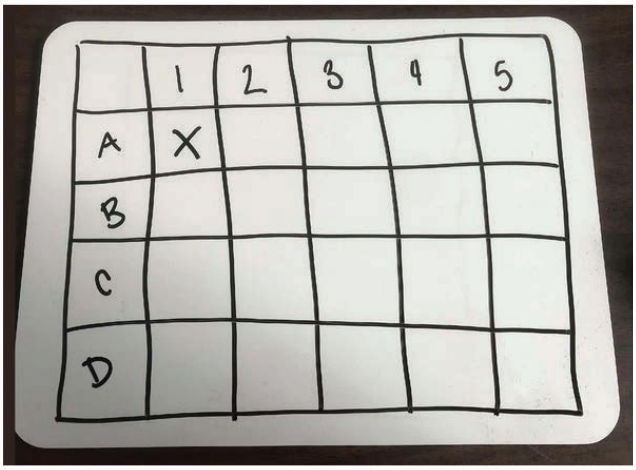
Battleship fisheries coordinates grid



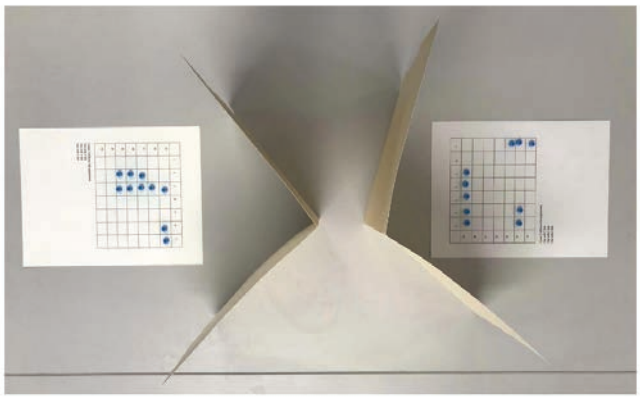
Bycatch-grid



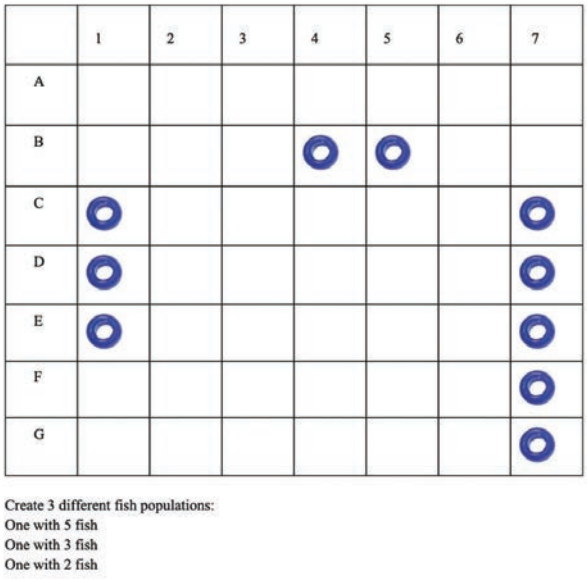
Example:a grid on the board



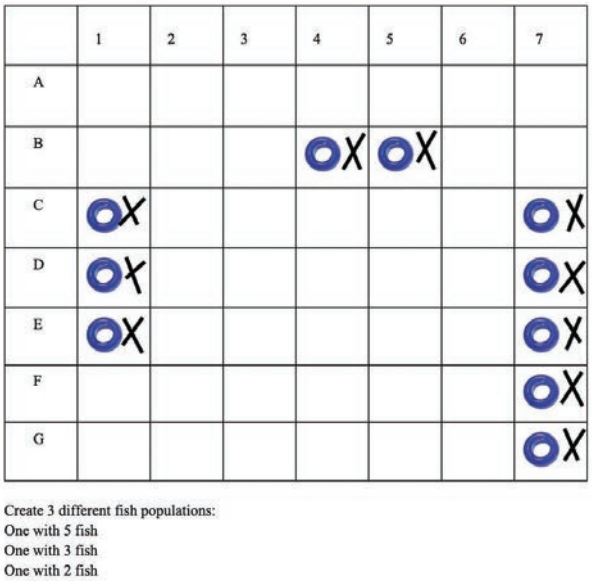
Example: adding numbers to top of the grid



Example: folders used create a barrier so their partner can't see their sheet.



Example: fish have to be 'connected', going either vertically or horizontally.



Example: using X and O indicated where they have guessed (putting an X) and which guesses they caught a fish (putting an O).

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4-H STEM Toolkit

Activity 5: Sustainable Fishing

Topic: Youth will play the role of fishermen in a fishing simulation that demonstrates the differences between sustainable and unsustainable fishing methods.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1. Compare and contrast the differences between fishing sustainably and fishing unsustainably.
2. Explore the difficulty in managing sustainable fishing.

Background Information for Facilitator

According to the Marine Stewardship Council, sustainable fishing has three branches: (1) sustainable fish stock, (2) minimizing environmental impact, and (3) effective fishery management. Keeping and maintaining a sustainable fish stock ensures that enough fish are left in the ocean after harvesting to reproduce and maintain population sizes for future generations (and future fishing). Minimizing environmental impacts helps support the quality of the fished ecosystems as a whole. This may include using biodegradable materials or not overfishing a population. Effective fishery management includes the laws and policies that need to be followed as the environmental circumstances around fishing change and update. **Why is sustainable fishing important?** Sustainability, in general, implies that the resources available now will also be available in the future, for future generations. For example, the Wabanaki people have lived in the area we call Maine for thousands (at least 9,000) of years. They have depended on the resources that this area provides, which they are able to hunt, fish, and gather off of. Due to the relationship they have with their resources, they are able to live off of them, generation after generation. The Wabanaki people practice what is called relational living, which means they see and value fish, water, animals, and plants as loved ones or family, doing everything in their power not to hurt them. When they need to take from one of these resources, they ask for permission, and only take a living thing when it is willing to give its life. For example, when a fish is offering its life and is caught, tobacco is offered in gratitude and to provide thanks. In order for the fish to return, they have to be respectful, correct poor behavior, and apologize when needed, just like we do when we hurt the feelings of friends or family. This is one example of sustainability.

Overfishing is a major factor of unsustainable fishing. It is when too many fish are caught that the population cannot reproduce enough to maintain a healthy size. Overfishing can deplete whole populations and species, which can have devastating results: lost jobs and low supply. Other unsustainable fishing practices are illegal fishing and destructive fishing. Illegal fishing includes the illegal, unreported, and unregulated fishing that happens when fishermen and boats fish outside the law (catching more fish than allowed, fishing out of the regulated season, etc.) or boundaries. Examples of destructive fishing are when fishermen use cyanide to stun fish before catching or using explosives to kill fish so they float to the surface for an easier catch. All of these unsustainable fishing practices not only do harm to the fish populations but also damage habitat, ecosystems, and other marine life.

Note for Facilitator: *The first activity in this meeting asks you and the youth to utilize a Venn diagram. The purpose of the diagram is for youth to illustrate the relationship between two concepts. It looks like two large circles, overlapping in the middle. The overlapping section in the middle shows commonalities, whereas the sections that do not overlap do not share traits.*

Materials

- Pony beads (10 per youth)
- Whiteboard
- Dry erase marker
- Spoons
- Aluminum bowls
- Data collection sheet

Vocabulary

- **Sustainability =** using resources in ways that meet the needs of the present but do not deplete the amount for future generations
- **Unsustainability =** using fishing and harvest methods that lead to declining fish populations, harm marine life, and damage ecosystems.
- **Sustainable fishing =** fish are harvested (caught and sold) at a rate that does not decline the populations for future harvesting due to fishing practices.
- **Overfishing =** When too many fish are caught that they cannot breed enough to maintain a healthy population size

Methods

Engage

1 Have youth take a moment (a minute or so) and think about what the word 'sustainability' means to them.
   - Then, pair youth up and ask them to share their ideas with each other.
   - Come back together as a group and ask for volunteers to communicate the ideas shared within their pairs to the whole group.

2 Share with youth the perspective of the Wabanaki people described in the 'background information' above.
   - "How does this make you feel about your perspectives of sustainability?"
   - "Does this challenge you to think any differently?"

3 Draw a Venn diagram on the board or use poster paper. Label one side 'sustainable fishing practices' and the other 'unsustainable fishing practices.' Have youth brainstorm what could be some sustainable and unsustainable fishing practices, perhaps taking ideas from their previous conversations. Below is an example diagram with some ideas.
   - Possible prompts to start the discussion: "What allows you to go back to the same spot to fish year after year?" "When you fish, do you ever throw any back? If so, why (size limits, recreation fishing)?" "What types of actions or decisions would make it so you couldn't fish somewhere year after year?" "What is your relationship with the resource(s)? What about your relationship with others?"

Explore

1 Split youth into groups of 3 or 4.

2 Give each group a bowl. Explain to the youth that the bowl represents a lake in which they are going fish out of.

- Put 20 blue beads in each bowl. The beads represent fish.
- Explain to the youth that they are going to play the role of fishermen, collecting fish from the lake.
- Give each youth a spoon to fish with. Emphasize that they are only allowed to collect fish with the spoon, no hands!

3 There is an option for youth to use a data table as they move through this activity. If you choose to use it, have youth fill in the number of fish at the start for round one (20). See the example below.

4 Explain the rules:

- You have to collect at least two fish to survive and move on to the next round. If you don't collect at least two fish, you sit out a round.
- For each fish left in the bowl, one fish will be added. This represents reproduction that happens in fish populations. For example: if two fish are left, you will add two for a total of four to start the next round.
- Explain to the youth that they can all catch fish at the same time, but it only works if everyone is respectful.
- Give youth 1 minute to fish.

5 Play the first round. Walk around to observe youth, including how fast it takes them to complete a round (adjust the time if necessary). It's very likely that the stock will be depleted within the first minute. If this happens, take a moment to discuss what this means for future fishing.

6 If you are using the data table, at the end of the first round have youth share how many fish they caught individually. Put those numbers in the second column. Have youth add up all the fish as a collective and put that number in the last column. See the example below.

7 Come around and replenish populations (if applicable). If youth are using data tables, have them add the number of fish to start after replenishing to round two.

8 Play a couple of rounds.

- **Optional:** change how many fish get put back in the bowl after each round. This adds a real-life component to the game because the reproductive rates of fish are not always consistent year to year. Factors that can influence reproductive rates are stress, ocean acidification, nutrition status of females, physiological and ecological factors.

Explain

1 Over time, fisheries can be overfished, meaning too many fish are caught so there are not enough adults to breed new fish and maintain a healthy population. When fisheries are overfished, the seafood supply is low. People who depend on fish for their main food source or protein are not able to get that nutrition source. People may lose their jobs because there are not enough fish to catch.

2 Overfishing can be an outcome of the tragedy of the commons, which is a situation where individuals who have open access to a resource neglect the well-being of society for self-gain. Visit the **Atlantic Cod And The Human 'Tragedy Of The Commons'** (WPUR website) for an article (published December 03, 2014, by David Ropeik) and video that summarizes how the cod decline in Maine as a result of the tragedy of the commons. wbur.org/cognoscenti/2014/12/03/overfishing-georges-bank-david-ropeik

Elaborate

Pick some of the prompts below for youth to discuss:

1 "What happened to the fish populations as you completed more rounds?"
   - "Was it sustainable or unsustainable?"

2 "How did you make your decision of how many fish to catch?"

3 "How is considering others a part of sustainable fishing?"
   - "Think of a body of water that means something to you. How does that relationship to that place change the way you're thinking? Would it change the way you fish? Would it change how you think about fish?"
      - Option here to have youth close their eyes and think of a body of water. It could be somewhere they go swimming or fish. Maybe somewhere they go year after year, or maybe it's close to where they live. Encourage them to think about how they feel when they are there and their relationship to that place. Then ask them to consider how their new understanding of sustainability might change how they fish at that location.

4 "What else might feed on fish in a lake? How might they be affected by the fish population?"

Evaluate

1 Play the game again. This time, have youth come up with a strategy in their groups to try and maintain a healthy population of fish so everyone survives to the next round. In other words, make an agreement or contract.

2 Play. If youth are using the data tables, mark this round as the one after collaboration.

3 Come back together as a group and discuss the activity.
   - "How did you feel about playing the game with an agreed-upon strategy?"
   - "What did you learn about collaborating through this activity?"
   - "Was it hard to get everyone to follow it?"
   - "Did you agree on any consequences if you didn't follow your rules?"
   - "What did you learn about your own skill in communicating with others?"
   - "How can you use what you learned?"

Extension (there are three different options provided below)

1 **Venn diagram connection:** Revisit the Venn diagram you added to at the beginning of the lesson.
   - "After completing the activities, is there anything you want to add to the Venn diagram? Things you want to change?"
   - Depending on how youth connected with the lesson and what they found relevant, you may want to explore/discuss how unsustainable fishing methods affect the environment (whether that is the quality of water or food webs).

2 **Play another round:** Illegal, unregulated, and unreported fishing is another contributor to overfishing. The unsustainable practices of some can impact the fishing of everyone.
   - To communicate this concept with youth, have them play a round (perhaps after they have agreed upon a strategy) silently. In this round, no one is going to hold you accountable for your actions. If you choose to respectfully acknowledge the agreement, great! If not, no one is allowed to say anything to you or stop you.
      - "What are the consequences if one member doesn't abide by the agreed rules?"
      - It's hard to regulate fisheries acting sustainably because it's a big area to manage. This provides space for fishermen to be dishonest or not follow regulations, as authorities have to trust fishermen they are practicing sustainable methods of fishing.

- If youth used the data tables, ask them if there are any trends or patterns they notice.
    - "How would having this data be helpful to fishermen? Scientists? Policymakers? Big companies?"
    - "Who should be making these decisions or regulations?"

3 **Local connection:** If you have access to technology, you can look up the fish and game laws for catch limits in their area: **Statewide General Fishing Laws for Inland Waters** (Maine Department of Inland Fisheries & Wildlife) www.maine.gov/ifw/fishing-boating/fishing/laws-rules/statewide-laws.html

4 Article and video on overfishing Georges Bank: **Atlantic Cod and The Humans "Tragedy of the Commons"** (WBUR) December 3, 2014, by David Ropeik www.maine.gov/ifw/fishing-boating/fishing/laws-rules/statewide-laws.html

Additional Resources

Children's books:

1 *Old Enough to Save the Planet*. Be inspired by real-life children taking action against climate change. Written by Loll Kirby and illustrated by Adelina Lirius. This book highlights several youth who took sustainable action or implemented change to better their community and the environment.

2 *Plasticus Maritimus: An invasive species.* Written by Ana Pêgo, Bernardo P. Carvalho, and Isabel Minhós Martins. This book personifies plastic and dives into the different types of plastic in our ocean and the consequences of plastic pollution.

3 *World Without Fish.* Written by Mark Kurlansky and illustrated by Frank Stockton. This book addresses the issue that at the rate things are going, most of the fish we are familiar with will be gone in 50 years. It touches on the history of fishing, population fluctuations, the socio-economic aspects of the issue, and ideas for change.

NOTE: This activity is an adaptation of the lesson "Fishing for the Future" (The Curriculum Guide ©2002), currently available on the PBS website: **Fishing for the Future (PDF).**

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4-H STEM Toolkit

Activity 6: Crime Scene Scientists

Topic: By looking at evidence of animals, we can determine whether they have been somewhere. This is another way in which we can narrow our search for animals and gather information about where they actually are within their species range.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1 Identify evidence that is left behind by animals.

2 Explain how evidence can be used to identify which animals are present in an area.

Background Information for Facilitator

Similar to a human crime scene investigation, animals and plants can also leave behind evidence. Evidence can range from feathers, scat, bones, hair, and more, thus communicating that a species has been in that spot. Observing that evidence can tell you what species it's from and possibly how long it's been there. This is another way in which we can narrow our search for animals and gather information about where animals are within their species range. By looking at the evidence of animals, instead of catching the animals themselves (catching a bunch of fish in a lake to see how many fish there are or trapping animals to see how many there are in an area), we can consider this a sustainable way to determine if an animal is present.

However, this evidence doesn't stay around forever. Time and disturbances are factors of evidence decay. Feathers blow away, tracks wear down over time due to weather and foot traffic, and scat breaks down to become part of the soil. When we take a closer look at our environment (soil, water, sediment, mud, ice), can we find traces of evidence? We're going to find out!

Materials

- Animal signs scavenger hunt cards
- Small pieces of paper
- Pencils
- Plastic baggies
- Pocket microscopes
- Soil samples (if youth are unable to go outside)
- Paper

Vocabulary

- **Evidence =** facts that come from observations or artifacts
- **Habitat =** the natural home or environment for a living animal (or plant)
- **Inference =** a conclusion or explanation based on evidence
- **Soil =** the upper layer of the earth, where plants grow, consisting of a mixture of organic remains, clay, and rocks

Methods

Engage:

1 Ask youth to think about this question: "How do you know where an animal has been? What clues can you look for that give away the presence of something?" Then ask them to share their ideas.
   - If they need some help, give them an example: you know your dog was here because there is hair on the floor, you know a bird was here because there is a nest in a tree.
   - Have them share some examples.
     - "What do deer leave behind?"

Explore: (there is an indoor option if youth are unable to go outside)

Outside:

1 In this activity, youth go outside with scavenger hunt cards that list animals signs that could be found in the backyard/schoolyard. Before bringing youth outside, establish rules (what do you pick up vs. leave, behavior expectations) and boundaries (between these trees, no father than __). If you have time, brainstorm some ideas before handing out the cards, "What are some things we should be looking for?"
   - This could be physical evidence, sounds (ex. birds chirping or chipmunks) or even smells.

2 Pass out scavenger hunt cards once you're outside and let youth explore within the boundaries you have identified. Let them know that they are not limited to only signs of animals that are on the list (i.e. sounds, smells, anything they think could be evidence).

3 After youth have had time to explore, bring them back as a group.
   - Creating a circle allows everyone to see each other and what they brought back from their scavenger hunt.

4 Allow youth some time to do a little show and tell to share what they found.
   - Here is a prompt you can use: "What did you find? What do you think it's evidence of? What questions do you have based on what you found?
   - "Did anyone find the same thing?" "Do you agree with what it came from?" Limit youth sharing to a sentence or two so everyone can share (if they want).
   - If your group is large and you think this will take too much time, allow students to put the evidence they collected on the ground to create a museum so everyone can appreciate, comment, or ask questions.

5 Explain to the youth that as scientists, we could consider these animal signs evidence of their presence.
   - Have youth consider and share "What are your inferences or conclusions based on evidence (what animal did the evidence come from? How did it get here?)?"
     - "What can you infer about what is going on here?" The area may be passing for deer or small mammals, or squirrels may like the seeds from the trees.

Inside: Who am I (with clues)?

1 This activity allows youth to create their own evidence of species presence and gives others a chance to guess what the species is.

2 Split youth into groups of 3 or 4.

3 Explain to the youth that they will be drawing animal signs on small pieces of paper (one sign per paper, have them try to shoot for 3-4 total).

4 Before that happens though, each group has to decide on what animal they will be drawing signs for.

5 After youth have agreed on a species or animal, supply them with pieces of paper and writing utensils.

- On these pieces of paper, they will draw and label animals' signs that signal their animal has been somewhere. Consider these signs as clues. "What clues do you want to give to your peers in order to guess the animal?"

6 As the facilitator, model what this would look like. Pick an animal (ex. a chipmunk), think of three signs that are evidence of an animal (ex. A golf ball-sized hole in the ground, the "chip-chip" sound they make, and a collection of eaten acorns).

7 Once groups have completed their clues, exchange them with another group.

8 With their new clues, encourage groups to discuss and infer what species or animal was present based on the clues.

9 After groups have decided on an animal, come back together as a group.

10 Have groups report out what animal they inferred was present based on the clues. In other words, have youth justify their claims with evidence.

- "Were they correct?"
- "Was this easy or hard? Why?"
- "How did your group come to one agreed-upon conclusion?"

Explain

1 Creatures leave behind evidence of themselves in their habitats. Oftentimes the evidence is actually bits of the species or remains (i.e. feathers, crab legs, hair, scat).

- Remind youth that habitat is the natural home for an animal or plant.

2 These pieces of evidence can be considered clues for what species are present in an area. Like crime scene investigators! They find hair from a person, supporting a claim that the person was there.

- If youth are unfamiliar with crime scene investigation, share the video: CSI: Who Did It? | Science Trek mainepublic.pbslearningmedia.org/resource/idptv11.sci.life.gen.d4kcsi/crime-scene-investigation/

3 Thinking back to the last lesson, we learned about species range and the factors that limit where a species can live. Species range tells us where species maybe, but finding evidence of them tells us they were actually there and perhaps even what they were doing.

Elaborate

1 We've looked at large-scale evidence, now let's look at the evidence at a smaller scale and see what we can find.

2 Have youth collect soil samples from outside. If youth are going outside for the animal sign scavenger hunt, they can collect samples at that time, putting them in plastic bags to transport inside and save for later.

- To get youth thinking about where to collect soil and how to do it safely, ask youth "What counts as soil?" "Where should we be going to collect it?" They should collect a large handful of soil.
  - Soil collection can happen just under the surface of the ground (i.e. below the grass). It can be from the schoolyard, backyard, or woods. Be careful to not grab soil near poison ivy, any thorny bushes, or scat.

3 Have youth wash their hands after coming back inside.

4 Once youth have their soil samples, have them (carefully) pour their soil onto a blank white piece of paper.

5 Hand out pocket microscopes and review how to use them (pictures at end of document).

- To turn it on, move the light switch from 'off' to 'on' on the side of the pen.
- To look at something, bring the top of the pen (the side with the light) close to your soil sample.
- Use the focus and magnification adjustments on the top of the pen to adjust your focus. Youth may need to play with adjustments or practice looking at something first.

6 Allow youth to look closely at their soil sample.
- Encourage youth to make observations about their soil (color, moistness, texture) and look for evidence of animal presence.
- After, have youth clean up their soil and wash their hands.

7 Come back together to discuss as a group.
- Have youth share out what evidence they found, if any. "Can you infer anything from your observations?"
  - "Do you think someone in another state or another country would infer the same things you did?"
  - "How does your background knowledge influence your inferences or explanations?"
- Over time, the big pieces of evidence we see outside (feathers, scat, tracks, fur, etc.) get broken down over time by weather and foot traffic, to smaller and smaller pieces. It's possible that you have small bits of evidence right in your hands!

Evaluate

1 "How did the evidence change going from a larger scale (from the 'explore' portion) to a smaller scale (using microscopes to look at soil)?"
- "Did you look for the same type of evidence at both scales? "If not, what changes did you make?"

2 "How did the evidence change from the large area of the explore portion (either going outside for the scavenger hunt or picking any animal you wanted in the drawings) to a small area?"

3 "What would make you more certain about your inferences?"

Extension

1 Have youth write a narrative about an animal leaving evidence in an area.
- "How did the animal leave the evidence?", "Does it match where the animal lives or their species range?"

Additional Resources

1 Video explaining crime scene investigation: CSI: Who Did It? | Science Trek (PBS|Maine Public website) There is an emphasis on forensics, but the PBS video does mention DNA, fish, and other uses for forensics.

mainepublic.pbslearningmedia.org/resource/idptv11.sci.life.gen.d4kcsi/crime-scene-investigation/

Supported by National Science Foundation award #OIA-1849227 to Maine EPSCoR at the University of Maine.

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Animal Signs Scavenger Hunt

Pocket microscope

Photos for Elaborate, Step #5

Button to turn light on and off.

Adjust to focus.

Adjust to magnify.

THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 7: DNA

Topic: DNA is genetic material that is found in every cell of the body and it also makes you one-of-a-kind. Because DNA is found in every cell, when evidence is left behind by people and animals, we can extract DNA from that evidence to identify who left it, just like crime scene investigators.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1 Explain how DNA is passed down from generations, while still making you unique.

2 Explore ways in which DNA information can be used.

Background Information for Facilitator

DNA stands for deoxyribonucleic acid. Your DNA is unique to you and is different from every other person in the world (unless you're an identical twin). DNA is in every cell in our body, we have around 10 trillion cells. DNA tells each cell what it is (liver cell, skin cell, etc.) and what it's supposed to do (your job is __). DNA stays the same throughout your entire life, it doesn't change or grow as you grow older.

Crime scene investigators can extract DNA from blood, urine, and saliva samples. Investigators can then match the DNA they extracted to a library of DNA samples they have. This helps them catch suspects of crimes. DNA is also inherited, meaning that it gets passed down from generation to generation. In other words, you have some DNA from your father and some from your mother, making you unique. If you have a sibling, they will share some of your DNA because it was passed from the parents as well, but it may not be exactly the same (different eye color, hair color, heights, they can roll their tongue and you can't, etc.).

Note for Facilitator: Allergy warning: Strawberries are required to perform the experiment in the 'elaborate' phase.

Materials

- Whiteboard
- Pony beads – 4 different colors
- Inheritance bead template
- Strawberries
- Dish detergent
- Salt
- Water
- Plastic cups
- Coffee filters
- Rubbing alcohol
- Coffee stirrer
- Measuring tools
- Extraction observation sheet

Vocabulary

- **DNA (deoxyribonucleic acid) =** material that is present in all living organisms, which is present in every cell. It communicates to the cells what they are and what their role in the body is. It contains all the genetic information needed to make and maintain us.
- **Inheritance =** something that gets passed on from generation to generation
- **Dominance =** because individuals get two versions of each gene (one from each parent), if they are different only one is expressed, which is the dominant gene. The other version of the gene is recessive, meaning is gets masked (or doesn't get expressed)
- **Generation =** the offspring that are the same stage of descent from a common ancestor (a mother and daughter represent two generations because they are at different stages of descent, whereas your mother and all her siblings are one generation).
- **Offspring =** young (inclusive of both people and animals, so it includes children, fawn, cubs, etc.).
- **Traits/physical characteristics =** feature of an organism
- **Genes =** a unit of DNA that controls the development of a trait(s) and is responsible for the passing of genetic information from parent to offspring.

Methods

Engage:

1 Ask youth to help you complete a survey about human characteristics.
   - Detached earlobes (earlobes with a little hang) are the dominant trait (more common), making attached earlobes recessive.
   - Record numbers (on Google Slide, whiteboard, etc.).

2 Survey the youth whether they can roll their tongues (into a hotdog shape).
   - Record numbers. Tongue rolling is dominant, the non-rolled tongue is recessive.

3 Survey the youth on their hairline. Do you have a straight hairline or does your hairline form a point at the center of your forehand (widow's peak)?
   - Record numbers. Only 35% of the world's population has a widow's peak (even though it is the dominant trait).

4 "What do you think determines these characteristics?" "How did you develop that inference from what you just saw?"

Explore

1 To understand better what all of this means, we're going to use beads to model inheritance. Notice that the template uses "generation" to label the different stages of descent. Review this vocabulary with youth.
   - Distribute 6 of each color bead to every youth.
   - Using pony beads, layout 6 of the same color represent one individual within one set of individuals in the first generation. Layout 6 of another color to represent the other individual. This represents one set of individuals within a generation (ex. One set of grandparents).
   - Pick two different colors, not yet used (i.e. your remaining two colors), to create the other set of individuals. Combine half of the beads from each individual of a set to create an individual for the 2nd generation. Do the same with the other set. Be careful not to mix between the sets.
   - Now combine half of the beads from each individual in the 2nd generation to create an individual for the 3rd generation. Have youth close their eyes and pick 3 beads from the 2nd generation to create the 3rd generation individual.
     - "Are there any beads that made their way all the way from the 1st generation to the 3rd?"

- "Are there any beads that didn't travel at all?"
- "Do you think all your templates look the same?" Youth can also share their templates here, even if it's just the 3rd generation.
- "How does this relate to your life?" "What connections do you see to your own life?" "How might you use this information in the future?"

Explain

1 Inheritance is something that gets passed down from generation to generation. Each of us gets half our characteristics from our biological mom and a half from our biological dad.
   - Scientists use the word 'inheritance' when describing characteristics and information that gets inherited or passed down.
   - Imagine the beads that were just used as characteristics. Some characteristics traveled through generations, others did not.

2 The characteristics are determined by DNA. DNA stands for deoxyribonucleic acid. Your DNA is unique to you and is different from every other person in the world (unless you're an identical twin). DNA is in every cell in our body, which means there are around 10 trillion of them. DNA tells each cell what it is (liver cell, skin cell, etc.) and what it's supposed to do (your job is __). DNA stays the same throughout your entire life, it doesn't change or grow as you grow older.

Elaborate

1 Because DNA is in our cells, anything that has our cells contains DNA.
   - Crime scene investigators can extract (take out) DNA from hair, dead skin, and saliva. It's even in our scat.

2 Let's extract some DNA together (see 'Strawberry extraction instructions ' in 'Additional Resources' for a PDF form of the instructions with pictures)! See directions below (starting at a).

3 "Before we start. What do you predict will happen? What will the DNA look like?". These predictions can be recorded on the whiteboard, prediction sheet included, or just discussed aloud.

4 Share the directions of the extraction with the youth and let them lead you through the steps. Ask clarifying questions if needed.
   - Take out the strawberries and pull off any green leaves
   - Put the strawberries into the plastic bag and gently smash them with your hands for a couple of minutes until they are completely crushed. This helps break down the cells of the strawberry, releasing the DNA.
   - In one of the plastic cups, create the liquid that will extract the DNA. Mix together 2 teaspoons of dish detergent, 1 teaspoon salt, and ½ cup of water.
   - Add 2 teaspoons of the DNA extraction liquid to the bag of smashed strawberries.
   - Seal the bag and gently smash for another minute. Try to avoid creating a lot of soap bubbles. This helps break open the cells even more.
   - Place the coffee filter inside the other (clean) plastic cup.
   - Pour the strawberry liquid into the filter. Squeeze out the remaining liquid from the filter.
   - Start to pour the ½ cup of rubbing alcohol down the side of the cup that contains the strawberry liquid. Use as much rubbing alcohol as there is strawberry liquid (you may not use the whole ½ cup). Do not mix or stir. Have youth observe what happens next.
   - Watch the cup, as a white substance should start to settle on the top of the strawberry liquid. This is the DNA!
   - Using the coffee stirrer, tilt the cup of strawberry liquid and pick up some of the DNA.

5 Show youth what the DNA looks like.
   - "What did you observe?"
   - "How do your predictions compare to your observations?"
   - "What are your reactions?" "What are you thinking or feeling as you see this?"

6 You (and youth) may be wondering how these activities relate to sustainable fishing or themselves. Share 'No to fish fraud: How DNA testing ensures the authenticity of MSC labeled seafood' video in Additional Resources (#6).
   - After watching the video ask the youth "How is what we did like what scientists do?"
     - Crime scene investigators and scientists extract DNA from plants, animals, and humans to track its inheritance and to determine what it is (who the person is or what animal/plant it's from).
   - "Did anyone notice in the video the scientist explaining how this is new, innovative technology?" "What do you think that means?"
     - This means that we were not always able to identify species with DNA. Technology, just like science, changes and develops over time. As we continue to ask questions and test them we refine what we know and how the world around us works. Oftentimes this includes developing solutions, more sustainable practices, or improving lives.

Note for Facilitator: the charge and polarity of the alcohol solution penetrate the cell wall and that is why it's able to extract DNA. If you (or youth!) are more interested in this, check out the article, 'Role of alcohol in DNA extraction' in Additional Resources.

Evaluate

Discuss the following questions as a whole group.

1 "You observed and evaluated a scientific phenomenon. How would you communicate what you saw and learned?" "If someone asked you what DNA is, what would you tell them? What important things would you want to make sure you talk about?"
   - "What about inheritance?"

2 "Why was this activity important to you?"

Extension

1 Allow youth to draw a picture of themselves, coloring it as accurately as possible.

2 Have them notice their characteristics: eye color, hair color, curly or straight hair.

3 Choose a few characteristics to survey as a group.
   - Survey the youth and record the characteristics.

4 "What can we infer about this data?", "How could this data be helpful to us as scientists?"

Additional Resources

1 **What is DNA and How Does it Work? —** detailed description of DNA (the molecular structure, proteins, and chemistry behind it) YouTube video: https://www.youtube.com/watch?v=zwibgNGe4aY

2 **Biometrics Activities: Create a DNA Fingerprint (STEM-Works website) —** the introduction to the activity has a simplified explanation of DNA stem-works.com/external/activity/178

3 **What are Traits?** Basics of inheritance and traits (Learn.Genetics Genetic Science Learning Center website) learn.genetics.utah.edu/content/basics/traits/

4 Directions for strawberry DNA extraction: **How to Extract DNA from a Strawberry (PDF)** (National Human Genome Research Institute website) extension.umaine.edu/4h/stem-toolkits/sustainable-fishing/activity-7-dna/

5 **Role of Alcohol in DNA Extraction** (Genetic Education/Learn Genetics website) geneticeducation.co.in/role-of-alcohol-in-dna-extraction/

6 **No to fish fraud: How DNA testing ensures the authenticity of MSC labeled seafood (YouTube)** (Marine Stewardship Council – Sustainable seafood) https://www.youtube.com/watch?v=kexsUnF6t6I

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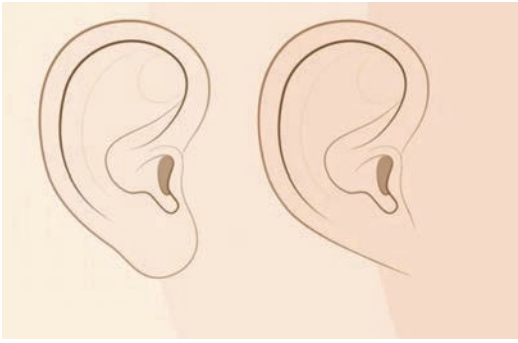
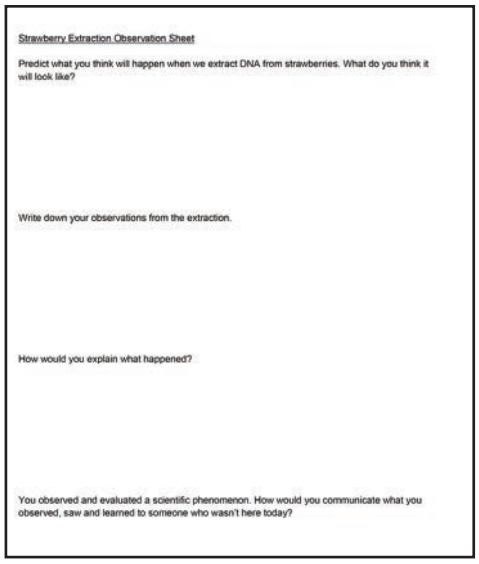


Example of an attached earlobe (left) and a detached earlobe (right). Drawing, Jessy Brainerd



Strawberry Extraction Observation Sheet

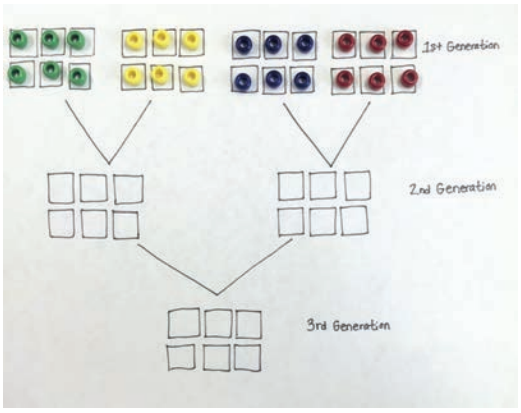
Predict what you think will happen when we extract DNA from strawberries. What do you think it will look like?

Write down your observations from the extraction.

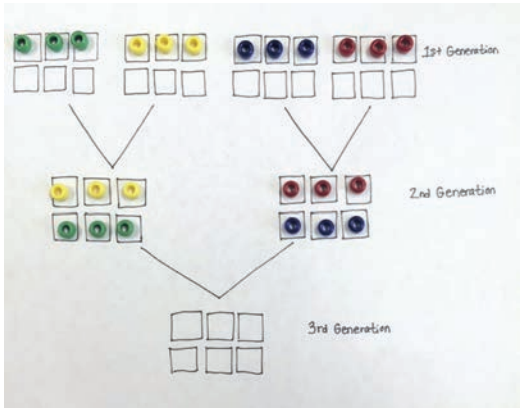
How would you explain what happened?

You observed and evaluated a scientific phenomenon. How would you communicate what you observed, saw and learned to someone who wasn't here today?

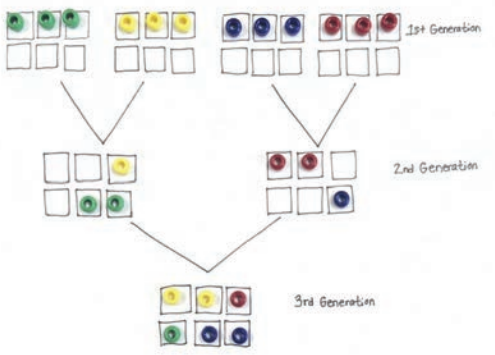
Strawberry-Extraction-Observation-Sheet



Generation-sheet-with-beads-filling-in-the-1st-generation-tier.



Generation-template-with-two-tiers-filled-in.



Generation-template-with-all-three-tiers-holding-beads.

THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 8: eDNA

Topic: Model how eDNA collection helps us understand what aquatic species are present (or absent) in an area.

Time: This lesson should take approximately 45-60 minutes to complete.

Learning Outcomes

At the end of this activity, youth should be able to…

1. Work through a simulation of collecting eDNA.
2. Explain what eDNA is.
3. Explain how eDNA can inform us about what species are present.

Background Information for Facilitator

When aquatic species leave behind evidence of themselves (scat, scales, tissues, etc.) those little bits of fish contain the DNA from that fish. This is what scientists call environmental DNA or eDNA. It's DNA that is found in the environment and communicates what species are present or absent in a habitat. They can also communicate population estimates by how many samples are collected for each species (lots of brook trout DNA → probably lots of brook trout).

eDNA is favorable over physically catching fish to sample a habitat for several reasons: (1) it doesn't harm the fish (even if you're being careful when you catch fish, they are still being taken out of the water and handled), (2) it includes all the fish, even the ones that are hard to catch (some fish are hard to catch because there aren't many of them, they live deep in the water, like to hide, or are not active during certain parts of the day), (3) it's time and energy-efficient, as you only have to collect water samples instead of catching actual fish and releasing them.

This information can be applied in several different ways. Fishermen can use this information so they can fish where species are known to be present. It can also help us track where species move as our climate changes. For example, as water temperatures rise, fish will start to move to areas where the temperature is still cool (within their range), and by collecting eDNA we can monitor this. It can help us track the population of species. If a species is declining, we can identify that sooner and intervene as necessary.

Materials

- Large aluminum trays
- Habitat labels (pond, river, ocean)
- Bead/species key
- Water
- Pencils
- Pony beads
- 50 white, light blue, yellow, red, dark blue, and green beans
- 10 orange beads
- Data collection sheets (for individual youth)
- Data collection sheets (for the whole group)
- Plastic cups
- Folders
- Whiteboard
- Paper towels

Vocabulary

- **Terrestrial =** animals that live on land (all or most of the time)
- **Aquatic =** animals that live in water (all or most of the time)
- **eDNA (environmental DNA) =** the genetic fingerprint in an aquatic habitat or environment. Animals leave behind little bits of themselves, which contain DNA, wherever they go in the water, air, and soil. This DNA can be collected, identified, and traced back to species by matching collected samples to a DNA library, just like investigators would with a crime scene.
- **Sampling =** a method that allows scientists to infer things about a population based on a small portion of that population

Methods

Engage:

1 Terrestrial animals, or animals that live on land, leave behind evidence like tracks, feathers, nests, scat, and more. Ask youth to brainstorm ideas of what aquatic animals would leave behind as evidence.

2 Aquatic animals leave behind scales, scat, shells, and sometimes even tracks.

3 Youth may have a hard time coming up with evidence and that's ok! Finding evidence of aquatic animals is hard and can be frustrating. Because water is fluid evidence doesn't fall in one place like on land, it floats around and moves. Evidence may also dissolve or decompose faster because it's in water.

4 If you have access to technology, share the video: **Floods Pond: Protecting Maine's Rare Arctic Charr (YouTube)** (can also be found below in **Additional Resources)**. youtu.be/JfMVT8MqziE

5 The video sets the stage for the activity. If you do not have access to the video, explain the problem: Arctic charr are only present in 14 lakes and ponds throughout Maine. Arctic charr populations are at risk due to predation and competition of the Rainbow smelt.

6 Rainbow smelt is starting to replace the Arctic charr populations in *areas where they are not native* because they eat the charr's food source and have even been known to feed on young Arctic Charr. The video shows University of Maine student researchers as they collect data to record the population information of the Arctic charr population in Floods Pond.

Explore Set-up:

1 Place three large aluminum trays around the learning area. There will be various stations youth explore. Fill them about halfway with water.

2 Place a habitat card with each tray.
- River: Salmon, alewife
- Pond: Brook trout, rainbow smelt, arctic charr
- Ocean: Haddock, bluefin tuna

3 Place specific bead colors in habitats:
- River: red (50), yellow (50)
- Pond: white (50), dark blue (50), orange (10)
- Ocean: green (50), light blue (50)

4 Cover aluminum trays with folders so youth can't see inside the trays as well.

5 Hand out plastic cups (2 per group) and a bead key to each youth.

Explain

1 Split youth up into groups of 3 or 4.

2 Demonstrate how to collect a sample.
- Trying not to uncover the tray, collect a water sample with your cup using one hand.
- Come back to your table/station and see if you collected any beads. If you collected a bead(s) match the bead color to the species on the key.
- Youth have the option here to record what species was found and in what habitat on a data collection table. If you chose to use it, show youth where they would record their first sample.
- Have youth discard 'used' evidence (beads collected from habitat) in a community cup at each table. This ensures that DNA/evidence is not being put back into the habitat to be recollected (and rerecorded) by someone else.

3 Assign each youth group to one habitat. Depending on the number of youth, more than one group may be assigned to a habitat. More samples make for a more accurate representation of what is in the habitat.
- It may be helpful for youth to assign or define roles within their group: field data collector (collects eDNA sample), data manager (records data), lab manager (discards the sample), etc.

4 Allow youth to collect data and possibly record what species they found in their habitat.
- If youth don't catch all the species within an ecosystem, that is part of the process! Collecting eDNA does not guarantee you'll collect samples from all fish that are present. Just like when you go fishing, you don't catch all the species that are present in the lake.
- The same goes for if a sample doesn't contain any eDNA…you don't always catch a fish when you cast a line.

5 Come back together as a group.

Explain

Note for Facilitator: Depending on what the youth find relevant, choose a few questions below.

1 "What did you do? What was your procedure in this activity?"

2 "What did the beads represent?"
- The beads represent the evidence that fish leave behind that contains DNA (just like a hair sample from us contains DNA). When fish and other aquatic species leave behind DNA in water, scientists call it environmental DNA, because its DNA comes from the environment. We call it eDNA for short.

3 "What story can you tell from the data you collected?"
- "Did anyone find something similar with their data? Did anyone find something different with their data?"

4 "How did this model represent an ecosystem?"

5 "How is this model similar to what we watched in the video?"
   - "How is what you did similar to what scientists do?"

6 Today youth modeled the work that scientists are doing to protect Arctic charr populations. They collected data in three different habitats to see if Arctic charr were present and if there was evidence of Rainbow smelt.

Eloborate

1 Using the data collection sheet for the whole group, allow youth to compile their data. This can be done whether or not youth used data collection sheets as individuals/groups. They can use the beads they discarded in their cups to see what they found.

2 Ask groups to report out on (1) what habitat they sampled from, (2) what species they found, (3) how many of those species.

3 Record this information on a whiteboard and youth can follow along with their own copy. See the example below. Include the following:
   - Habitat
   - Species found
      - "How many different colors were collected?"
      - "Looking at your bead key, what species of fish do the colors represent? What are the names of the species?"
   - Number of fish per species
      - "How many of each color bead was collected?"

4 Discuss as a group how their inferences changed when they pooled their data and about the broader applications of this activity.
   - "What differences do you see between your data story and the group data story? How might that happen? What does that tell you about analyzing and interpreting data?"
      - "How is this similar to what scientists do?"
   - "How do you think collecting eDNA compares to catching the actual fish?"
      - You get a lot of information in just one easy water sample.
      - Collecting water and eDNA doesn't harm the environment or fish. When you catch fish, even if you're being careful, you're bringing them out of the water for some time as you handle them.
      - eDNA can be collected from those sneaky fish that are rare or hard to find.

Extension (two options below)

1 If you have time, talk about how the orange arctic **charr beads translate to real life, article: Maine scientists hope DNA in water could be way to save rare fish**, February 10, 2019, by The Associated Press (BDN) bangordailynews.com/2019/02/10/news/state/maine-scientists-hope-dna-in-water-could-be-way-to-save-rare-fish/
   - Arctic charr is only present in 14 lakes and ponds in Maine. Those 14 lakes and ponds are the only place these fish live in the whole continental United States (excluding Alaska)!
   - They are in trouble of being replaced by an invasive species (rainbow smelt), a species that has not lived in Maine before this, and is now replacing the arctic charr species (rainbow smelt eat the charr's food source and has even been known to eat the young charr).
   - Arctic charr is a mysterious species as they are hard to find and catch. That is why using eDNA to see whether they are present or absent in a lake or pond helps determine if they are still there. Then, scientists and researchers can begin to eliminate invasive (rainbow smelt) species from these lakes and ponds.

2 **The Reclamation of Big Reed Pond (YouTube)** (Maine Department of Inland Fisheries and Wildlife) — This video of the reclamation of Big Reed Pond, a unique and undeveloped pond in Maine, summarizes the process of how several groups of like-minded people saved native populations of arctic charr from invasive rainbow smelt. The video shows how Black Ops helicopters, seaplanes, boats, and canoes helped with this process if you have any youth especially interested in crafts.
https://youtu.be/rh0VudWLeaw

Additional Resources

1 **Floods Pond: Protecting Maine's Rare Arctic Charr (YouTube)** (Native Fish Coalition). This video explains why Arctic charr populations are at risk, as it documents what scientists and researchers are doing to help protect them. The video highlights University of Maine student researchers and experts in the field collecting data from Arctic charr they catch.
https://youtu.be/JfMVT8MqziE

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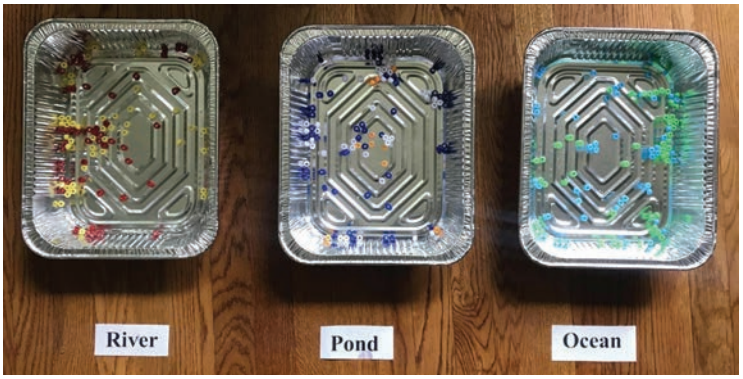
(red) = Salmon
(yellow) = Alewife
(white) = Brook trout
(dark blue) = Rainbow smelt
(orange) = Arctic charr
(green) = Haddock
(light blue) = Bluefin tuna

Bead species key



	River		Pond			Ocean	
	Alewife (yellow)	Salmon (red)	Brook Trout (white)	Rainbow smelt (dark blue)	Arctic Charr (orange)	Bluefin Tuna (light blue)	Haddock (green)
Sample 1							
Sample 2							
Sample 3							
Sample 4							
Sample 5							

Data collection sheets (for individual youth)

	How many different species (types of fish) were found?	What are the species' names?	How many fish per species?
River habitat			
Pond habitat			
Ocean habitat			

Data collection sheets (for whole group)

	River		Pond			Ocean	
	Alewife (yellow)	Salmon (red)	Brook Trout (white)	Rainbow smelt (dark blue)	Arctic Charr (orange)	Bluefin Tuna (light blue)	Haddock (green)
Sample 1							
Sample 2							
Sample 3							
Sample 4							
Sample 5							

	How many different species (types of fish) were found?	What are the species' names?	How many fish per species?
River habitat	Ex. 2	Ex. Salmon Alewife	Ex. 6 10
Pond habitat			
Ocean habitat			

Data collection sheet for a whole class or group with the River habitat row completed.