THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Harmful and Shifting Species

When people think of Maine's coastline, often they think of scenic ocean views and delicious seafood. Maine's coastline is home to humans, but also to many species of plants and animals that are adapted to the environment. Maine's coastal areas are undergoing changes. Some changes are due to a changing climate, which makes the area more or less habitable for specific species. Other changes include movement of species to the area – intentionally or not. This kit has youth explore species changes on Maine's coast through activities that introduce food webs, ecosystems, and invasive or harmful species, like the European green crab (green crab) and Asian shore crab.

Toolkit Activities

- **Activity 1:** What is an Ecosystem, and What is a Food Web?
- **Activity 2:** What's an invasive species? Where did they come from?
- **Activity 3:** How Do Invasive Crabs Differ from Native Crabs?
- **Activity 4**: How Fast Do Invasives Multiply?
- **Activity 5:** How has the Maine Coast Changed?

Note: While each activity can stand alone, the concepts within the kit do build on each other. We suggest that the activities be completed in order. At times, youth will be asked to recall aspects of a prior activity to build upon their previous knowledge.

Acknowledgments

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4-H STEM Toolkit

Harmful and Shifting Species — Introduction

What is an Ecosystem, and What is a Food Web?

What's an invasive species? Where did they come from?

How Do Invasive Crabs Differ from Native Crabs?

How Fast Do Invasives Multiply?

How has the Maine Coast Changed?

Learning Outcomes

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

1. Define what an ecosystem is.
2. Explain the difference between native and invasive species.
3. Name two invasive species in the Gulf of Maine and describe how they negatively impact the ecosystem.
4. Explain ways the Gulf of Maine ecosystem has changed over the last 70 years.

The first activity in this kit has youth exploring ecosystems and species interactions. We present ecosystems as collections of species that interact with each other in order to survive. These interactions can take different forms. We have chosen to explore this topic with an ecosystem the youth are familiar with and use predator and prey relationships. Youth begin by looking at a land ecosystem found in many parts of Maine. In short, the sun provides energy to the grass, and then the grass is eaten and used as a home by insects and small animal species like the grasshopper. This grasshopper is then food for birds, and the birds are food for the foxes.

Sun → Grass → Grasshopper → Bluebird → Fox

Youth then expand on this to build a food web model. They then apply what they have learned to add marine and coastal species to their food web:

- Seaweed: an aquatic plant that lives close to the shoreline
- Puffin: a seabird
- Sea urchin: a small sea creature
- Oyster: a type of shellfish
- Clam: a type of shellfish
- Plankton: a microscopic plant or animal that is often eaten by "bottom feeders"
- Cod: a medium sized fish
- Shark: the big ones that live deep in the ocean

- Lobster: a Maine classic!
- Black sea bass: a medium sized fish
- Jonah crab: a crab native to Maine
- Green crab: a crab invasive in Maine
- Asian shore crab: a crab invasive in Maine

Youth explore marine species interactions in the same way they explored the land species interactions, by building a food web to demonstrate predator and prey relationships. They then explore what could happen if a species disappears from the ecosystem.

Building Upon Activity 1: Activity 2 and Beyond

It is important for the youth to come away from the first activity with an understanding of what an ecosystem is and how species are connected. This knowledge is used for the rest of the activities as youth explore how changes happening on the Maine coast affect the coastal ecosystem as a whole.

Multiple activities in this kit use a modified case study to show how the presence of introduced crab species has led to ecosystem changes. Asian shore crabs and green crabs are species not native to Maine; both cause harm to the ecosystem and are considered invasive species. These crabs are eating the food sources of other species causing the populations of native crabs to suffer. These invasive species do not have many predators in the Maine coastal ecosystem so their populations continue to grow unchecked.

The second activity in this kit allows youth to explore how these crabs made their way to the Maine coast with the help of humans. The following activity then explores how these crab species are different from the native crab species. Videos of native and invasive crab species are used to collect data about how the crabs walk and move at different temperatures. Through this activity youth learn about adaptations that can give the invasives an advantage over the native crab species.

After participants have a better understanding of how the invasive species differ, they will be introduced to how invasive species affect the growth rates of other species. The invasive species are often able to grow at a faster rate than native species. Activity 4 is a game-like exploration.

The final activity in this kit allows youth to investigate habitat changes driven by ocean water temperature changes. Two maps are provided, one that shows temperatures of the ocean of today and the other with temperatures from 70 years ago. Youth will investigate how the changing temperatures can affect the species in the Gulf of Maine.

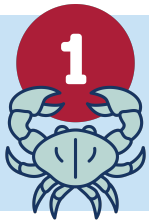
THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 1: What is an Ecosystem, and What is a Food Web?

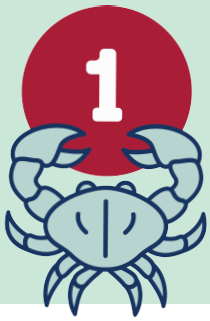
Topic: Youth are introduced to the concept of ecosystems and species interactions in both land and water habitats.

Time: This activity should take approximately 60 minutes to complete.



Materials

- Aquatic species cards
- Land species cards
- Whiteboards
- Whiteboard markers
- Whiteboard erasers
- Printed copies of an example food web
- Aquatic Species fact sheets
- Aquatic Food Web Memory game rules



Learning Outcomes

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

1. Understand that an ecosystem is a community of interacting organisms and their physical environment.
2. Explain that food webs show predator and prey relationships and model the flow of energy through ecosystems.

Background Information

The first activity in this kit has youth exploring ecosystems and species interactions. We present ecosystems as collections of species that interact with each other in order to survive. These interactions can take different forms. We have chosen to explore this topic with an ecosystem the youth are familiar with and use predator and prey relationships. Youth begin by looking at a land ecosystem found in many parts of Maine. In short, the sun provides energy to the grass, and then the grass is eaten and used as a home by insects and small animal species, like the grasshopper. This grasshopper is then food for birds and the birds are food for the foxes.

Sun → Grass → Grasshopper → Bluebird → Fox

Youth then expand on this to build a food web model. They then apply what they have learned to add marine and coastal species to their food web:

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- Jonah crab: a crab native to Maine
- Green crab: a crab invasive in Maine
- Asian shore crab: a crab invasive in Maine

Youth explore marine species interactions in the same way they explored the land species interactions, by building a food web to demonstrate predator and prey relationships. They then explore what could happen if a species disappears from the ecosystem.

Vocabulary

- **Aquatic:** relating to water
- **Carnivore:** organisms that eat mainly meat
- **Consumer:** organisms that get their energy from eating plants and animals
- **Decomposer:** organisms that break down dead organic material
- **Ecosystem:** community of organisms living together and interacting in particular a habitat
- **Food chain:** linear sequence that shows how energy is passed from one organism to another
- **Food web:** many food chains that are linked together
- **Herbivore:** organisms that eat mainly plants
- **Omnivore:** organisms that eat plants and animals
- **Producer:** organisms that get their energy from the sun

Methods

Engage

1. Have participants work in small groups of 3-4 youth. If you have a smaller group, have them do this activity in pairs.
2. Ask youth to discuss in their groups what animals they have seen in Maine. If they struggle to come up with ideas you can prompt them with these questions: "What is an animal you see a lot in Maine?" "Do you see different animals in different parts of the state?" "If you could be an animal that lives in Maine, what would you be? Why?" "What kind of habitat would you find yourself in if you were that animal?"
3. Once you start to see conversations slow down, call the groups back together and have them share what they talked about.
4. Introduce today's activity. Example script: "It seems like you have seen many animals around you! Have you ever stopped to think about how all of these species could be connected?" Allow the youth time to answer the question then continue on: "One way these species are connected is what we are going to explore today! I am going to present you with some animals and plants and challenge you to explore how they could be connected. Some connections might be difficult to make – don't worry, just do your best!"

5. Pass out the land species cards, one set per group. Have groups take a look at their cards. Give them time to spread the contents on the table so everyone in the group can observe the materials they are working with. At this time they should only have only the land species cards.
6. Have groups sort the species by connections they come up with. Explain that this is a warm up activity to get them thinking about background knowledge they already have about these species. There are no wrong connections that they can make as long as they can explain why they have put something into a category.
7. Encourage all youth in a group to be involved in making decisions about the categories they create and how they sort their species.
8. If you notice any groups struggling you can prompt them with these questions: "Do you notice anything similar between any of the species?" "Would sorting based on plants and animals be appropriate?" "Do you see any connections based on where they live or what they eat?"
9. Encourage deeper thinking with these questions: "Why are you sorting this way?" "What are the connections between these species?" "Why isn't this in the other category?" "Do any of your species fit in more than one category?"
10. Come together and ask the youth to share how their group sorted the species cards. Discuss how their categories for sorting were the same and different.

Explore

Review the video instructions below or watch the video "Activity 1: What is an ecosystem and what is a food web?" https://youtu.be/KhLLuUcfB-k?si=lHlwUX_vFAbAWipu

1. Now that youth have had some experience working with land species, it is time to introduce the idea of an ecosystem. Example script: "You have made some great connections between these species and I think everyone has noticed that these species all live in a similar area. These animals are all part of the same ecosystem. Have any of you ever heard that term before?"
2. If any of the youth have heard the term 'ecosystem' give them a chance to share what they think it means.
3. Clear up any misconceptions that may have come up and define an ecosystem: "An ecosystem is a community of species that all live in the same area and interact with each other in order to survive. One of the easiest ways to think about an ecosystem is to sort all the species together in the order of who eats who or what eats what, and that is going to be our next task!"
4. If youth have not already done so, work together to have youth sort their species into the following categories: **producers** (species that get their energy from the sun, these will be the plants) and **consumers** (species that get their energy from eating other things, these will be the animals). Have them further sort their consumers into the categories: **herbivores** (animals that eat plants for energy), **omnivores** (animals that eat plants and animals for energy) and **carnivores** (animals that eat other animals for energy).
5. Pass out two white boards to each group. Instruct the youth to place the white boards next to each other to make a bigger workspace as shown in Figure 1.

Figure 1: Two white boards side by side to use as a work space.

6. Pass out markers and white board erasers. Ask the youth to look at the land species they have sorted and explain we are going to organize them on the white board based on who eats who. Example script: "Look at the connections we have already made, now we are going to sort your species based on who eats who using the white boards. You will place your cards on the whiteboard and then use the markers to draw an arrow to show who eats who. Arrows show the flow of energy so it points at the organism doing the consuming."
7. Work together as a whole group to build their first food chain (they do not all need to be the same).
    a. Have youth start by drawing a sun on their group's white board.
    b. Ask: "What species can you connect to the sun?" Youth should select a plant (producer) card and draw an arrow from the sun pointing to the plant. Remind them that they have limited space on their boards and many cards to add so they don't want to spread them out too much.
    c. Ask: "What eats the plant?" Youth should select an animal from the herbivore (or omnivore) group and add it to their white board, drawing an arrow from the plant to the herbivore.
    d. Carry on until they have built a food chain with a few species in their chain (they will not have used all their cards). If they notice that more than one species could connect to another, have them pick just one for now. You are looking to have a linear food chain where each species has one arrow connection for energy that it uses and one arrow connection for another species that eats it for energy.

Figure 2: An example of a food chain. The species may vary based on what cards youth choose for this first food chain.

8. Explain that they have built a food chain. A food chain is a series of predator-prey connections between plants and animals that shows the flow of energy from the sun through an ecosystem.
9. Explain that in nature ecosystems aren't this simple. Each species can have multiple connections with other species. Now that they have built a food chain they are going to work with their small group to make connections to add the rest of their species cards to the chain they have already built.

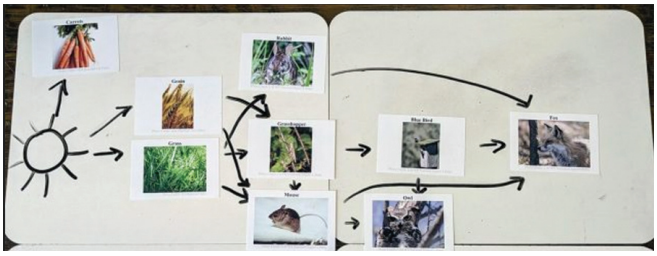

Figure 3: An example of a food web for the land species. Not all youth webs will look the same, they may make different connections based on their background knowledge or they may place the cards in a different order.

10. Youth should work together to place cards on their white board and draw the appropriate arrow to show the flow of energy. This will mean that their food chain will start to grow branches as species connect with multiple other species. Model this for them if they need help understanding. Some species will be connected to many others with many arrows, others will have just a few connections.

Explain

1. When they have added all their species cards ask the youth if they know if what they are creating has a name. They have created a food web! Explain that a food web is many food chains that are connected together. A food web is the building block of ecosystems, each species needs the other organisms they are connected to in order to survive.
2. If there is a projector in the room, you can project an example of a food web for students who may be struggling. A good example is the article, The Bottom of the Arctic's Food Web Is of Top Importance (Frontiers for Young Minds), which shows the arctic food web. If no projector is available, a printed example is included in the kit. Make sure to show a food web of species they are not currently working with.
3. Have youth look at the food web example and go on a gallery walk around the room to observe the food webs other groups have created.
4. Come back together as a whole group and discuss what they saw. Encourage youth to back up their observations with specific evidence that they have. Example questions: "How are all of our food webs the same? How are they different?" "Do all of our food webs need to look the same to show the predator prey relationships between our species? Why or why not?" "How did you make decisions about where to place and how to connect the organisms?" "What do you notice about the example food web?" "How is it the same or different from our food webs?" "Does seeing these different food webs make you wonder about anything?" "Why do you think these connections are called a food web and not a food chain like we learned about earlier in this lesson?"
5. The species cards are not the only species that exist together! Participants might think of others that could be included. Have the youth draw or write the species they are thinking of and add it to their ecosystem. Having youth do this can allow them to see other connections that they can make and let them be creative. This is also helpful if you notice some groups finishing earlier than others, give this task to the quicker groups so everyone still has something to do.

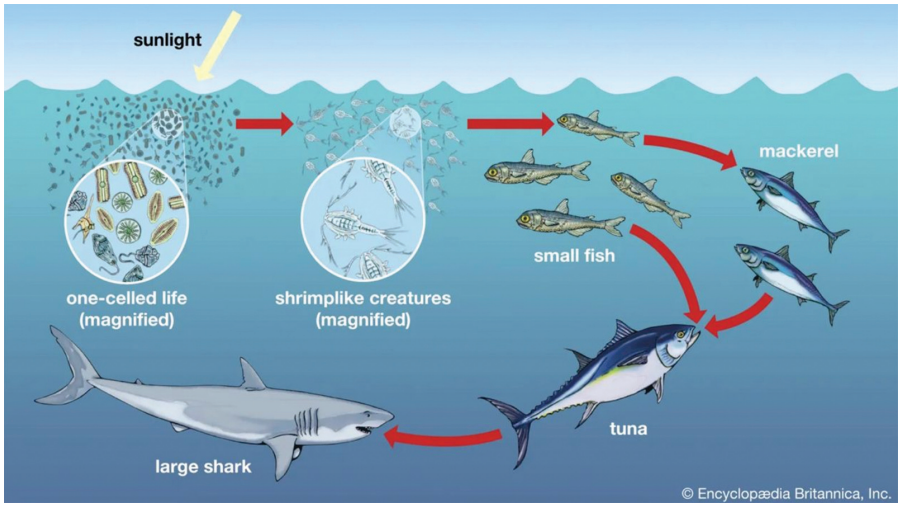

Figure 4: An example of a food web. – Graphic: Encyclopædia Britannica, Inc.

Elaborate

1. Give instructions for the next part of the activity. Example script: "I am going to pass out more species cards to connect to the food web you have already made. These species represent an aquatic ecosystem. There will be some connections to your land food web, but not as many as between your land species. You are going to play a cooperative game to work together to add all of your aquatic species cards to your food web."
2. Pass out the aquatic species cards, the instructions for the Aquatic Species Food Web Memory and the Aquatic Species Fact Sheet and two more white boards to expand their work area.
3. Explain how to play the game. Remind youth that this may be different from the memory games they are familiar with so they should pay careful attention.
   - **a.** Remove Asian shore crabs and green crabs from your deck of cards. Set these two cards aside for now. You will use them later.
   - **b.** Lay cards face down in a grid pattern. There are eleven cards so they will not make a rectangle.
   - **c.** The youngest player goes first.
   - **d.** To take a turn, the player flips over one card.
   - **e.** The player identifies what species they have on their card and reads the fact sheet about that species out loud to the group.
   - **f.** The group decides together if they can add the species to their existing food web by connecting it to another species already in the food web. If there is disagreement the player who is taking their turn makes the final decision.
   - **g.** If the card can be added to the food web the player adds the card and draws an arrow to show the flow of energy through the ecosystem. More than one arrow may be drawn to represent multiple connections between different species.
   - **h.** If the card cannot be added to the food web at this time the card is flipped back over to remain in play.
   - **i.** Play goes to the next person in the circle (the group can decide which direction play goes in).

Figure 5: Two more white boards should be placed next to the land species food web to expand the work area.

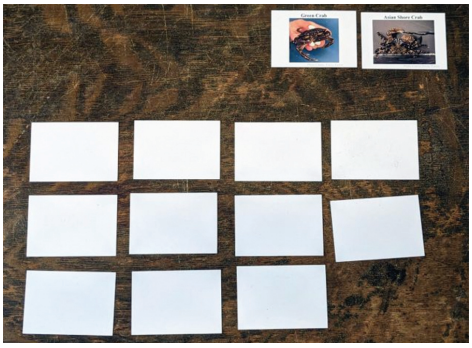

Figure 6: Aquatic species cards in a grid face down. The two invasive crab cards are set to the side for now.

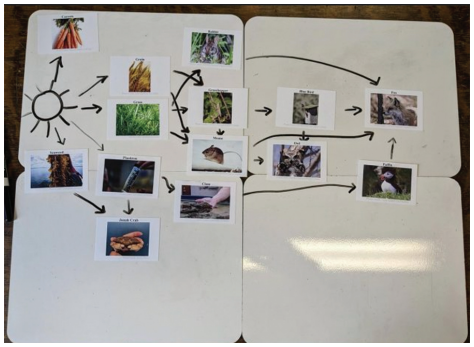

Figure 7: After a few turns the aquatic species food web begins to grow alongside and connected to the land species food web.

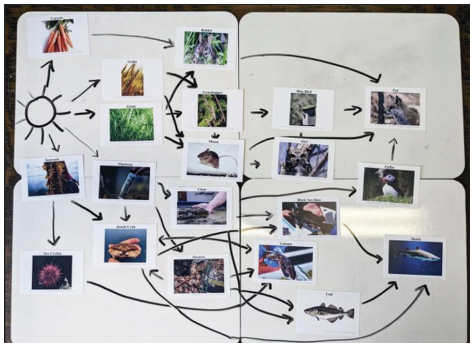

Figure 8: An example of a food web with all of the species cards added. This may not look the same for all groups depending on the connections they added and order they placed their cards in. This group could go back through the Aquatic Species Fact Sheet and add more connections.

j. Play continues until all eleven cards are added to the food web.

k. As groups finish, tell them: "If you finish with extra time, go back and see if you can add arrows for other connections between species that you missed the first time. Think about other species you could add to your food web (they need to be ones that could be found in your ecosystem in nature. You won't find a tiger in the Gulf of Maine, but you might find a person or a whale). Use the predator/prey connections mentioned on the fact sheet to help you. Write that species on your white board and decide as a group what other species it could be connected to and draw arrows to show the flow of energy. As a group, talk about what kind of impact that species would have on your ecosystem."

4. Offer help to groups who are struggling. Some questions you can ask to try and encourage deeper thinking: "Can you think of more than one connection for this species?" "What species do you think eats the most other species?" "Is this species a plant or animal?" "Do you think this species is an herbivore, omnivore or carnivore?" "What do you think might eat this species you have placed on your board?"
5. Note: there can be more than one connection between species. If the youth are struggling with this concept, direct students to look at the example food web and ask them to think about similarities/differences between what they have created and what an expert has created.
6. When the food webs are complete, call the youth back together and ask them to share what they created. You may choose to do this as a gallery walk. Have youth walk around the room to look at what other groups created.
7. Once the youth are back at their table, give them a minute to think about what they saw or to discuss with their group. Ask them some reflection questions: "Were there similarities between the food webs?" "Were there differences between the food webs?"
8. Read out loud the fact sheet about the Asian Shore Crab and Green Crab. Have groups add these two species to their food web. Have them think with their group about the consequences of these two invasive species on the ecosystem. Example script: "These invasive species are voracious eaters and have very few predators. They have come into your ecosystem and reproduced rapidly. They have eaten all of one of the species they are connected to in your food web. Together with your group decide which species that is." Continue on: "The species you just chose is no longer part of the ecosystem, how does that change the web you have created? Show this by adjusting your food web."

9. Ask: "What will happen to the species this one is connected to?" (Answer: Some will increase in numbers and some will decrease. Have youth identify which ones will increase and which ones will decrease.) Youth can use a plus sign next to species whose populations would increase and a minus sign next to species whose populations would decrease. Groups should remove species they think would no longer survive and show what would happen to the species connected to that one.
10. Ask youth to reflect on the food web changes by discussing: "How many other species would be impacted if these two invasive crabs were introduced into the ecosystem we created today?" "Are only species with direct connections (arrows) to the invasive crabs impacted by their presence in the ecosystem or are there indirect impacts to other species? Why do you think that is?" "Is this a healthy ecosystem that is sustainable?" (Answer: The food web could fall apart after losing some of the species!)

Evaluate/Reflect

1. Ask youth to reflect on their learning by asking these questions: "Were there any connections that surprised you?" "Have you seen any of these connections in real life?" "How would you describe an ecosystem to your friends or family?" "What do you wonder about the connections between species in an ecosystem?"

Extension

1. Mention a species off the top of your head. Ask youth to write the name of the species on a white board. Ask youth if they can connect the new species into the web they have created. Adding a new species may require them to add other species to the web to make a connection – that is fine! Challenge youth to think about how all species are connected.
2. Humans can be added to almost every food web. Challenge the youth to add humans into the web they have already created.
3. The activity "Oh Deer" from *Growing Up WILD: Exploring Nature with Young Children* can be used as a supplement to this activity.

NGSS alignment

- 5-PS3-1 Energy (Next Generation Science Standards) www.nextgenscience.org/pe/5-ps3-1-energy
- 5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics (Next Generation Science Standards) www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics

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Activity 2: What's an invasive species? Where did they come from?

Topic: Youth are introduced to the concept of invasive species and explore how species can be transported unintentionally to new geographic locations.

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

Materials

- Aluminum trays
- Presorted bags of beads and pom poms (sorted by what goes in each tray)
  - Green pom-poms: 30-35
  - Blue pom-poms: 120-130
  - Green beads: 80-90
  - Other beads: 160-175
- Plastic cups
- Paper, pencils, colored pencils (optional)
- Computer and projector to show video (optional)

Learning Outcomes

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

1. Describe how species can travel around the globe with human help.
2. Explain the difference between native, introduced and invasive species.

Background Information

Many species that now live on the coast of Maine have not always been here. Green crabs and Asian shore crabs are some examples of invasive species. Invasive species are plants or animals that have been introduced to new areas and do harm those new ecosystems. These crabs traveled to the coast of Maine decades ago with human help. Plants and animals are transported around the globe via planes, trains, trucks, and, most important to this lesson, ships.

Cargo ships play a huge role in transporting plants and animals. Due to their massive size, many small creatures can be attached to or travel in these ships and not be noticed. This is how many of the introduced crab species arrived in Maine; on ships and with human help. These crab species add a new link to the food web and, with few predators, high reproduction rates and voracious appetites, disrupt the native ecosystem of the Maine coast.

Vocabulary

- **Ballast water:** water held in tanks on large ships to provide stability in rough seas
- **Biofouling:** the accumulation of plants and animals on wet surfaces such as the hull of a ship

- **Introduced species:** a organism that has been intentionally or accidentally brought to an area where it is not native
- **Invasive species:** an introduced species that has the potential to do harm to the environment
- **Native species:** the natural distribution of an organism.

Methods

Engage

1. Reflect on what was learned in the first activity. Ask youth to think about what species they learned about. Give the group a chance to share what they remember.
2. After a few species have been named, ask the youth some questions to get them thinking about how animals travel from place to place. Some example questions to start are: "How do animals travel?" "How far can they travel?" "How do land/terrestrial animals travel vs. ocean/marine animals?"
3. Movement activity (if you have the time and space): Name one of the species they came up with at the start of this activity and ask them to travel across the room the way they think that species would move. They could walk like a crab, swim like a fish or fly like a bird, etc.
4. Shift into discussing how humans travel. Start with generally how humans get from one place to another. This could be a continuation of the movement above. Ask youth to walk/crawl/run/skip/swim across or around the room as a person might.
5. Introduce the concept of using machines to aid global travel. Some example questions are:
    a. "How do humans travel long distances?"
    b. "What machines or technology help humans travel?"
    c. "How do humans travel across the ocean?"
    d. "How far do humans travel?"
    e. "How far have you ever traveled?
    f. How did you get there?"
6. Ask the youth to think about the ways in which human travel differs from animal travel. Example questions:
    a. "How does human travel and animal travel differ?"
    b. "Do animals use machines or technology to help them get to where they need to go?"
    c. "Which can travel farther, a person or an animal?"
7. Discuss: "How can human travel affect how animals travel?" There is no right or wrong answer, and it might be difficult for youth to come up with ideas for this. Some examples you could provide are:
    a. Roads are often in the path of where animals want to go. Animals sometimes need to cross them and it can be difficult for them because cars get in the way.
    b. A mouse or chipmunk might build a nest in a car engine and unintentionally hitch a ride to a new location.
    c. Insects will often fly right into car windshields.
8. Automobile examples are often easier for youth to understand, but that does not mean that cars are the only example they will share. If you do not get any marine or boats as examples ask that explicitly now: "How do you think boats affect how animals travel?"
    a. Some examples could be how motorboats create a big wave and this can affect animals swimming nearby, or how in paddle powered boats sometimes seaweed is picked up and moved around.

9. Shift the conversation to big boats, such as cargo ships Example Cargo Ship Image (Flickr) if needed. Ask youth if they think that boats like this can affect how animals travel.
10. Throughout the discussion make sure that youth understand that humans and other animal species can travel. The way humans travel might be different or involve more technology but animals still make their way from place to place. Make sure to note that both animals and humans travel in many different ways and they can both affect each other.

Explore

1. Group students into groups of four to five and pass out a set of materials to each group. Each group gets one tray filled with the pom poms and beads and every student should have a cup.
2. Explain to the youth that you are going to explore one way humans transport animals to new places. Take a moment here to introduce the green crab. Start by asking youth if they remember anything about green crabs from last week. Share that these crabs are native to Europe and traveled to North America, with the help of people, in the mid 1800s and have been in Maine since 1900. Share the Range map of invasive crab (Carcinus maenas) map on the Look Out for Invasive Crab! page (fisheries.noaa.gov/alaska/habitat-conservation/look-out-invasive-crab) on NOAA Fisheries website if it is helpful. If time and equipment allow, show the video, Attack of the Green Crabs (O'Chang Studios/YouTube), (youtube.com/watch?v=5Rcy71DSBus) to introduce green crabs, how they traveled to Maine and their impact on the environment.
3. For this simulation the tray with the pom poms and beads represents the Atlantic Ocean and all the plants and animals living in it. Their cup is a cargo ship traveling across the ocean.
4. Each participant will take a look at the tray and what it is filled with. They need to determine a path to take a scoop with their cup from one side of the tray to the other. They will each take a turn, close their eyes (because ships don't see what they are picking up along the way) and scoop with their cup. Make it clear that the action of them scooping is meant to model a ship traveling across the Atlantic Ocean from Europe to Maine to deliver goods. When they take their scoop their cup should travel from one side of the pan to the other and touch the bottom of the pan as it travels.
    a. Every member of the group should take a turn and then dump the contents of their cup carefully (the beads will roll) onto the table.
    a. Separate what they picked up into different categories, each represents different things:
        - Blue pom poms: water that was picked up along the way
        - Green pom poms: seaweed picked up along the way
        - Beads that aren't green- small animals picked up along the way
        - Green beads: green crabs picked up along the way
5. Ask the youth to compare what they picked up with the other members of their group.
6. After this initial comparison, have youth put any of the pom poms they picked up back into the bin. Example script: "The plants that have traveled over have a difficult time leaving the boat. This boat is only docking in Maine for long enough to unload the supplies and then it will travel back to where it came from. This ship will take the plants back with it. Likewise, the water the boat transported is not a threat (only the living things in it are). The blue and green pom poms can all be put back into the tray."
7. Have the youth focus on the animals they picked up. Have them count: How many green crabs did each individual get? How many green crabs did the group get?

8. Give the youth a chance to share their numbers with the whole group. Example questions: "Did anyone (individual or group) avoid picking up any green crabs?" "Was it easy or hard to accidentally transport a green crab on your boats?" "Did you intend to pick up any green crabs when you took your scoop?" "How did it feel to find out you transported a green crab to a new location? Why did you feel that way?"
9. Once the group has a chance to explore the number of green crabs transported, make connections with their learning from last week by discussing the green crabs impact on the food web. Example questions: "Is bringing a new species to a place it didn't previously live something we want to happen?" "Is having these crabs in Maine beneficial or harmful to the ecosystem? How?" "Do you think these new crabs will compete for food with crabs that are already on the Maine coast?" "Do you think there is enough food to support both native and introduced crabs?" (Answer: The green crabs will compete with the native crabs for food and there is not always enough food for all of the crabs to survive.)
10. Introduce the concept of native species vs introduced species (species that came from a different area, but is not necessarily a threat to the ecosystem) vs invasive species (introduced species that are a threat to the ecosystem). Ask if they think the green crab is native, introduced or invasive and why.

Video — Activity 2: What is an invasive species? Where did they come from?
https://youtu.be/nDlOMGSQYek

Explain

1. Discuss the ways that cargo ships may inadvertently carry plants and animals across the ocean. Explain that large ships can have 'stowaways' that don't get seen and get transported unintentionally with the cargo. Ask youth how they think this might happen.
2. Have youth think about what the hull, or bottom, of a ship looks like when it has been in the ocean without being cleaned for a long time. It is covered in sea life, like seaweed and barnacles. This is called biofouling and is one way plants and animals may be transported from one port to another.
3. Explain also that large ships, like cargo ships, pump water, called ballast water, from the sea into tanks to help provide stability in rough seas. The ballast water is then pumped out, along with any tiny plants and animals growing in it, into other ports when it is no longer needed. Many marine species (both plants and animals) start their life cycle as plankton and can be transported this way without even knowing they are there.
4. Discuss: "How is what you did today similar to a cargo ship traveling across the ocean?" "When you took a scoop with your cup did you intentionally pick up any green beads?" "Do you think cargo ships intentionally transport species to new places?" "What could you do differently to avoid picking up green beads with your cup?"
5. Do the simulation again with any strategies or changes that they came up with as ways to avoid picking up green beads.
6. As before, count the beads. Were they able to pick up fewer green beads with the changes they made? Do they think cargo ships could make changes to transport fewer species?

Elaborate

1. Have youth apply what they have learned through their model to explore how we can prevent invasive species from spreading in the real world. Example script: "Now that we have seen an example of how humans have helped animals travel around the globe, can we brainstorm some ideas on how we can prevent this from happening?"

2. Have youth brainstorm with their group how they would prevent the transport of species in the ocean on ships. This could be a change in how the boats operate while doing their job or something they could invent to prevent transporting unwanted plants and animals.
3. Have youth share with the whole group any solutions they came up with.
4. Ask youth if they think there are laws or regulations that could be put in place to prevent the spread of invasive species and what might be the challenges of implementing these changes? Some real world examples are:
    - **a.** International maritime regulators have worked to develop regulations to treat ballast water before it is dumped back into the ocean to try to prevent introducing marine species to new places.
    - **b.** Some countries are also exploring regulating cleaning protocols for large ship's hulls to prevent biofouling contributing to the movement of invasive species.
    - **c.** Unfortunately, the spread of marine species can be hard to regulate since oceans are connected together and it takes the cooperation of many different governments world wide.

Evaluate/Reflect

1. Make connections to other bodies of water found in Maine. Unintentionally transporting plants and animals is a problem on small recreational boats that travel on lakes and rivers, too. Ask youth to think about how this could be prevented. Example questions: "How would you apply what we learned about cargo ships to recreational boats?" "How could boaters prevent the spread of plants and animals from one lake to another?" "Have ever heard about laws and regulations to prevent animals and plants from moving to new places?"
2. Introduce current boat laws in Maine by sharing the flier with the participants: Infested Ramp Sign (JPG) (maine.gov/dep/water/invasives/images/2012infestedrampsign.jpg)and also pages 8 and 9 from the State of Maine Department of Inland Fisheries and Wildlife's The Boater's Guide to Maine Boating Laws and Responsibilities (PDF) (maine.gov/ifw/docs/maine-boating-laws.pdf). Example script: "Maine currently has laws in place to make sure species aren't allowed to travel between bodies of water with human help. The best way to remember this is 'clean your boat before you float.' Maine boat laws require you to clean your boat before going into the water so no stowaways can be transported from waterbody to waterbody."
3. Wrap up today's learning by asking some reflection questions: "What can you do to help animals stay in their natural habitat?" "Can you think of any other examples of animals traveling long distances?" "Can you think of any other laws similar to the boating law we learned about? (does not need to be boat or waterway related, think of 'Buy is where you burn it' for campfire wood)" "What is something new you learned today?" "How do you feel about species moving from place to place?" "How can movement be beneficial? How can it be bad for an area?" "Why should we care if species move from their natural habitats?"

Extension

Create a sign or poster to:

1. Explain their new rules for the scooping game and how to not collect green crabs.
2. Inform the public about cleaning your boat and/or not dumping bait to protect waterways from invasive species.

3. Have youth research another invasive species found on the Invasive Species page (Maine.gov) or on the Invasive Pests page (Maine.gov Got Pests) and create a sign, poster or slogan to warn others about the dangers of introducing that species to the ecosystem and what steps they can take to prevent the spread of that species.

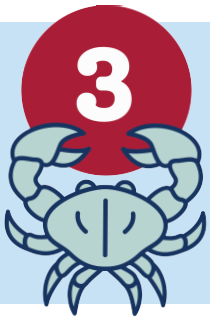
NGSS alignment

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics: www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics

Activity 3: How Do Invasive Crabs Differ from Native Crabs?

Topic: Youth observe crab movements at different water temperatures and use elements of the scientific method to make predictions, collect data and draw conclusions.

Time: This activity should take approximately 45-60 minutes to complete. This activity may be 90 minutes or more if all parts of this activity are completed.



Materials

- Rulers
- White boards
- Dry erase markers
- Erasers
- Life size crab images
- Stopwatches
- Activity 3 data sheet
- Computer/projector/internet (to view the videos)

Learning Outcomes

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

1. Name ways invasive crab species differ from native crab species.
2. Explain how changing temperatures affects crab behavior differently for different species.

Background Information

In this activity youth will explore crab species differences. This activity has youth collect data from videos of crabs on a specialized treadmill and crabs flipping upright after being placed on their backs. The experiment is to determine differences after the crabs are exposed to different temperatures of water.

The native Jonah crab differs from invasive crabs (green crabs and Asian shore crabs). A visual difference is their size and color. The Jonah crab is much larger and a different color from the invasive species. This is not the only difference, the crabs react differently to different water temperatures. The invasive crabs are more thermally tolerant; they can live in higher and lower water temperatures. This characteristic makes the crabs a successful invasive species because they can survive in many different habitats. In comparison, the native crabs are less thermally tolerant, meaning they can't survive in extreme temperatures. Because of this, Asian shore crabs could outcompete native crabs as ocean temperatures rise.

Vocabulary

- **Ambient:** the natural temperature of an environment
- **Carapace:** the protective back covering of an animal, like a crab
- **Conclusion:** making meaning of data
- **Data:** information collected from observations
- **Hypothesis:** a testable explanation based on evidence
- **Invertebrate:** animals that do not have a backbone
- **Observation:** watching what happens
- **Prediction:** what you think will happen

Methods

Engage

1. Lead a discussion to review what youth have learned about crabs in Maine. Sample questions: "What did we learn about crabs last time?" "What types of crabs are there on the coast of Maine?" "How did those crabs get here?"
2. Ask youth if they think there are any differences between the native crab species living in Maine and new species that have traveled here. At this point you are planting the seed of differences between native and invasive species. Any answers are acceptable, but they should be able to explain their thinking.
3. Break the youth into groups of three or four and pass out the crab images. Ask the youth to inspect them. Have groups discuss what they notice as differences. Differences could be anything from the shape of the shell to the color of the crab.
4. Pass out rulers to each group and encourage groups to utilize their rulers to compare sizes with actual values. They will be able to notice how much the Asian shore crab and Jonah crab differ in size
5. Bring the group together to share what they observed. Ask the group if they think the crabs differ in ways that we cannot see. What might some of those ways be?

Explore

1. Explain that they are going to watch videos of the different crabs. They will be scientists investigating differences in the crab species! Example script: "Today we are going to be scientists making observations. We are going to watch videos of the crab species either walking on a specialized crab treadmill or flipping over after being placed on their backs. These crabs were collected off the coast of Maine and these videos were made by a scientist named Emily who works with these crabs everyday."
2. In this first video the scientist, Emily, introduces the three crabs: Asian shore crabs, green crabs, and the native Jonah Crab. Emily explains the equipment/activity. These crabs will be walking on a treadmill and flipping over at three different water temperatures. The first will be ambient, or the typical ocean temperature, then both warmer and cold water temperatures. The goal for these experiments is to determine which crab species reacts the best at each temperature, or which crab can move the fastest.

3. Play the introduction video: Introduction: Invasive Crabs Versus Native Crab (YouTube: https://youtu.be/dCWpjoE2SzU?si=NLzcdHZWB-59QLWQ).

If time permits you may do both of the following activities. If you are limited by time, we recommend the "Crab Walking" activity for older (5th and 6th grade) youth, and the "Crab Flipping" activity for younger students.

A. Explore: Crab Walking

1. Hand out white boards, markers, erasers, datasheets and pencils. Add to the explanation to prepare the youth. Example script: "In this video you will see crabs on a treadmill. The goal is to count how many steps the crab takes in a 30 second period. Pick one leg to focus on (make sure it is a leg and not a claw!) and count how many times that leg moves in a 30 second period. The video will show two different views, front and top for 30 seconds each so you will see each crab on the treadmill for one minute. You only need to count for 30 seconds so you can pick if it is easier for you to count from the front view or the top view."
2. Before watching the video explain that scientists make a hypothesis, which is what they think will happen in an experiment. Based on what we have learned so far, have youth write a hypothesis. An example of this could be "The Jonah crab will take fewer steps than the others at all temperatures." or "The invasive crabs will move faster than the Jonah crab in warmer water." Have youth make predictions: which crab do they think will move fastest or take the most steps? Which will be slowest or take the fewest steps? Do they think this will change at different temperatures? How?
3. The whiteboards or back of their data sheet can be used to make tally marks for each movement. You will show the video clip and have the youth make their tally marks. Then pause the video and give the youth time to count all of their marks and come up with a final number.
4. This activity can be challenging for some youth, make sure to let them know that this is HARD and it is okay if counts differ from person to person. The count will change based on which leg is chosen to focus on and if they are counting the front view or top view.
5. The videos show the three species of crabs completing the task at one temperature and then the next temperature. You may need to pause the video periodically to give youth a chance to write down their counts and remind them which crab and temperature they are counting.
6. Start the Crab Walking Video. After the youth have seen the three crabs at the ambient temperature pause at 5:27 so the data (number of leg movements) can be counted and collected. Collect all the data and calculate a group average for each crab at ambient temperature. Youth should record the average on their data sheets. As a group identify which crab took the most steps? Which one took the fewest steps? Which one moved the fastest? Which crab was hardest to count the steps? Why do they think it was hard to count?
    a. Play the video: Invasive Crabs Versus Native Crab: A. Crab Walking (Youtube: youtu.be/n-SWmNWkuF8?si=DMliULRwelj_HF0B)

A. Explain: Crab Walking

1. Continue watching the video and collecting data for the warm temperature (starts at 5:27) and the cold temperature (starts at 10:00). Pause the video as needed to compile data and collect numbers from youth. At the end of the treadmill videos you should have 9 average numbers of steps (3 species at 3 different temperatures).
2. Ask the youth to think about how the different temperatures affected each of the crabs. Sample questions: "Which crab moved the best in the cold water? What about the warm water?" "What was the fastest moving crab overall?" "Can you make any connections about why this is important?" "What do you think our observations mean for the crabs' ability to survive in the wild?" "What impact could ocean temperature have for our crabs on evading predators or competing for food?"

B. Explore: Crab Flipping

1. Pass out stopwatches and show the youth how they work. Have them practice timing something simple by saying "go", waiting several seconds, then saying "stop".
2. Put youth in groups of 3. Each group member is responsible for timing a different crab species
3. Before you begin the data collection explain that scientists make predictions called a hypothesis before they begin an experiment. Based on what we have learned so far, youth predict which crab they think will flip back upright slowest, and which will flip the fastest. Do they think this will change at different temperatures, and if so, how?
4. Start the Crab Flipping Video
    a. Play the video: Invasive Crabs Versus Native Crabs: B. Crab Flipping (YouTube: youtu.be/WxvNnzUPsIo?si=AuDfPqwNyGNLittF).

B. Explain: Crab Flipping

1. Discuss what they observed. Sample questions: "Which crab species was able to right itself the fastest at each temperature?" Which ones were the slowest?" "Does the temperature affect each crab species in the same way?" "How might a crab in the wild end up on its back?"
2. Connect the flipping experiment with nature: "What does the ability to flip over mean for an animal?" "Do you think crabs, or any animals, are more likely to get hurt on their back or on their stomach?" "Can crabs run away when they are on their back?" They need to flip over first! Relate this back to getting away from predators if youth don't make the connection on their own.

Elaborate

1. If you completed both parts of this activity ask: "Do you think it was easier to make a prediction about what would happen to the crabs ability to flip at different temperatures because we had done the treadmill experiment first? Why?"
2. Reflect on their predictions. Example questions: "Were the predictions we made before each experiment correct?" "What evidence do you have of this?" "Are scientists' predictions always correct?" No! Sometimes scientists are surprised by their data! They use the evidence they collect to form conclusions and come up with new questions and design new experiments to find answers.

3. Explain that after scientists collect their data they look for patterns and form conclusions about what it means. Example questions: "Do you notice any patterns in the data we collected today?" "Look at the data you collected, was the same crab always the fastest or slowest?" "Did the different crabs react to the changing temperatures the same way?" "What conclusions can you infer from what you observed?"

Evaluate/Reflect

1. Apply what they have learned to the Maine coast. Example questions to get the conversation started:

- **a.** The invasive species (green crab or Asian shore crab) moves and flips over faster in warmer water. What does that mean for Maine? Keep in mind that researchers tell us that the ocean temperature in Maine is rising.
- **b**. Which crabs do you think are the better predators or have an advantage to finding prey in the wild?
- **c.** Which crabs do you think have an advantage for survival and/or population growth? Why? What evidence did you see today to support your thinking? Think about if movement or another attribute gives a species an advantage. For example the small, fast Asian shore crab may be better able to hide from predators. The hard shells and lack of meat may make green crabs less likely to be eaten by a seagull. If individual crabs are able to better survive they have a better chance at reproducing and growing their population.
- **d.** Think about what you have learned about ecosystems and food webs. What could it mean to the food web if the invasive crabs have an advantage both as predators and in population growth? What evidence did you collect today to support your thinking?

NGSS alignment

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics: www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics

THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 4: How Fast Do Invasives Multiply?

Topic: Youth are introduced to the concept of population growth and decline and explore factors like reproduction, predation and migration that contribute to changes in population size.

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

Materials

- Data sheet
- Pencils/ erasers
- Dice
- Rule sheet
- Plastic disks in multiple colors

Optional

- White boards
- Markers

Learning Outcomes

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

1. Understand that invasive species have advantages over native species.
2. Describe the difference between a predator-prey relationship and a competitor relationship in an ecosystem.
3. Explain that a lack of predators is a major contributing factor to population growth for invasive species.

Background Information

This activity shows youth how the growth and reproduction of invasive species on the Maine coast can cause problems for other native species. The invasive crabs eat food that other species need and create competition for scarce food resources. This activity is meant to model a potential way in which invasive species can multiply and how their multiplication can affect other species. This can also be explained as the 'population growth rate' of each species, in this case how the population of a species changes over a period of time. It can increase or decrease depending on factors such as the food present, the environment, or the population of predators. This definition might be complicated for youth to grasp.

This activity consists of youth rolling dice. Each roll corresponds to an action that affects the total number of a

species. Actions correspond to green crabs, clams, and lobsters depending on the section of the activity. This activity should result in green crabs increasing, and clams/lobsters decreasing. This may not happen after every roll but should be the trend after the activity is completed. It is important to have youth compare their results.

This activity models how invasive species can populate areas and spread quickly due to lack of predators in the area. This uncontrolled population then leads to the decrease in other populations. The youth should have learned from the lessons prior that all things in this ecosystem are connected, so an increase in one species affects every other species in the ecosystem.

After a season there should be an increase in green crabs which eat the clams. The clam population will then decrease. This also affects the lobster population, for they also eat clams; the increase in green crabs means there are fewer clams available for lobsters to eat. The lobster population tie-in is included to show how an invasive species affects not just one thing in the ecosystem, but their presence can affect almost every connection in the ecosystem.

Vocabulary

- **Competitors:** species in an ecosystem who need the same resources to survive
- **Predator:** animals that survive by consuming other animals
- **Prey:** animals that are consumed by predators

Methods

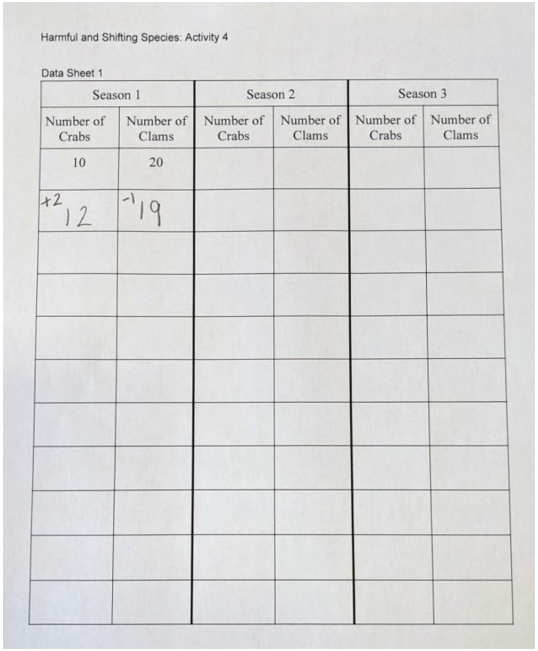
Engage

1. Ask the whole group some questions to get the youth thinking about the clams and green crabs that they have learned about. Example script/questions: "Think back to the green crabs we watched in our last session. What do you remember specifically about the crabs?" "What do you think (or remember from previous activities) these crabs eat?" "What do you think might eat green crabs?"
2. If they are stuck, ask the youth to think back to their food webs. Present them with the aquatic species cards if they are struggling. They can organize them like they did in Activity 1 to model the connections.
3. After the youth have explored what they think eats these species, ask: "Do you think the green crabs we learned about last time eat clams?" The answer is yes – green crabs will eat clams, and eat a lot of them!
4. Explain that green crabs eat clams, but there are not a lot of predators in Maine that eat green crabs. Ask youth if they think this could be a problem for Maine's coastal ecosystem and to explain their thinking.
5. If you did not have time to watch the Attack of the Green Crabs (O'Chang Studios, YouTube) video mentioned previously in the second activity and you have a computer and projector now would be a good time to show it.

Explore

1. Break youth into groups of four and pass out materials. Each group will receive two dice, one Data Sheet 1, one Rule Sheet 1, a pencil, and two colors of plastic disks to use as manipulatives.
2. Explain the roles shown below. Have each group decide who will have what role. Alternatively, the roles could be assigned by the facilitator by having youth count off by 4s and have all the 1s have the role of data keeper, 2s and 3s dice rollers and 4s population trackers. If there is a group of 3 have one youth roll for both the crabs and clams. If there is agroup of 5 you can have two populationtrackers, one for crabs and one for clams.
   a. Data keeper: keeps track of the values rolled on the data sheet. This job can get complicated so it is recommended this is their only job.
   b. Die roller 1: rolls the die for the green crab turns
   c. Die roller 2: rolls the die for the soft shell clam turns
   d. Population tracker: works with the data keeper to use the plastic disks to keep track of the number of individuals in each population
3. Have youth look at their data sheet. Notice that there is space to follow their green crab and clam population for three seasons. Ask them how many crabs and clams they are starting season 1 with (10 crabs and 20 clams). Explain that green crabs are a new species to this area so their population has not established itself the way the native species of clam has.

   To start, each group needs to count out 10 plastic disks of one color to represent the green crab population and 20 plastic disks of another color to represent the clam population.
4. To start, each group needs to count out 10 plastic disks of one color to represent the green crab population and 20 plastic disks of another color to represent the clam population.

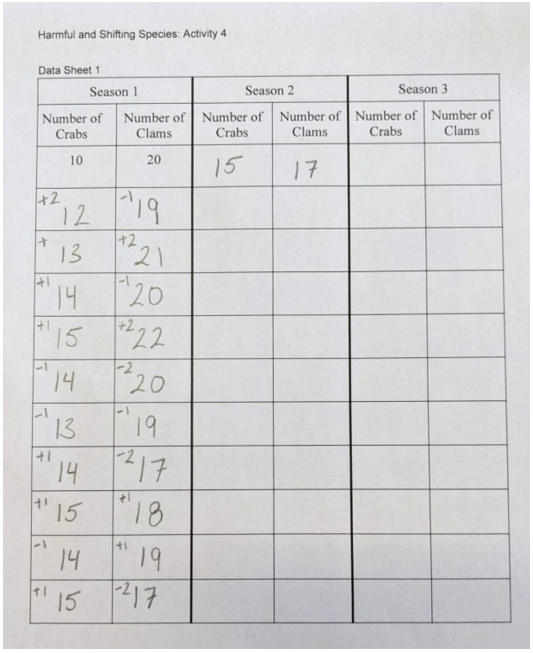


Harmful and Shifting Species: Activity 4

Data Sheet 1

Season 1		Season 2		Season 3	
Number of Crabs	Number of Clams	Number of Crabs	Number of Clams	Number of Crabs	Number of Clams
10	20				
+2 12	-1 19				

Figure 1: Example of a data sheet filled in after one roll for green crabs and one roll for clams.



Harmful and Shifting Species: Activity 4

Data Sheet 1

Season 1		Season 2		Season 3	
Number of Crabs	Number of Clams	Number of Crabs	Number of Clams	Number of Crabs	Number of Clams
10	20	15	17		
+2 12	-1 19				
+ 13	+2 21				
+1 14	-1 20				
+1 15	+2 22				
-1 14	-2 20				
-1 13	-1 19				
+1 14	-2 17				
+1 15	+1 18				
-1 14	+1 19				
+1 15	-2 17				

Figure 2: Example of a data sheet at the start of season 2.

5. It is important that as youth do the simulation they work together as a group. The die roller will roll the die then read the rule sheet to the group. The population tracker will add or take away plastic disks of the right color based on what the die roller reads. The data keeper will fill in the data sheet for how many crabs or clams are in the population. They may find it helpful to write the number they are adding or subtracting small in the corner of the square for that roll and then writing the total larger in the center.
6. It is important that everyone has a chance to complete their task before going on to the next roll. The first roll should be for the crabs then the next for clams. They should alternate crab and clam turns until they have filled in a full season on the data sheet.
7. As groups work the data sheet keeps track of the number of animals in the population after each roll, while the plastic disks show the numbers at the present time/cumulatively. The data sheet can be used to look back on and show the totals throughout the 'season'. Note – for younger audiences or small groups, you may choose to not use the data sheet, and simply use the manipulatives.
8. At the end of the first season the youth stack their plastic disks by color to represent the amount of clams and green crabs that they have. This can be used to visually compare their crab and clam populations as a 'bar chart'.
9. Have groups leave their stacks and data sheets on their table as a display. Youth should walk around the room and look at the other groups' results. Do this as a silent gallery walk without talking. Encourage the youth to think about what they notice. Do the stacks of disks look the same for every group? Do the data sheets all follow the same patterns? Is one species more likely to increase or decrease its numbers after each roll?
10. Call the group back together and ask what they noticed. This can be what they observed in their small group as they rolled or in the results from the class as a whole. Example questions:
    a. "Was there more of one species left than the other?" "Was this the same for every group?"
    b. "Did the population for each increase or decrease?" "Which one increased more?"
    c. "Were there any patterns you noticed?"
    d "Was one species more likely to increase or decrease after each roll?"
11. Have groups to complete the other two seasons on the data sheet. For each new season they start with the number that they ended with the previous season. This means that whatever number they ended with in the bottom square for season 1 is what they start with in the top square of season 2.
12. For the second and third season you may choose to repeat the group walk that took place after season one.
13. It would also be appropriate to do a quick check in after season two and see what trends the youth noticed. Are they the same as what they saw in season one? Ask participants to predict what will happen in the last season. What will have a greater population at the end of the third season? How are the three seasons similar or different?

A. Explain

1. Help youth make sense of the data. Ask them what trends they noticed in each season. Example questions: "Was one species more likely to have its population increase or decrease?" "Why do you think that is?" "Look at the rule sheet, which species had a higher reproduction rate (added more with each reproduction roll)?" Was reproduction the only way a green crab could increase its population?" "Is that the same for the clam?" "Why do you think there are more opportunities for the green crab to increase its population?"
2. Be sure to discuss the predator-prey relationship between green crabs and clams. Example questions: "Think about what we have learned about predators and prey in the food chain, which of these species has more predators?" "What does that mean for the crabs and clam populations?" "What is the relationship between green crabs and clams in the food chain?" "Did you see any evidence of green crabs affecting the clam population or vice versa?"

Elaborate

1. Pass out the second data sheet, and say we are going to repeat the game, but with green crabs and lobster. Example script: "Now that we have seen what happened for three seasons between the green crab and clam population, we are going to explore for a fourth season what might happen between the lobster and green crab populations."
2. Ask youth to predict what they might see happen with the lobster population. Why did they make this prediction? (note: green crabs don't eat lobster, but lobsters eat clams.) Make sure youth understand that in the first scenario the relationship between green crabs and clams is predator and prey. The relationship between green crabs and lobsters is not a predator-prey relationship, but that of competitors for the same food source. They are predicting if the green crabs will have the same impact on the lobster population as the clams, even though they are not eating the lobsters.
3. Have the youth discuss their predictions with their groups. This could be written on a whiteboard or the back of their date sheet.
4. Ask a few groups to share their predictions. What evidence have they seen that led them to that prediction? Ask the youth to use what happened with the green crabs and clams to support what they think will happen with green crabs and lobsters.
5. Play the game for another season (or more as time allows) using the green crab and lobster rule sheet and data sheet. The green crabs can stay as the same color disks, and the lobsters can be the disk color that was once clams.
6. After the youth have rolled the dice on one more season, bring the group back together. Example questions: "What did you notice or observe?" "Were your predictions correct?" "What evidence supports your claim?"

Evaluate/Reflect

1. Reflect on today's activities. Example questions: "What impact does having green crabs move into a new area have on the ecosystem?" "Why do you think this and what evidence do you have to support it?" "What's the difference between invasive species, and non-native or introduced species?"
2. If the youth are struggling with this, ask them to think about what eats the green crab and how likely was a green crab's population to decrease? Remind youth from the last lesson about how the green crab got to Maine – is this their natural habitat?
3. Discuss what an increased green crab population means to the Maine coast. Have youth think back to the food web activity, what happened when they added green crabs to the web? Invasive species like green crabs affect more than just clams and lobsters. What could happen in the future with growing green crab populations?

NGSS alignment

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics: www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics

THE UNIVERSITY OF MAINE Cooperative Extension

4-H STEM Toolkit

Activity 5: How has the Maine Coast Changed?

Topic: Youth use present day and historic maps to investigate where species live in the Gulf of Maine and draw conclusions about the impact of climate change on native and non-native species.

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

Materials

- Aquatic Species Fact Sheets (from Activity 1)
- Two each of map A (2020) and map B (1950)
- Map data sheet
- Four sets of species images with velcro – two each for A and B
- Species lanyards
- Map comparison Venn diagram

Learning Outcomes

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

1. Name a physical change to ocean conditions in the Gulf of Maine over the last 70 years.
2. Describe how organisms living in the Gulf of Maine have changed and shifted over time.

Background Information

The temperature of the ocean is rising, and that is changing where species live and what species exist along the Maine coast. As the temperatures increase it has caused Maine species to slowly shift the place they call home further north and has allowed species who couldn't previously survive in Maine's cold ocean waters to now call the Maine coast home.

This rising temperature has not only affected where things live, but also the total population of certain species. In Activity 3 youth learn that invasive crab species are able to thrive in warm water, while other native species cannot. This means that as the ocean temperature rises the green and Asian crab populations have been able to increase faster than the native Jonah crab population has.

Vocabulary

- **Habitat:** where a species lives

Methods

Engage

1. Play a game of aquatic species "Who am I?". Place a species lanyard so it hangs down on each participant's back so they cannot see which species is on their card. Use the fact sheet for the food web from Activity 1 for species characteristics, these may need to be shared among small groups.
2. Have youth ask each other yes or no questions to try to identify their species. Example questions: "Does my species live in deep water?" "Is my organism green?" "Do people eat my species?" "Is my species invasive?" "Does my species have any predators?"
3. Using the fact sheet from Activity 1, youth should eventually be able to figure out which species is on their back!
4. Pick one of the plants or animals that lives in open water. Ask: "Would you ever see this species on the beach? Why or why not?" Suggested examples: seaweed is something that you can see on the beach or out on a boat, but large fish like cod are something you do not see at the beach but see in the open water.
5. Now take some time to introduce the idea of a habitat. Example script: "Many animals only live in certain places because they need certain things to survive. A lobster is not seen in tide pools or on a beach because it lives best in deeper water, but a crab can live close to the beach or in the intertidal zone (the area covered by water at high tide and uncovered at low tide) because it can breathe out of water. The place that has the conditions just right for an animal or plant to live is called its habitat."
6. Ask youth to review the fact sheet for the species they had during the game. What is its habitat? What characteristics or adaptations do they think their plant or animal has to make it suited for living in that place?

Video — Activity 5: How has the Maine coast changed? https://youtu.be/5thhupP0FFo

Explore

1. Break youth into groups of 4-5. There should be an even number (either two or four) groups. Half of the groups should work with the map and species cards A and the other half of the groups work with map and species cards B.
2. Pass out the map, map data sheets, and the species card for their map. The data sheets are the same for both but one species set is for the map of today, and the other species set is for the map of 60 years ago. Make sure the species you gave each group match the map they are given! Groups may also find the habitat information on the Aquatic Species Fact Sheets useful to have.
3. Discuss how to read the map. Where is the water deeper? Where is it shallow? Where is it warmer or cooler? How can you tell?
4. Explain that they may have to estimate where the depth and temperature is right for a species, the exact depth and temperature they need may not be labeled on the map.
5. Have the youth look at the data sheets and as a group work together to place all of the species on the map in a place that makes sense.

6. There are multiple places that each species could be placed, and there is not a correct or wrong answer. Make sure that the youth are using the data provided to them to back up their placements. As the youth are completing the activity make sure to ask why they are placing things in certain spots and encourage them to explain thoroughly.
7. If the youth are not liking the velcro dot options, they are also able to place the species anywhere on the map as long as they can back up their choices, just be aware if the map is moved these species are not attached and may fall off or move around.
8. Each group member should be involved, but it is up to youth how they want to divide the labor. They could assign each person a job, one to pick the species card to place, another to read the data sheet for that species and another to locate where it should go and put it on the map. They may also decide to assign each person a particular species they are responsible for learning about and placing all of those on the map; or if they work particularly well together they may decide to do it all cooperatively as a group.
9. As they are placing their species on the map, circulate to help groups who may be struggling with how and where to place their species.

Explain

1. When all of the species pictures are on the maps discuss the process and trends they see on their map. Remember there are two different maps. For now we are not going to compare the two (that will come later) and each group is going to focus on what they did for their own map.
2. Ask groups how they came to place species where they did. How did they make decisions about where to put species when it wasn't obvious where it should go? Did any of the placements surprise them? Do they notice any trends with where species ended up on their maps?
3. Have the youth take a good mental image of their map and try to remember what went where and what species they had. Have them make a prediction for what they think they will see on the maps for the other year. They should be able to justify their prediction with a reason for why they think it will be the same or different.

Elaborate

1. Have the youth switch places, and look at the other groups' maps. They should start by looking at the new map quietly, and think about what they notice. Are there any differences from the map that they helped to create?
2. Youth then talk to the person next to them, have them share what they noticed about what is in front of them. What are the similarities between the maps and what are the differences? Did their neighbor notice anything that they did not?
3. Together with their group, have the youth share what they observed. What was the biggest difference that they found? Was there anything the same about their map and the map that they are now looking at?
4. Hand out a Venn diagram to each group and have them work together to fill it in to organize their observations. You may need to explain how to use the Venn diagram, the differences between the maps go in the outer parts of the circles and the similarities go in the overlapping part of the circles. They may need to go back and forth between the two maps to confirm their observations.

5. Encourage deeper thinking by asking groups questions: "What do you notice about the coastline?" "What do you notice about the species living in the Gulf of Maine?" "Are they the same?" "Do they live in the same places?" "Do you see any differences in where they live or how many there are?" "What do you notice about the water temperature for each map?"
6. Have all the youth get together in one big group, and if possible find a way to display both/all four maps so they are visible to the whole group.
7. Invite the youth to share what they noticed with the whole group. Example questions: "Did both groups notice the same things?" "How are the maps the same?" "How are the maps different?"

Evaluate/Reflect

1. Reflect on why they think there are differences between the maps. It might be helpful to remind the youth which map is from today (A), and which map is from 70 years ago (B). Encourage the youth to think back to how animals travel and what they have learned about how species interact with each other in their ecosystems.
2. The youth are likely to notice that the species have changed location, but there are also differences in the numbers of each species and the temperature of the water has changed. Use targeted questions to guide youth to these insights: "How many green crabs are on each map?" "Why do you think there is a difference?"
3. Discuss if they think human activity could have any influence on these differences. If necessary, remind youth about what they have learned about green crabs, and how their voyage over here was due to human travel. This also could be a time to talk about fishing and lobstering and how that can affect the population of different species. Example questions: "Can you think of other ways humans may influence where and how many species are found somewhere? Explain your thinking." "What do you think would happen if people were allowed to take as many fish/lobster/clams/crabs as they want from the Gulf of Maine? Why do you think that would happen?"

NGSS alignment

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics (Next Generation Science Standards): www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics