Invasive Crayfish Collaborative
Great Lakes

Lesson 1

Crayfish + Freshwater Ecosystems

Subjects Science, Language Arts, Art

Grade Levels Ideal for grades 2–8, adaptable for 9–12

Time 75 minutes or more

Lesson Overview

This lesson is designed to be highly adaptable, but options include a brief "crayfish trivia" activity to assess students' current understanding of crayfish and their freshwater ecosystems, followed by a quick brainstorming session in pairs about what students already know, then a short multimedia presentation. Next, students can act out a simple food chain of different organisms that feed on each other in freshwater ecosystems. They may conduct a short research project about a freshwater organism and create a more complex model of freshwater food webs with the whole class, which demonstrates the resilience that comes with biodiversity.

A northern (virile) crayfish *(Faxonius virilis)* in its freshwater ecosystem
Photo: Missouri Dept. of Conservation

The lesson closes with a short discussion of the many interdependent relationships in the ecosystem that allow species, including crayfish, to survive. Their important roles in freshwater ecosystems are highlighted.

See the "Enrich/Extend" section at the end of the lesson for more ways to engage all learners, including field experiences.

Goals

- Students will understand that crayfish and a multitude of organisms in freshwater ecosystems are woven together in an interconnected web of life known as a food web. They will understand that this interdependence among species, supported by nonliving things such as water, air, rocks, and soil, enables animals and plants to survive and live in balance with each other for the ecosystem's long-term health.
- Students will think critically about the particular roles of crayfish in freshwater ecosystems, and how they can help keep the ecosystem healthy.

Objectives

- Students will create a visual representation of the concepts of a food chain and food web and how organisms are linked to one another by the transfer of matter and energy in an ecosystem.
- Students will research an organism from the freshwater ecosystem and write about its interactions with other organisms in it.
- Students will show visually and explain verbally how energy from the sun and photosynthesis forms the foundation of freshwater ecosystems.
- As a class, students will simulate a freshwater web of life, including the interactions in the ecosystem and the factors which create healthy ecosystems, including biodiversity.

Next Generation Science Standards

Performance Expectations

- MS-LS2-3: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.
- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Building toward

- MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- HS-LS2-4: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Crosscutting Concepts

- Energy and Matter
- Systems and System Models
- Stability and Change

Science & Engineering Practices

- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Core and Component Ideas in the Life Sciences

LS1: From Molecules to Organisms: Structures and processes

- LS1.B: Growth and Development of Organisms

LS2: Ecosystems: Interactions, Energy, and Dynamics

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Core and Component Ideas in Earth and Space Sciences

ESS2: Earth's Systems

- ESS2.C: The Roles of Water in Earth's Surface Processes

Common Core State Standards

Speaking and Listening Standards for Grade 6

(similar standards for grades 4–5; 7–12)

Standard 4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

Standard 6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

College and Career Readiness Anchor Standards for Writing

Standard 6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Standard 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Center for Great Lakes Literacy Principles

Principle 5. The Great Lakes support a broad diversity of life and ecosystems.

Teacher Background

Crayfish

Crayfish are **crustaceans** that are closely related to lobsters, their saltwater cousins, and they play an important role in freshwater ecosystems, such as rivers and lakes. They are an important food source for many species of fish, birds, amphibians, reptiles, and mammals, even those that spend much of their time on land, such as raccoons.

Crayfish are opportunistic **omnivores** that eat both dead and living plants and animals, including insects, snails, and fish on river and lake bottoms. Their role in reducing decaying matter and filtering the water is especially important for improving water quality. In addition, their habit of burrowing provides benefits for water quality, although burrowing near the water's edge can sometimes contribute to erosion (Helfrich, Parkhurst, and Nevis 2001). Predators as well as scavengers, crayfish—especially **invasive**, non-native species, can sometimes negatively impact ecosystems in other ways. We will explore the positive and negative roles more fully in later lessons.

There are 620 species of crayfish (also called crawfish, crawdads, or mudbugs) worldwide, and 39 of these species are native to the Midwest United States (Taylor et al., 2015). Crayfish are a diverse group of decapod (10-legged) crustaceans related to shrimp, crabs, and lobsters. Crayfish breathe primarily through gills but can breathe air when necessary, as long as their gills are wet or humidity is very high. They live semi-aquatic lifestyles in lakes, streams, ponds, flooded fields, or ditches. Some species spend most of their lives in underground burrows, while others burrow only if necessary, such as during droughts. Midwestern crayfish species live on average three years but have been known to live up to six years.

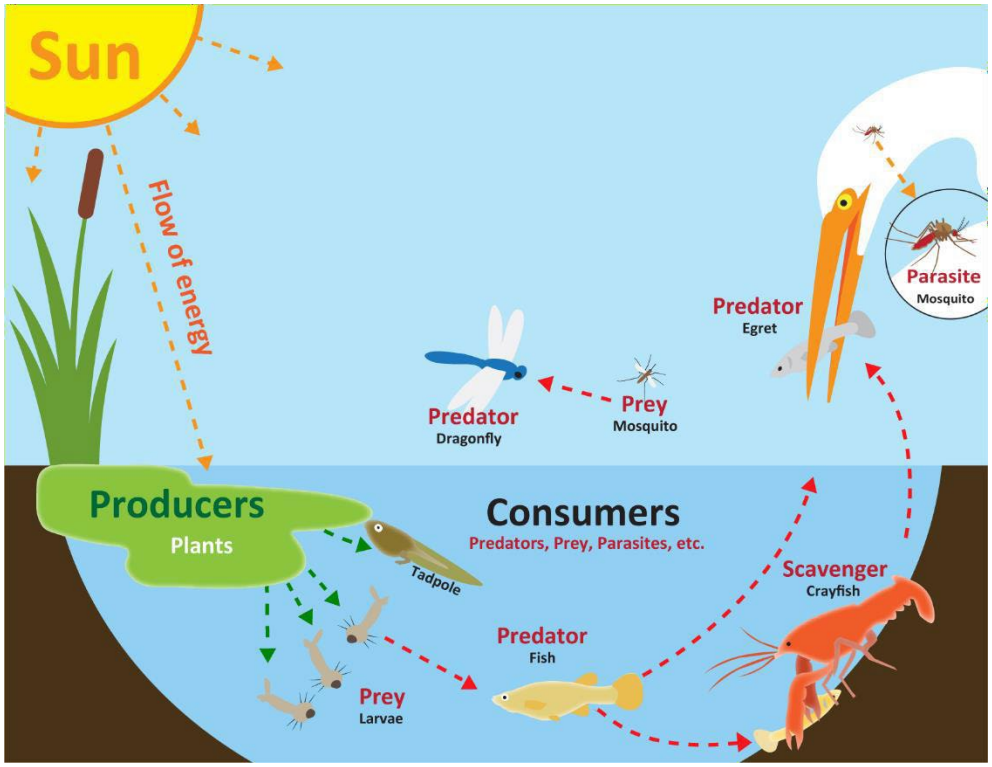
The vast majority of the world's crayfish species are found in North America, especially the southeastern United States. They can be found on every continent except Antarctica. Many species are at risk of extinction due to a variety of factors, such as habitat loss, pollution, and the spread of invasive crayfish species and disease (Larson et al. 2020).

Photo: Jeff Benca; used by permission

Ecological Concepts

An **ecosystem** is any group of living and nonliving things that interact with one another. Some are relatively small like streams and ponds where crayfish often thrive, and others are large **biomes** like wetlands or forests.

Biodiversity is a measure of the number of different species in a specific area, and it is also used as a general description of species richness, ecosystem complexity, and genetic variation. In general, the more biodiversity, the more stable the environment and the less it is impacted by changes. The organisms that interact with each other in their ecosystems are called a **community** (or **ecological community** for high school students).



Visual model of a freshwater ecosystem showing flows of energy
Graphic by Eric Engh and Rick Reynolds; used by permission

Some members of a community, such as crayfish, are particularly important to the community's vitality. For example, crayfish recycle nutrients through the consumption of decomposing organisms. This helps clean the water. They are also an important food source for many predators such as fish, birds, reptiles, and amphibians. Because of all these important roles, crayfish can be considered a **keystone species** for their ecosystem; just like the keystone at the top of an architectural arch that helps hold the whole structure together, a keystone species is vital to the stability of an ecosystem. If it is in trouble, the whole ecosystem can be negatively impacted.

Creating ecosystem **food webs** helps students understand the basic ecological principle that everything in nature is connected. By analyzing the relationships between the various living and nonliving things, students will increase their understanding of community ecology and the underlying relationships that bind living things together.

Materials

- "Crayfish Trivia" handout (one for each student, found at the end of the lesson)
- "Crayfish and Freshwater Ecosystems" PowerPoint presentation available on the Invasive Crayfish Collaborative website: invasivecrayfish.org/products
- Computer access and Microsoft PowerPoint software
- Display screen
- Markers, crayons, or colored pencils for students to share
- Ball of yarn
- Class whiteboard, chalkboard, or interactive whiteboard

- *Optional:*
    - Copies of the "Organism Presentation Rubric" found at the end of the lesson
    - "Curious Crayfish + Freshwater Ecosystems" activity, which follows the lesson
    - Large pieces of paper or poster board (one per student or one per group), if available, for the activity listed at the end of the Enrich/Extend section

Preparation

1. Ensure all materials above are ready for student use.
2. In addition to helping students understand crayfish and freshwater ecosystems, this lesson is designed to help you teach and reinforce a variety of concepts and skills, and it is adaptable for a wide range of grades and connections across the curriculum. For example, several different kinds of models are suggested, including diagrams and kinesthetic models to help students understand the content presented, while simultaneously helping them to understand how to use models themselves to find deeper meaning in the science and better convey information to others.

   Your focus could be on crayfish and their roles in freshwater ecosystems, or you might choose to focus on the importance of biodiversity, or a concept such as adaptation. Keep in mind that Lesson 3 of the curriculum focuses on fascinating crayfish adaptations, including their structures and functions, as well as their behaviors that help them to survive.
3. *Optional:*
    - Review more information about crayfish and freshwater ecosystems to prepare to answer student questions. Good sources include those listed at the end of the lesson in the Expand Knowledge + Skills section.
    - Identify an expert partner to work with your class. Contact invasivecrayfish.org/contact-us for possible recommendations.

Teaching Suggestions in the 5E Model

Engage

1. Introduce the expert visitor if one is present and tell students they will be starting an exciting new unit about crayfish and their habitats (where they live).
2. *Optional:* Explain to students they will first find out what they already know. Pass out the "Crayfish Trivia" handout to each student and allow 10–15 minutes for them to complete it. Tell the students they are not expected to know the answers, so they should just do the best they can. This activity serves many purposes, including evaluating current student knowledge, helping students focus on topics to be discussed, and evaluating change in understanding over time. Collect the handouts. This activity could also be done later as a review game or assessment.
3. Ask students to turn to a neighbor and brainstorm everything they can think of about crayfish, where they live, what they eat and what eats them, etc. They should record all their ideas on a piece of paper, without worrying about if they are right or wrong. Circulate around the room, answering questions, if necessary. After about five minutes, ask for a few to share their best ideas. Then explain to students that this lesson will be

all about the fascinating places where crayfish most often live, called freshwater ecosystems.

4. Open the "Crayfish and their Ecosystems" PowerPoint presentation and you and/or the visitor can lead a brief interactive discussion about crayfish and their ecosystems, drawing on the student ideas shared earlier and the information in the slide notes to talk about the important roles crayfish play, and how they get what they need from their environment, including food, water, shelter, space, and oxygen. If available, you can show the students live crayfish and/or any other organisms from freshwater ecosystems that interact with them, such as a variety of plants, fish, turtles, or frogs/tadpoles.

Explore

5. Ask the class to arrange their desks in groups of four, if necessary, and pass out blank paper (one sheet per student) and coloring supplies. Ask the students to each share the name of one of their favorite species from freshwater ecosystems with each other and demonstrate how they can write its name in large letters in the top third of a blank piece of paper using a pencil. Then they can make the names dark enough to read from across the room with a marker or other coloring supplies. This can be an animal or plant that they have learned about in the presentation or seen in nature. Each student should choose a different organism, and one or more students in each group should choose a plant, because plants are so important for almost every ecosystem.
   Note: To help students understand what to do, you can show them the "Rainbow Trout" example that follows the lesson, create your own example, and/or show student samples. For more advanced students, it may be valuable to have them write the common *and* scientific names of the organism they choose. This will teach them the importance of understanding scientific names, as they provide a universal code for identifying species.

6. Ask the students to create a basic illustration of their organism below the organism's name on the paper. They can use available reference sources such as books and the Internet for reference and/or live specimens if you are lucky enough to have some. Tell students they will only have about five minutes (or however much time you want to allow) to create their illustrations, but that they will be able to add more details and color later if they wish.
   Depending on where you live you might suggest:
   - Animals and plants presented in the PowerPoint presentation, including those shown in the food web diagrams
   - Options of freshwater plants such as those presented in the PowerPoint presentation

7. Next, have students conduct research about the organisms using the available reference sources to prepare a short (perhaps one minute) oral presentation or short nonfiction piece (perhaps 2–3 paragraphs) about:
   - Where the animal or plant lives (its habitat).
   - What it eats and/or what eats it.
   - Other ways in which it interacts with living and nonliving things in the ecosystem (i.e. getting energy from the sun, nutrients from decaying plants and animals, etc.)

- *Note:* These details could be written below the illustration and/or on the back of the sheet. They could also be used as a sample English Language Arts assignment or performance assessment. Pass out the "Organism Presentation Rubric" at the end of the lesson so students know how they will be assessed.

Explain

8. While the students finish their illustrations and/or short research projects, ask the groups to choose 2–3 species and choose volunteers to represent the group to act out a simple **food chain** for the rest of the class. Write the term on the board and ask one of the student groups to send a representative to the front of the room (or the center of the circle if you'd like to ask the groups to arrange themselves in one) to play the role of an animal at the top of the food chain, a large predatory one that eats other animals. Ask the student to try to make themselves look and/or act like the animal they are playing.
9. Ask another group to send a representative to play a different animal that eats other animals, but that might be eaten by the first animal. Ask the second student to act out their animal, while the first gets ready to try to eat it. Ask the class if they know a word used for animals that eat other animals and a word for the animals that get eaten. Write or type the words **predator** and **prey** on the board. Then ask the groups to identify another animal that might get preyed upon and what predator might eat it; have a student representative come to the front of the room (or center of the circle) and ask one of its predators to move near its prey, as well. Ask if students know the name for a meat eater—**carnivore**—and a plant eater—**herbivore**—and write those words on the board below "predator" and "prey." Then ask if they know the name for an animal that eats many types of food. Discuss the term **omnivore** and write that on the board, too.
10. Ask the class what important parts of the freshwater ecosystem food chain are missing. Where do the prey species get their energy from? Instead of calling on a student raising her/his hand, tell the class that at the count of three, all of them should shout out the organisms (living things) they think are most important for the ecosystem. Count 1-2-3, and hopefully many of them will shout PLANTS!—or something else important, like algae (a type of plant) or insects.
11. Ask for volunteers from the groups to play the role of freshwater plants—the **producers**—and invite those students to join the food chain simulation while you write the word producers on the board, as well. Ask the class to again shout out—at the count of three—where the plants get their energy from, and hopefully many of them will shout THE SUN! or PHOTOSYNTHESIS! Write the words **Sun** (perhaps within a quick doodle depicting it as a large circle with rays coming out of it) and **photosynthesis** (perhaps within a quick doodle of a leaf) on the board. Ask the students playing plants to act like they are soaking up the sun's energy so they can convert it into food—sugar, starch, and other nutrients—that supports the whole ecosystem.
12. Ask students if they know the prefix of the word photosynthesis, and what the prefix means. Write **photo-** when someone says it and ensure students understand that it means "light." Then ask what the main part of the word—synthesis—means. Some students may already know that it means "combining." Then ask: How and what do plants combine to make energy? Review with students that plants use **chlorophyll** (write the word on the board)—what makes them green—to combine sunlight with

water and carbon dioxide (CO_2) gas found in the air to complete the amazing process. Ask the students to say at the count of three what gas the plants give off, which animals need to live, and many should shout OXYGEN! Finally, ask the students to share at the count of three what gas animals exhale—CARBON DIOXIDE!—and ask the students playing the role of plants to inhale the CO_2 and exhale "oxygen" dramatically for the students representing animals to inhale deeply; this will complete the photosynthesis analogy and reinforce the idea that all of the living things in an ecosystem—as well as non-living things such as sunlight, air, and water—are interconnected.

13. Explain that all other organisms that don't produce their own food are called **consumers**, and write that word below carnivore and herbivore in the middle.

14. Ask students what prey species in freshwater ecosystems might eat, and they may suggest smaller organisms such as tadpoles or insect larvae. Hopefully, one will also say dead things, the way **scavengers** like crayfish eat, or you can suggest dead organisms and ask students which living organisms eat them. Explain that this function of eating dead matter is very important for keeping the water clean and with enough dissolved oxygen for animals to breathe. Also explain that freshwater ecosystems can be very complex, with many hundreds of animal and plant species, all interconnected through a complex **food web** and supported by nonliving things such as sunlight, water, and air. Write food web under food chain and explain that it is the interaction of many food chains and cycles.

15. Ask for a round of applause for the ecosystem actors, and they can take their seats. Explain to students that they will now create a more complex model of the food web—or web of life--that will better represent the rich **biodiversity** of a healthy freshwater ecosystem. Write the word on the board, and if time allows, talk about the prefix bio- (life) and the root diversity (variety).

16. Simulate the freshwater ecosystem web of life with yarn:

    - Lead the students outside so you have a large area in which to form a circle with the whole class, directing students to take their organism illustrations with them. Anywhere outside will work, but it is best if you can go to the most natural area available, ideally one with native plants, or even better, an area that is close to a freshwater ecosystem, such as a stream or pond.
    - Ask the class to form a large circle and tell students that you will now be recreating the freshwater ecosystem web of life.
    - Take your place in the circle and tell students that you represent the ultimate source of just about all the energy in the ecosystem—the sun.
    - Hold the end of the ball of yarn firmly in your hand while you toss the ball to one of the students representing a plant species, saying the species name out loud. Ask students to hold up their organism signs if they think the organism you tossed the yarn to interacts with them. This will help the students know who to toss the ball, and keep the whole class engaged. Ask the student to say the name of an organism it interacts with and toss the ball of yarn to the student representing it. (Each student should hold onto their piece of yarn while tossing the ball to another classmate.)

Students create a model of a web of life as a class. If you can, go outside for the activity, ideally near a freshwater ecosystem or other natural area.

17. Ask the second student to do the same thing, passing the ball to another organism it interacts with while holding the end of the yarn; continue until all the students are connected in the web of life, completing the model of the freshwater ecosystem.

18. Ask the students to step back and/or gently pull on the yarn until the web is taut. Then ask the students to remain still. Explain that in a moment, the student who started the web will tug on it, and only those students who feel a tug will tug back.

    Ask the student playing the plant to begin the process, and continue until all the students can feel a vibration moving through the web. Then ask students to choose an organism that might be less critically important for the ecosystem and ask that student to drop the yarn.

19. Continue this "organism removal" process several more times, then ask students a few questions to promote critical thinking and generate discussion:

    - How did removing organisms from the freshwater ecosystem impact the web? *Possible answer:* Organisms that depend on the food web are impacted and the web changes shape.
    - When were the changes to the web most dramatic? *Possible answers:*
        - When there were fewer species; losing one of them had a greater impact on the ecosystem.
        - When certain species that had multiple interactions were lost.
    - When was the web the most stable and why? *Possible answers:*
        - The web was most stable when there was the largest number of species.
        - In general, the more **biodiversity**, the more stable the environment and the less it is impacted by changes in the environment.
    - How might humans impact the web if they were added to it? *Possible answers:*
        - They might cause more species to leave the web.
        - This would be especially true if humans don't try to minimize their impact and to protect the biodiversity of the ecosystem.

20. Direct students to roll up the yarn, walk back to the classroom, and help clean it up. Write **community** on the board and close by having students discuss how all the different organisms living in the interconnected communities of freshwater ecosystems—and every other ecosystem, such as forests or grasslands—are linked together, enabling them to survive. Ask students if they hear the word community used in other ways, too. Briefly discuss how both humans and other living things exist together and support each other in communities, as well, such as the ones found in your neighborhood, city, and/or town.

21. Extend the lesson with activities such as those listed below and/or pass out the "Curious Crayfish + Freshwater Ecosystems" handout that follows the lesson and ask students to complete it for homework or in class as time allows as another way to reinforce the concepts you just talked about. An answer key follows the activity, which can also be used as a short reading prior to asking students to complete the activity version with missing vocabulary words.

Enrich/Extend

- Pass out cards with the names of freshwater species and other important components of freshwater ecosystems. Students can use these to get them started on their short research projects to prepare to create the "web of life," or the cards themselves could be used for the activity if you are limited for time. Sets of cards can be found online, including:
    - "Pond Connections–The Food Web" listed in the Procedure section of the "Pond Connections" lesson plan from New Mexico Game & Fish: wildlife.state.nm.us/discover-new-mexico-home/aquatic-wildlife/pond-connections
    - "Aquatic and Marine Ecosystem Connections" lesson plan from the Univ. of Florida Ext. Service (pp. 50–52): studylib.net/doc/8282863/lesson-1-aquatic-and-marine-ecosystem-connections
- Have students work with a partner to create a visual diagram of freshwater ecosystems. Pairs will need a large sheet of paper or poster board to share; consider having a few stacks of used sheets around the room from which students can choose (to use the backs of them). Completed diagrams—or the best of them—can be displayed on the classroom walls or on a hallway bulletin board or other display.
    - Consider directing students to use different colored arrows for the different types of interactions on their diagrams, and write this on the board with color-coded markers or chalk, if available, or type it to display on the screen or interactive whiteboard:

      Orange to connect the **sun** with producers (plants)

      Green to connect **herbivores** to plants

      Red to connect **predators** to their prey

      Brown to connect **decomposers** to the plants and animals they break down after they die.
    - *Optional:* Show students the Sagebrush Ecosystems poster/graphic available from the U.S. Fish and Wildlife Service on the Greater Sage-Grouse Education page as an example of one type of visual diagram they could create: fws.gov/media/sagebrush-education-posters
    - *Optional:* Students can include humans in their diagrams, if desired.

- It is recommended that you take students on a field trip to a stream or other area of freshwater to explore the ecosystem firsthand. Have students engage in an activity such as observing the macroinvertebrates found in the water and/or creating a nature journal and/or field guide of the organisms they observe.
- Students can work together to create a large mural of a diagram depicting freshwater ecosystems with their illustrations and/or nonfiction writing about them. Diagrams can be created on classroom walls and/or other walls in the school or larger community. Yarn and/or arrows can be used to show ecosystem interactions, and students can help to illustrate additional important aspects of the ecosystem, such as the sun, algae, bacteria, and detritus.
- Discuss the important role of watersheds and create a model of one using crumpled paper, as explained in this lesson from the Ferguson Foundation: fergusonfoundation.org/resources. Search "crumpled paper" to access the PDF.
- Show a short video clip about crayfish and/or freshwater ecosystems, such as:
    - "Queen Nerdling Presents Freshwater Ecosystems:" youtube.com/watch?v=hdeGM65Enko
    - "I Speak for the Fish: Facing the Wrath of a Crayfish:" greatlakesnow.org/2023/07/i-speak-for-the-fish-facing-wrath-crayfish
- Students can write fictional stories or poems about one or more organisms from freshwater ecosystems.
- Have each student choose a freshwater ecosystem organism to research in depth. They can research elements, such as what the organism needs to survive and how human activities have impacted it over time. Provide a rubric so students know how they will be evaluated on the project, and findings could be shared with the rest of the class through written reports and/or oral presentations.
- For younger grades, read a story or nonfiction book with your class about crayfish. Examples include:
    - "Crayfish" by Meg Gaertner: barnesandnoble.com/w/crayfish-meg-gaertner/1129536594
    - "Crayfish" by Phillis W. Grimm: amazon.com/Crayfish-Early-Bird-Nature-Books/dp/0822530309
    - "The Life Cycle of a Crayfish" by Bobbie Kalman: amazon.com/Crayfish-Cycle-Paperback-Bobbie-Kalman/dp/0778707032

Evaluate

- Ask students to reflect on the lesson in writing and/or orally, including about what they learned and what you, as the teacher, might do to improve the lesson next time.
- Use completed student diagrams to evaluate student understanding of the concept of freshwater ecosystems.
- Review the short research projects about an organism from freshwater ecosystems and its interactions with other organisms.
- Use student participation in class discussion and activities, including the simulation of a freshwater web of life, to determine student understanding.

Expand Knowledge + Skills

- "The Crayfishes." Missouri Stream Team: mostreamteam.org/assets/factsheet22.pdf
- "The Freshwater Biome." UC Berkeley: www.ucmp.berkeley.edu/exhibits/biomes/freshwater.php
- "Freshwater ecosystems filter pollutants before they reach oceans." ScienceDaily: www.sciencedaily.com/releases/2018/04/180430212349.htm
- Helfrich, L.A., Parkhurst, J., and Neves, R. 2001. The control of burrowing crayfish in ponds. Dept. of Fisheries and Wildlife Services, Virginia Tech: vtechworks.lib.vt.edu/items/9f97d586-a543-4613-b707-44f137b4930b
- Taylor, C. A., Schuster, G. A., & Wylie, D. B. (2015). Field Guide to Crayfishes of the Midwest. Manual 15. Illinois Natural History Survey, Champaign, Illinois. 145 pages: shop.inrs.illinois.edu/inhs-man.html

Freshwater Food Web Diagrams

- "Aquatic Food Web." Univ. of Michigan: michiganseagrant.org/wp-content/uploads/2018/08/09-400-Aquatic-Food-Web-GLEP.pdf
- "Freshwater Channel Food Web." Cary Institute of Ecosystem Services: caryinstitute.org/eco-inquiry/teaching-materials/hudson-river-ecology/freshwater-channel-food-web

Plants and Animals of the Great Lakes Area Connected to Freshwater Ecosystems

- Great Lakes Wildlife: glerl.noaa.gov/data/waterlife/additionalResources.html
- Great Lakes Water Life (PowerPoint): Highlights different plants and animals that one can find in the Great Lakes: glerl.noaa.gov/data/waterlife/docs/WaterlifeAnnotated.ppt
- "Priority Colonies for Great Lakes Waterbirds." Audubon: gl.audubon.org/sites/default/files/colonial_waterbird_summary_may_1_update.pdf
- Reptiles and Amphibians of Michigan: michigan.gov/dnr/education/michigan-species/reptiles

Lessons/Activities

- "Freshwater Lesson Plans." Fresh Water Live: freshwaterlive.org/resources/lesson-plans
- "Aquatic Food Web" flashcards in Quizlet: quizlet.com/40755546/aquatic-food-web-flash-cards
- "Food Webs" lesson plan. CPALMS, Florida State University: www.cpalms.org/Public/PreviewResourceLesson/Preview/75952

Education Standards

- More information about the Next Generation Science Standards, to which this lesson was aligned: nextgenscience.org
- More information about the Common Core State Standards and links to the complete documents: thecorestandards.org

Crayfish Trivia

1. What kind of animals are crayfish? (Circle one)
   a. Amphibians
   b. Crustaceans
   c. Fish
   d. Insects
   e. Mollusca (mollusks)

2. Put an "X" or checkmark in front of all the places where crayfish live.
   _____Dry sand
   _____Lakes and ponds
   _____Mud puddles
   _____Oceans
   _____Rivers and streams

3. Mark all of the animals below that eat crayfish.
   _____Birds, such as herons and ducks
   _____Fish, like trout
   _____Amphibians, such as frogs
   _____Reptiles, such as turtles and snakes
   _____Mammals, like raccoons, river otters, and humans

4. Crayfish breathe through their:
   _____Gills
   _____Lungs
   _____Mouth
   _____Nose
   _____Skin

5. Do crayfish live in our state? Circle one: Yes No

6. In what ways can crayfish be good for the environment?
   _____They are scavengers that eat dead animals and plants.
   _____They are food for many different animals.
   _____They can eat lots of food that other animals like to eat.
   _____They can eat lots of salmon and trout eggs.
   _____They help to keep streams and other bodies of water clean.

7. Which of these are better for ecosystems?
   a. Invasive plants and animals
   b. Native species

8. Please write all the reasons why you think native or invasive crayfish are better for their ecosystems below and on the back of this paper.

Crayfish Trivia Answer Key

1. What kind of animals are crayfish? (Circle one)

a. Amphibians

b. Crustaceans

c. Fish

d. Insects

e. Mollusca (mollusks)

2. Put an "X" or checkmark in front of all the places where crayfish live.

_____Dry sand

__X__ Lakes and ponds

__X__ Mud puddles

_____Oceans

__X__ Rivers and streams

3. Mark all the animals below that eat crayfish.

__X__ Birds, such as herons and ducks

__X__ Fish, like trout

__X__ Amphibians, such as frogs

__X__ Reptiles, such as turtles and snakes

__X__ Mammals, like raccoons, river otters, and humans

4. Crayfish breathe through their:

__X__ Gills

_____Lungs

_____Mouth

_____Nose

_____Skin

5. Do crayfish live in our state? **Yes! Crayfish are found in all 50 states, with more than 400 species found in North America. Over 600 total species have been identified around the world.**

6. In what ways can crayfish be good for the environment?

__X__ They are scavengers that eat dead animals and plants.

__X__ They are food for many different animals.

_____They can eat lots of food that other animals like to eat.

_____They can eat lots of salmon and trout eggs.

__X__ They help to keep streams and other bodies of water clean.

7. Which of these are better for ecosystems?

a. Invasive plants and animals

b. Native species

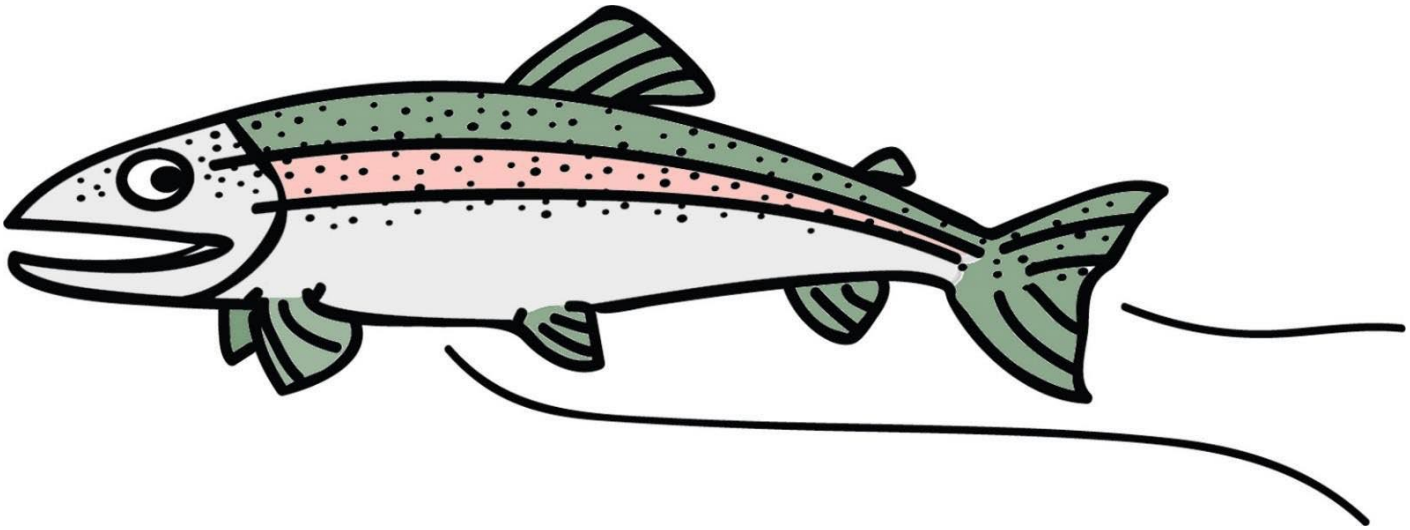
8. Please write all the reasons why you think native or invasive crayfish are better for their ecosystems below and on the back of this paper.

Native crayfish live in balance with other species in their ecosystem. They are important food for many other native species of animals, and they are omnivores/scavengers that consume dead animals and plants, helping to keep their freshwater ecosystems clean and recycling nutrients.

Invasive crayfish can outcompete native species for food, shelter, and space. They can sometimes reproduce more quickly, too, and can be consumed less by native predators. Their burrowing activity can also be a problem, increasing erosion and decreasing water quality, for instance.

Rainbow Trout

(Steelhead trout that stay in freshwater)
Scientific name: *Oncorhynchus mykiss*



Habitat: Clean, cool freshwater in streams, rivers, and lakes

Diet: Eats invertebrates like insects (larvae and adults), crayfish and other crustaceans, and zooplankton; small fish and fish eggs; algae

What eats them?

- Fish, like bass and larger trout
- Birds, like herons, kingfishers, eagles, and osprey
- Mammals, like raccoons, otters, and humans
- Crayfish (as scavengers of dead fish and when trout are eggs)
- Decomposers, like bacteria

Other interesting facts:

- Steelhead and rainbow trout are the same species, but steelhead travel to the ocean to continue growing into adults. Then they travel back to where they hatched as eggs. There they spawn (lay eggs) and die. The nutrients from their bodies feed the ecosystem for the next generation.
- Rainbow trout are the only salmonids that stay in freshwater their entire lives.
- Native to the west of the Rockies, rainbow trout were introduced in almost every other state and on every continent except Antarctica.

Sources:

- “Rainbow Trout *(Oncorhynchus mykiss)*.” U.S. Fish and Wildlife Service. fws.gov/species/rainbow-trout-oncorhynchus-mykiss
- “Rainbow Trout and Steelhead.” National Wildlife Federation: nwf.org/Educational-Resources/Wildlife-Guide/Fish/Rainbow-Trout-Steelhead

Name: _____ Period: _____ Date: _____

Organism Presentation Rubric

Name of Organism: _____

Presentation Component	**Maximum Points Possible**	**Self-Score** (fill out before presentation)	**Teacher Score**
Content			
Organism's key traits explained, including: • Habitat(s) and ways it survives in freshwater ecosystems • What it eats and/or what eats it	10		
Interactions with other living and nonliving things clearly explained	10		
Delivery/Audience Engagement			
Speech delivered clearly at appropriate volume and speed (not too fast, slow, loud, or soft)	5		
Speed, volume, and voice inflection are varied to engage audience and emphasize key points	5		
Speaker connects with audience through eye contact and does not spend too much time looking at notes or screen	5		
Speaker demonstrates enthusiasm for topic throughout presentation; audience is persuaded by speaker about important role(s) in ecosystem	5		
Visual(s)			
Illustration helps to explain organism's adaptations and/or role(s) in ecosystem	10		
Writing Conventions			
Grammatical/spelling conventions followed in written summary	10		
TOTAL:	**60**		

Teacher Comments:

Crayfish + Freshwater Ecosystems

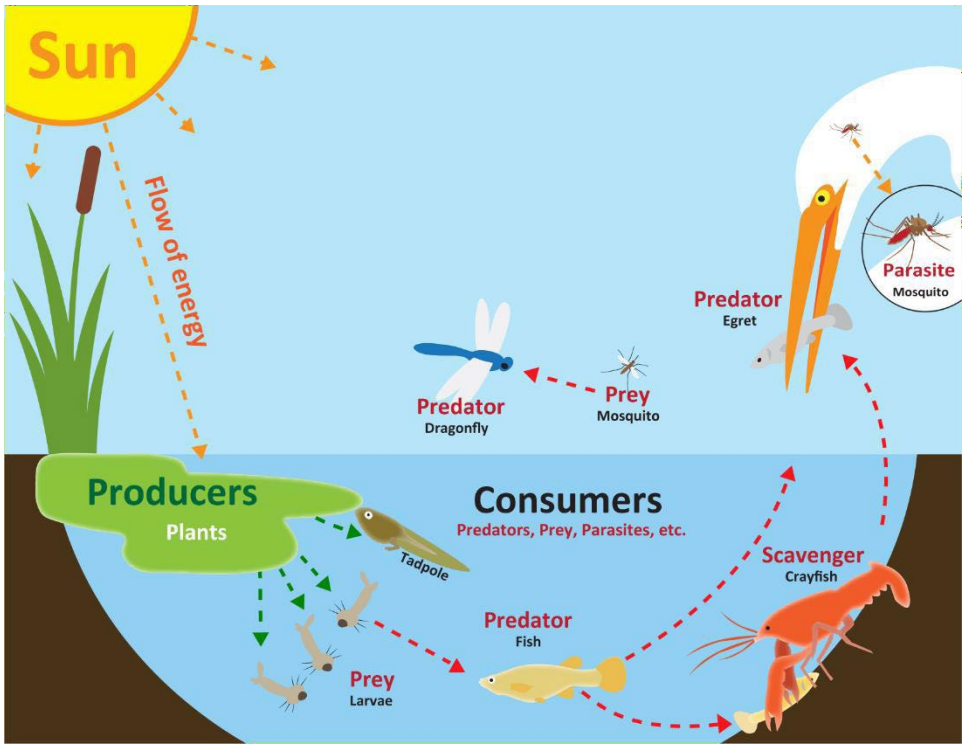
Crusty Crustaceans

Crayfish are **crustaceans**, named for their hard, crust-like **exoskeleton**. Their upper shell is known as a **carapace**. They are closely related to lobsters, their saltwater cousins. Like insects and spiders, crustaceans are **arthropods**, named for their jointed legs. Crayfish have ten legs: four pairs of **walking legs** and two **chelipeds** with **chelae** (claws). They have two pairs of **antennae** for sensing food and danger in their murky **habitat**; the smaller pair are known as **antennules**.

Image by Jeff Benca

Key in the Web of Life

Crayfish are an important part of **freshwater ecosystems**, such as rivers and lakes. They are food for many species of fish, birds, amphibians, reptiles, and mammals. Even some land-dwelling animals, such as raccoons, love to eat them, so they play important roles in **terrestrial** ecosystems, as well. Many people enjoy cooking them for dinner, too—especially in southern states like Louisiana.



Model of a Freshwater Ecosystem

Graphic by Eric Engh and Rick Reynolds

What Do Crayfish Eat?

Crayfish are **omnivores** that eat both dead and living plants and animals. Their role in reducing **detritus** (decaying **organic matter**) and filtering the water is important for improving **water quality**. (One way to remember what "detritus" means—and what a crayfish might say about it—is that it sounds like, "Dude, try this!") Crayfish eat almost anything.

A crayfish feast!

Crayfish, along with **microorganisms**, such as **bacteria** and **plankton** (tiny plants and animals), breakdown and **recycle** nutrients in the

ecosystem's complex **food web**. Dead fish and leaves can be a feast for a crayfish, which becomes a feast for a **rainbow trout**, which can feed a human family. All living things are linked in countless ways to the web of life, which also includes essential nonliving things, like water, oxygen, carbon dioxide, and space.

Heroes or Villains?

Predators as well as **scavengers**, crayfish can negatively impact ecosystems, too. **Invasive**, non-native species have the most impact. For example, they can outcompete **native** species for food, and eat too many fish and amphibian eggs. Their habit of **burrowing** in mud can provide benefits for water quality, but burrowing near the water's edge can sometimes increase **erosion** (Helfrich, Parkhurst, and Nevis 2001). This can add more **sediment** to the water, reducing its **clarity** and overall quality for wildlife and humans.

Can you spot this camouflaged crayfish in its burrow? *Photo: Brocken Inaglory, Wikimedia Common*

Where are Crayfish Found?

About 400 of the world's 600+ crayfish species are found in North America, especially the southeastern United States. The rest are found on every continent except Antarctica. Many species are at risk of **extinction**, due mainly to habitat loss, pollution, and the spread of invasive crayfish species and disease (Larson et al. 2020).

Ecology: The Study of Interconnections in Nature

An **ecosystem** is any group of living and nonliving things that interact with one another. Some are relatively small, like streams and ponds where crayfish often thrive. Others are large **biomes**, like wetlands or forests.

Biodiversity is a measure of the number of different species of **organisms** (living things) in a specific area. The term is also used as a general description of species richness, ecosystem complexity, and genetic variation. In general, the more biodiversity, the more stable the environment and the less it is impacted by environmental changes. The organisms that interact with each other in their ecosystems are called an **ecological community**.

Animals like crayfish need food, water, air, shelter, and space to survive. This clear spring is excellent crayfish habitat, with plenty of rocks for shelter.
Photo: Eric Larson

Name(s): _____ Period: ____ Date: _____

Delving Deeper into Crayfish + Freshwater Ecosystems

1. How would you describe crayfish to someone who had never heard of or seen them before? Continue on the back if you need more space.

2. How might freshwater ecosystems be impacted if there were no crayfish? Include at least three positive and two negative impacts in your answer. Continue on the back if you need more space.

3. What does **extinction** mean? Why are many crayfish species at risk of it?

4. How can the loss of **biodiversity** be a problem for ecosystems? Provide an example to help explain your answer. Continue on the back if you need more space.

5. Crayfish are **polytrophic** (opportunistic feeders) that will eat almost any organic matter. A crayfish might eat 50% plant detritus, 40% living plant matter, 8% dead animal matter, and 2% living animal matter. Create a graph to show this crayfish's diet visually.

6. If the crayfish described above in question 5 consumed 100 grams (0.22 pounds) of food in a week, what would the mass of the food types consumed be in grams and pounds?

   plant detritus: _____grams _____pounds

   living plant matter: _____grams _____pounds

   dead animal matter: _____grams _____pounds

   living animal matter: _____grams _____pounds

7. If the crayfish described in question 5 consumed 167 grams (0.37 pounds) of food in two weeks, what would the mass of the food types consumed be in grams and pounds?

   plant detritus: _____grams _____pounds

   living plant matter: _____grams _____pounds

   dead animal matter: _____grams _____pounds

   living animal matter: _____grams _____pounds

Name: _____ Period: ____ Date: _____

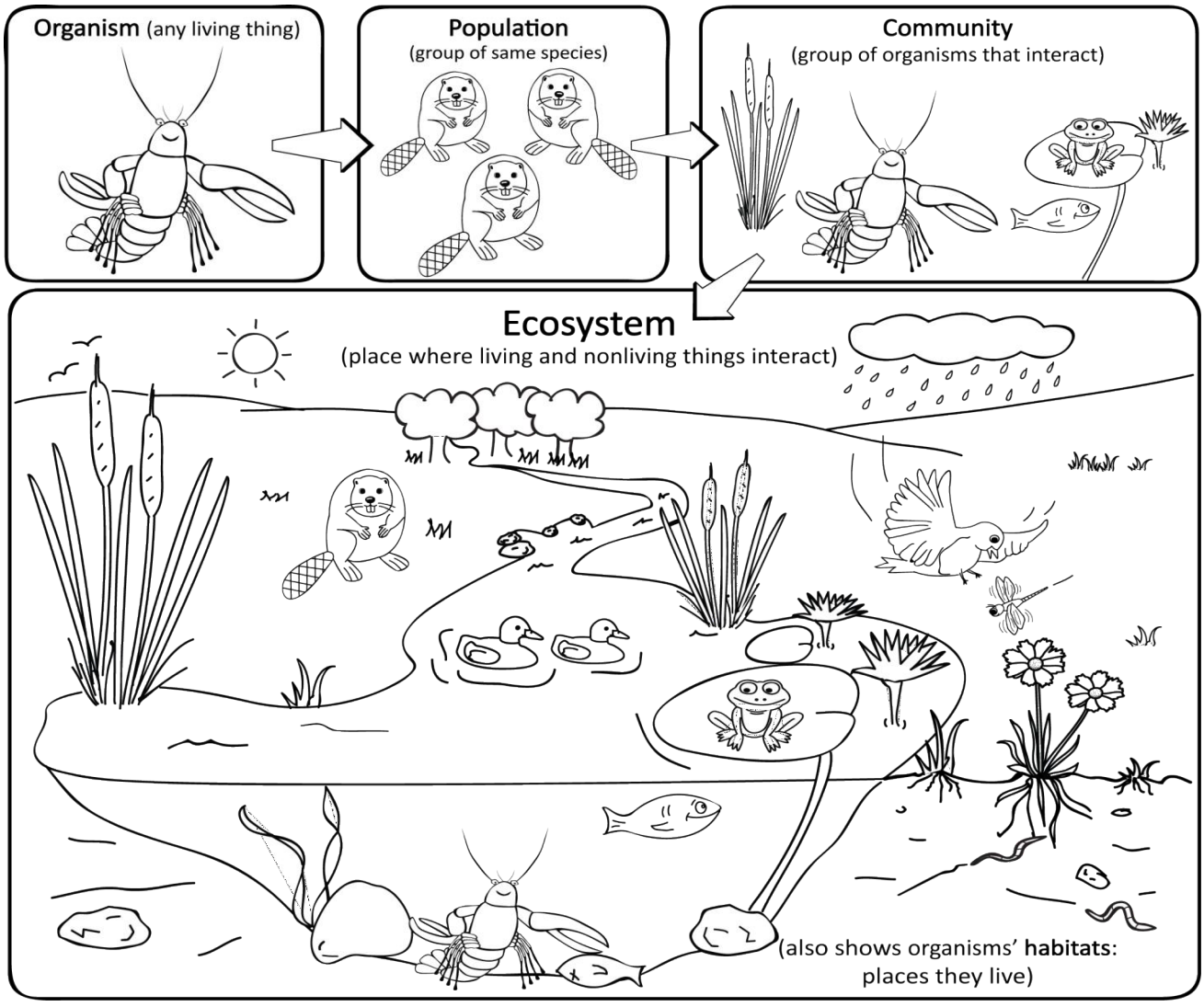
Curious Crayfish + Freshwater Ecosystems

Complete the description of crayfish and where they live with these terms: amphibians, biodiversity, birds, ecosystems, fish, freshwater, invasive, humans, lakes, native, omnivores, predators, reptiles, scavengers, species

Crayfish play an important role in **freshwater** _____, such as _____and _____. Most often found on river and lake bottoms, crayfish are _____that eat both animals and plants. As _____of dead organisms, they help to clean the water. Crayfish are also an important food for many organisms including:

- _____, such as trout.
- _____, such as herons and ducks.
- _____, such as turtles and snakes.
- _____, such as raccoons and river otters.
- _____, such as frogs.
- _____, especially in places like Louisiana.

Sometimes crayfish that come from other places can harm ecosystems, too. These _____ species can be _____of many _____species. They can also compete with natives for the food, water, shelter, and space that every animal needs to survive. This can reduce native populations and _____.



Curious Crayfish + Freshwater Ecosystems

Crayfish play an important role in **freshwater ecosystems**, such as **lakes** and **rivers**. Most often found on river and lake bottoms, crayfish are **omnivores** that eat both animals and plants. As **scavengers** of dead organisms, they help to clean the water. Crayfish are also an important food for many organisms including:

- **Fish**, such as trout
- **Birds**, such as herons and ducks
- **Reptiles**, such as turtles and snakes
- **Mammals**, such as raccoons and river otters
- **Amphibians**, such as frogs
- **Humans**, especially in places like Louisiana

Sometimes crayfish that come from other places can harm ecosystems, too. These **invasive** species can be **predators** of many **native** species. They can also compete with natives for the food, water, shelter, and space that every animal needs to survive. This can reduce native populations and **biodiversity**.