An Incredible Journey

Curriculum for Grades 4-5

Ten lesson plans exploring the environmental, cultural, and economic importance of salmon.

NOAA FISHERIES

www.fisheries.noaa.gov

An Incredible Journey

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Disclaimer

This curriculum is intended for elementary school classrooms. Information within this curriculum should not be cited in scientific journals or other publications.

About NOAA Fisheries

NOAA Fisheries is responsible for the stewardship of the nation's ocean resources and their habitat. We provide vital services for the nation: productive and sustainable fisheries, safe sources of seafood, the recovery and conservation of protected resources, and healthy ecosystems—all backed by sound science and an ecosystem-based approach to management. To learn more, visit: www.fisheries.noaa.gov.

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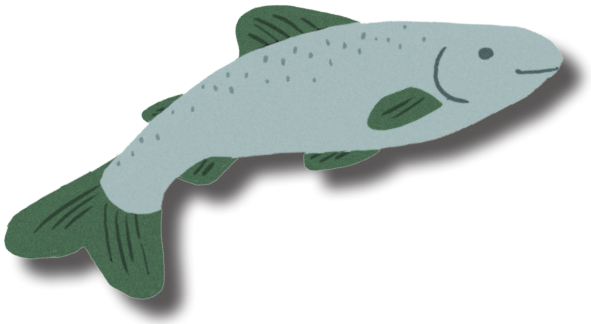

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Ten lesson plans exploring the environmental, cultural, and economic importance of salmon.

Designed for grades 4-5

NOAA FISHERIES

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Lesson 2: Smell Your Way Home

After a short discussion about migrations, students hypothesize how salmon can find their way from the ocean all the way back to their natal stream. The class learns that salmon navigate using their sense of smell, and then act out a salmon's migration by blindly following their sense of smell from a mock ocean to a natal stream. After students successfully complete one migration, pollutants—which interfere with a salmon's sense a smell—are introduced into the activity. Students must again find their way home, but this time with an impaired sense of smell.

Lesson 3: What's a Watershed?

An introductory questionnaire tests students' basic understanding of watersheds. After watching a video clip about watersheds, students retake the questionnaire and define watershed in their own words. Students explore a local watershed online before constructing their own watershed model. Through a series of hypotheses and observations, students learn how water and pollutants move throughout the watershed. A class discussion reveals how pollutants from land might affect aquatic organisms and what students can do to prevent water pollution.

Lesson 4: Ecosystem Interconnections

During a warmup exercise, students brainstorm the plants, animals, and other elements in local ecosystems. After defining the term ecosystem in their own words, small groups create a diagram that shows the interconnections between abiotic and biotic elements in one of six aquatic ecosystems. Using a graphic organizer, students discover the similarities and differences between the aquatic ecosystems upon which salmon depend.

Lesson 5: Keystone Species

Students examine a Roman arch and discover that the keystone holds up the whole arch. Students then compare the keystone of the Roman arch to the characteristics of a keystone species. Students return to their small groups from Lesson 4 to identify a keystone species from their ecosystem diagram. After learning that salmon are a keystone species in each of their ecosystems, students describe ways their ecosystem might be affected if salmon populations decline.

Scope and Sequence

Lesson 6: A World of Salmon

After brainstorming different examples of culture, such as language, art, and food, students write about and draw their favorite family recipe. Individuals share their favorite recipe and then discuss how food is a part of culture. Small groups read profiles from 10 different regions and learn how salmon are important to each of these cultures. After locating each of these regions on a map, students discuss how the migration of salmon has affected cultures around the world.

Lesson 7: Sustainable Seafood

In Part 1, students compare and contrast three types of fishing: commercial, recreational, and subsistence. A discussion about the characteristics of sustainability sets up a simulation in which students demonstrate the implications of overfishing and bycatch. In optional Part II, students use the data from their fishing simulation to discuss the economic and environmental effects of bycatch. After reading about different types of commercial fishing gear and common bycatch, students redesign the fishing gear to reduce effects on the environment and marine animals.

Lesson 8: Salmon Survival

During a free write, students brainstorm what salmon need to survive and the challenges they may face throughout their lifetime. A dice game is used to model the natural and human-made challenges facing salmon at difference stages of their life. Students use data from the game to calculate a salmon's chances of surviving into adulthood. A class discussion reveals the pros and cons of using a dice game as a model and how the game can be improved to better model salmon survival rates.

Lesson 9: Student Stewards

The lesson opens with a writing exercise in which students respond to prompts about the role salmon play in our society, economy, and environment. During a class discussion, students describe what the word stewardship means to them and list some reasons why stewardship is important. In small groups, students analyze case studies about youth environmental heroes and how their work ultimately helps salmon.

Lesson 10: Saving Salmon

Students answer a questionnaire that describes their everyday actions that affect the environment. Afterward, the class discusses whether or not small actions affect the environment. The class then brainstorms a list of action projects that promote salmon stewardship. Small groups work together to create an action plan to achieve their action project.

Introduction

For thousands of years, salmon have played a vital role in cultures and economies around the world. Their annual migration has inspired dances, festivals, poems, and family recipes. From the West Coast of the US to Russia and Sweden to Canada, these iconic fish have been the centerpiece of many different community traditions and fishing economies. Salmon are also a vital link in many marine, freshwater, and riparian food chains and a keystone species in many different ecosystems.

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Due to issues such as climate change, passage barriers, habitat loss, and water pollution, many populations are facing extinction. As salmon populations dwindle—and in some cases disappear—ripple effects are felt throughout ecosystems, cultures, and economies. To conserve these iconic species, communities, organizations, and governments are working together to slow climate change, help salmon overcome passage barriers, restore riparian habitats, and reduce water pollution.

Interdisciplinary Connections

Since salmon are the center of many cultures, ecosystems, and economies around the world, they are a naturally interdisciplinary topic for any classroom. By studying salmon, students have the opportunity to research an iconic species that lives in their community; grapple with many real-world challenges such as habitat loss, climate change, and urban runoff; evaluate the cultural, environmental, and economic importance of a keystone species; and design solutions to promote habitat conservation and species recovery.

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This curriculum draws explicit connections between salmon and our culture, environment, and economy and shows students how they can become stewards for these imperiled fish.

Cultural Connections

From the First Salmon Celebration of North American tribes to New Year's celebrations in Japan, salmon are central to many cultural traditions. For thousands of years, the annual return of salmon has been celebrated in many communities through dances, festivals, and religious ceremonies. Whether grilled, smoked, preserved, or raw—salmon recipes have been handed down for generations and are still the centerpiece of family celebrations today.

Fishing traditions are another key component of salmon culture. From subsistence fishing (fishing to feed one's family or community) to recreational fishing (fishing for fun), many families and communities have built cultural traditions around salmon fishing. Communities are rallying together to ensure that future generations have salmon to celebrate, catch, and cook.

Environmental Connections

While salmon are not the classic textbook example of a keystone

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species, they are a very important one. From grizzly bears to killer whales, at least 137 different species depend on salmon.[1] Not only are salmon vital for many food webs, but they also help ensure healthy forests by providing nutrients for plants and trees. Returning salmon transport millions of tons of nutrients from marine environments to wetlands, rivers, and streams. Salmon predators and scavengers transport marine nutrients deep into the forest. Spawning salmon return so much nitrogen to some forests, that the forests grow nearly three times faster than forests without spawning salmon.[2]

Throughout their unique anadromous life cycle (migrating from freshwater to saltwater and back again), salmon are a thread that stitch together many different ecosystems. When salmon populations decline or disappear, freshwater, saltwater, and riparian food webs and ecosystems can be dramatically altered, or even collapse. All around the world, communities are working together to restore the habitats on which salmon depend.

Economic Connections

Salmon are not just integral to ecosystems and our cultures, but they also support the livelihoods of many people working in commercial fisheries. In the North Pacific alone, approximately 432 million salmon are caught in commercial fisheries every year with an estimated value of $2.2 billion.[3] The North Pacific salmon fisheries support approximately 35 thousand harvesting and processing jobs.[4] When salmon populations decline, many people's livelihoods are at stake.

Stewardship Connections

From urban runoff to climate change and drought to habitat loss, salmon populations are facing many human-caused challenges. Every day, each of us make choices that ultimately affect the health of local watersheds and the species living in them, such as driving, fertilizing our lawns, and using household cleaners. When we help students draw connections between their daily actions and the health of local ecosystems, we can empower them to make informed choices and become salmon stewards.

Unit Features

An Incredible Journey is filled with 10 hands-on lesson plans that explore the salmon life cycle; the cultural, environmental, and economic importance of salmon; the major issues facing salmon today; and how individuals can get involved to protect these iconic species. While this curriculum was designed to be used as a complete unit, individual lessons can be used as a springboard for units of study on many different topics including animal migrations, keystone species, watershed health, stewardship, and more.

Action Projects

This unit encourages students to reflect upon how their actions can affect watersheds and how they can make salmon-friendly choices. To expand students' thinking about stewardship, each

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lesson is followed up with an easy-to-implement action project. These projects are designed to ignite a sense of wonder, help make topics more relevant to students' everyday lives, and to empower students to make changes in their own lives.

Additional Resources

The suggested books, interactives, videos, and websites at the end of each lesson will encourage students to delve deeper into topics of interest and will provide a more comprehensive picture of the topics at-hand. These resources can be used as a springboard for further units of study and independent student research.

Collaboration, Creativity, Critical Thinking

While building content knowledge about salmon and their ecosystems, students are also exercising their collaboration, creativity, and critical thinking skills. Each lesson in this unit allows students to work collaboratively while trying out different roles, such as background researcher, narrator, illustrator, etc. This format helps students distribute responsibility among group members and encourages every student to participate. As students practice these different roles, they also have the opportunity to develop new skills.

Throughout this unit, students are encouraged to explore the salmon life cycle through collaborative storytelling and visuals, to better understand the role of salmon in their ecosystem by creating diagrams and graphs, and to understand how

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communities can work together to protect salmon by designing their own service learning project.

Critical thinking questions are sprinkled throughout each lesson to help students grapple with real-world issues affecting salmon and to help students think about their role in their local watershed and the world at-large.

Differentiation

Each lesson contains a variety of individual, small group, and whole class activities. Many lessons also include opportunities for advanced students to dive more deeply into a topic or to provide striving students with additional support.

Discussion Questions

Five discussion questions are posed at the end of each lesson. These questions are designed to help students reflect upon key concepts, apply their learning to broader contexts, and brainstorm innovative solutions to complex issues.

Extensions

Are you looking to incorporate more art, music, science, or math in your classroom? Each lesson in this unit contains extensions that allow students to dive more deeply into the world of salmon through a multitude of topic areas and disciplines. These extensions also provide opportunities to team teach across multiple disciplines.

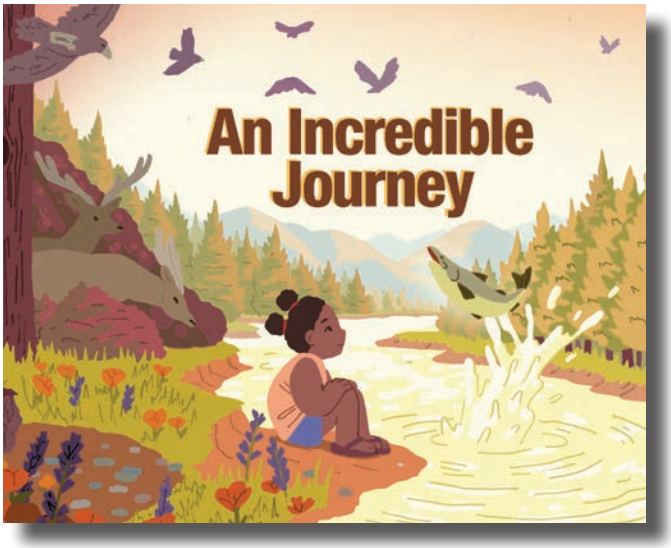
Pre/Post Assessment

The assessment beginning on page 187 is designed to test students' content knowledge about salmon and the role they play in ecosystems, cultures, and economies around the world. This assessment also helps reveal students' attitudes and beliefs about salmon and their own role in salmon stewardship.

Complementary Resources

Children's Book

To kick off this unit, consider first reading your class the accompanying children's book, ***An Incredible Journey***. This fully illustrated book introduces students to the key concepts presented in this unit, including: migration, keystone species, watershed, and stewardship.



A PDF of the book is available to **download for free** in English and Spanish. To request a printed copy, please email **wcr.education@noaa.gov**.

Board Game

The **Salmon Survival board game** walks participants through the salmon life cycle. During each life stage, participants attempt to survive the natural and human-made challenges salmon face, such as drought, passage barriers, and predators. But don't despair, the game also features ways that people are helping salmon, such as building rain gardens, conserving water, and constructing fish ladders.

A PDF of the game is available to **download for free** in English and Spanish. A limited supply of printed board games are available for public schools and nonprofit organizations conducting salmon outreach. To request a printed copy, email **wcr.education@noaa.gov**.

Outreach Materials

Additional outreach materials about salmon and marine ecosystems—including brochures, fact sheets, posters, and more—are available from the **NOAA Fisheries website**.

NOAA Education and Outreach

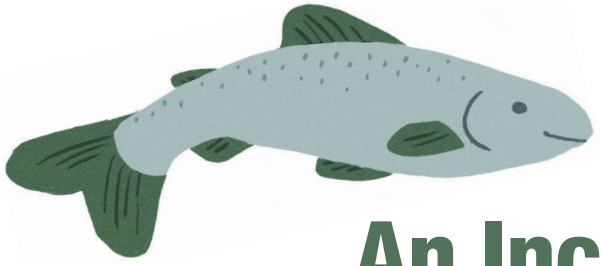
To connect with NOAA staff in your community, visit **NOAA in Your Backyard**. Outreach specialists are available to help coordinate guest speakers, field trips, and professional development.

Funding and Teacher Development

NOAA's Office of Education provides **scholarships, internships, grants, and teacher professional development** to help prepare the brightest minds from diverse backgrounds in NOAA-related fields.

Questions or feedback?

We are always looking for ways to improve and expand our products. For questions or feedback about this unit, please don't hesitate to contact: **wcr.education@noaa.gov**.



Lesson 1

An Incredible Journey

Students complete a diagram of the general salmon life cycle before researching the migration of local salmon from their natal stream to the ocean and back again. Students use their research to narrate and illustrate a storyboard about this incredible journey from the perspective of a salmon. The storyboard can be used as a springboard to create a digital story map.

Objectives

Students will:

- Summarize the salmon life cycle.
- Research the migration of salmon from a local stream to the ocean.
- Create a storyboard that narrates and illustrates the salmon life cycle through the perspective of a salmon.

Students will understand:

- Salmon migrate from streams to the ocean and back again.
- Salmon spend different parts of their life cycle in different ecosystems.
- Salmon face many human-made and natural challenges throughout their lifetime.

Time Required

At least 3 hours. The time will vary depending on: whether you have students work alone or in groups, if you have students complete the activity in class or as homework, how detailed you would like students to make their storyboards, and whether or not students create the optional story map activity.

Preparation

□ Handout: *Salmon Life Cycle*
Print 1 copy per student.

□ Display Copy: *Salmon Life Cycle*
Display this graphic during Step 4 of the Introduction.

□ Handout: *A Salmon's Journey*
Print 1 copy per student.

□ Computers with Internet access
Reserve 1 per student or group of 3-4.

□ Chose a story mapping tool (optional)
Choose and familiarize yourself with one of the following story mapping tools: Story Maps from ArcGIS (tutorial), Map Maker from National Geographic (tutorial), or My Maps from Google (tutorial). Alternatively, ask your school's technology coordinator to introduce students to story mapping.

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Keywords

Alevin—A newly hatched salmon that is entirely dependent upon its yolk sac for nutrition.

Anadromous—Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.

Egg—An animal reproductive body consisting of an ovum or embryo together with nutritive and protective envelopes.

Fry—Salmon become fry when they have absorbed their yolk sac and emerge from their gravel nest (redd).

Life cycle—The series of stages through which a living thing passes from the beginning of its life until its death.

Migration—The relatively long-distance movement of individuals, usually on a seasonal basis.

Redd—A gravel nest made by a spawning female salmon.

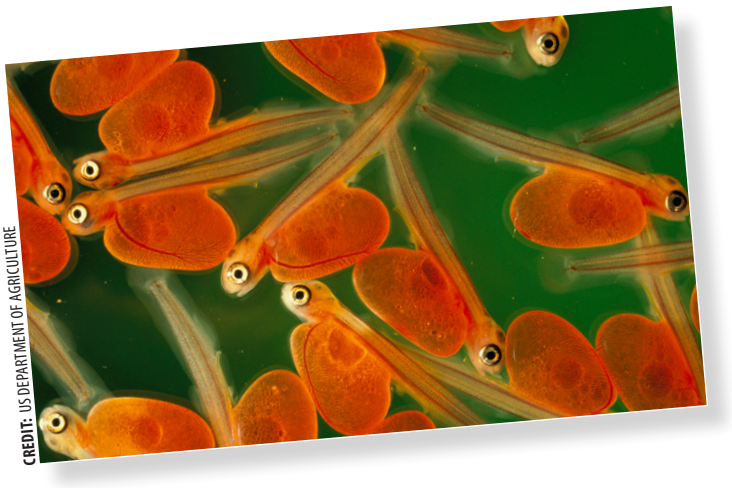
Smolt—A young salmon that assumes the silvery color of the adult and is ready to migrate to the sea.

Spawner—A mature salmon that is migrating back to its home stream to reproduce.

Storyboard—A sequence of drawings or photographs, typically with some directions and text, representing the shots planned for a book, movie, or TV show.

Supporting Vocabulary

Catadromous—Fishes that spend most of their life in freshwater and then migrate into saltwater to spawn.



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Milt—The semen of a male fish.

Natal stream—A salmon's home stream; where a salmon hatched.

Run—Seasonal migration undertaken by fish, usually as part of their life history.

Background Information

The salmon life cycle begins in freshwater, when a nest of **eggs**, called a redd, is fertilized. The eggs remain in the gravel throughout winter while the embryos develop. In the spring, eggs hatch and **alevins** emerge. These tiny fish have a yolk sac attached to their stomachs and stay near their nest. When they have consumed all of the yolk sac, the fish emerge from their nest and are considered **fry**.

Fry swim to the surface of the water to fill up their swim bladders with oxygen and begin feeding on small insects. Fry need high-quality stream habitat that contains boulders, logs, shade, and side channels. These features help protect salmon from predators and prevent them from getting flushed downstream.

Once salmon are about a year old they begin migrating toward the estuary. At this stage, they are known as **smolts**. In the estuary they undergo smoltification during which their scales turn a silvery color and their bodies begin preparing for life in saltwater. Estuaries, where fresh and saltwater meet, provide nutrient-rich habitats for growing salmon.

Once they are ready for life at sea, some salmon remain in coastal water while others swim further out to sea. Depending on the species, **adult** salmon may spend one to seven years in the ocean. During this time, they grow larger and stronger to make the journey upstream to their natal stream. While we do not know exactly how salmon detect their natal streams, it is suspected that scents and chemical cues play an important role.

Once **migrating adults** reach freshwater, they stop feeding. During the course of this upstream journey, their bodies prepare for spawning. Males of some species turn a reddish color and develop hooked noses in order to fight for dominance. This incredible journey—often hundreds or even thousands of miles—draws energy from their fat storage, muscles, and organs.

Upon reaching their natal stream, females build nests. These depressions in the gravel are made by the female by turning on her side and using her tail to dislodge stones or pebbles. Males fight with other males for spawning rights with a female. The dominant male will court the female. **Spawners** release eggs and milt into the gravel. The female will cover the eggs with loose gravel and may move upstream in order to prepare another redd. Both the males and females die after spawning, supplying the river and the next generation of salmon with nutrients.

Lesson

Introduction

1. Share with the class that salmon are **anadromous** fish. This means that salmon are born in freshwater, spend most of their life in the sea, and return to freshwater to spawn (mate).
2. Ask students to recall what they know about the salmon life cycle.
3. Give each student a copy of the handout ***Salmon Life Cycle***.
4. Project the display copy ***Salmon Life Cycle***. If students are already very familiar with the salmon life cycle, have them complete the handout from memory.
5. Ask students to complete their handout using the information in the display copy.
6. Review the correct answers with the class.

Activity I

1. Ask students to describe how an illustrator might plan their book or filmmaker might plan their movie before they make it.
2. Tell students that the process usually begins with a storyboard.
3. Ask students to describe what a storyboard might be.
4. Share with the class that a storyboard is a sequence of drawings or photographs, typically with some directions and text. The storyboard represents the images and dialogue for each scene of a book, movie, or TV show.
5. Give each student a copy of the handout ***A Salmon's Journey*** and review the directions with the class.
6. Allow students to work individually or break them into groups of no more than 4. If students work in small groups, consider assigning each student a different role (i.e., background researcher, illustrator, narrator, and copy editor).
7. Have students present their storyboards to the class or create a digital story map using the directions below.

Activity II (optional)

1. Tell students that a story map is an online tool that includes images, text, and locations on a map.
2. Guide students through one of the following story map examples: ***Native Trees of the Pacific Northwest***, ***The Lands We Share***, or ***Kenya National Parks & Game Reserves***.
3. Tell students that they will be making a digital story map to bring their storyboard to life. Their story map should show the migration of a salmon from a local stream or river to the ocean. It should also include how the salmon migrates, photos from each life stage, and the narration from each life stage.
4. Provide students an overview of the story map tool (e.g., ***Story Maps***, ***Map Maker***, ***My Maps***, etc.) that you would like them to use.
5. Let the class know when their map is due and how they should submit their map.

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6. After students have completed their maps, have them present them to the class. You may wish to create a simple rubric for the audience to score the presenters.

Discussion Questions

1. How is a salmon's life cycle unique?
2. How do predators affect salmon populations differently during different stages of the salmon's life cycle?
3. How might pollution affect salmon at different stages of their life cycle?
4. What are some pros and cons of an anadromous life cycle?
5. What are some reasons why salmon might have evolved to have an anadromous life cycle?

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Action Project

Scientists need your help counting salmon! Salmon are counted after spawning, after hatching, and during migrations. This helps scientists determine the health of salmon populations, evaluate the effect of restoration projects, and analyze the health of waterways. Several organizations on the West Coast offer volunteer opportunities to help survey salmon:

California
- Eel River Recovery Project
- Friends of Auburn Ravine
- Mattole Salmon Group
- Point Reyes National Seashore
- Salmon Protection And Watershed Network

Idaho
- Idaho Department of Fish and Game
- Idaho Rivers United
- Salmon-Challis National Forest

Oregon
- Coos Watershed Association
- Johnson Creek Watershed Council
- Salmon and Trout Enhancement Program
- Salmon Watch
- Tualatin River Watershed Council

Washington
- Community Salmon Investigation
- Lower Columbia Fish Enhancement Group
- Salmon Center
- Salmon Coalition
- Skagit Fisheries Enhancement Group

Extensions

Art
Gyotaku, or fish printing, is a traditional Japanese art form. Freshly caught fish are painted with a non-toxic ink and covered with a piece of rice paper. The paper is then smoothed down to create a detailed imprint of the fish. Visit Gyotaku - The Art of the Fish Print for step-by-step directions.

Biology
Male and female salmon may begin to look drastically different after they mature. For example, males tend to develop bigger heads and jaws and become brightly colored. Have students research these differences and describe why these differences might be advantageous.

Music
Work with your school's music teacher to have the class perform the song *Salmon Circle by Fraser Lang*. A corresponding video is available on Vimeo.

Technology
Using *Survive the Sound*, your class can adopt a fish online and follow its real migration. Students will see when a fish encounters a dam or other obstacle. Students will also see speed and distance statistics about their adopted fish. The fish are tracked using acoustic tags, which are implanted in juvenile salmon as they migrate downriver to the ocean.

Additional Resources

Activities and Curriculum

Fisheries and Oceans Canada: Salmonids in the Classroom
For a longer unit of study on the salmon life cycle, see Salmonids in the Classroom **primary unit** or **intermediate unit**.

Salmon in the Classroom:
California, Idaho, Oregon, Washington
Many state programs provide salmonid eggs to schools to be reared in a classroom aquarium. These programs are often accompanied by science curriculum focused on the salmonid life-cycle. When fish reach the fry stage, schools release their fish in a local watershed.

Department of Fisheries and Oceans: Scales and Tales
A collection of activities about the salmon life cycle, salmon anatomy, and different salmon habitats. **Primary**, **intermediate**, and **secondary** units are available.

Books

Joanna Cole: *The Magic School Bus Goes Upstream: A Book About Salmon Migration* (32 pages, 620L)
It is time for Walker Elementary's annual fish fry. Ms. Frizzle's class is planning to bring salmon, but there seem to be no salmon left in the sea. In order to fish for answers, Ms. Frizzle turns the bus into a salmon to find out about salmon migration. Also available in Spanish: ***el Autobus Magico Va Contra Corriente***.

Carol Reed-Jones: *Salmon Stream* (32 pages, NP)
Illustrations in this book follow salmon from their journey as eggs in a stream to adults in the wide ocean, eventually making a hazardous journey home to their natal stream.

Video

The Magic School Bus Goes Upstream (26:04)
Ms. Frizzle takes the class on a field trip to find out where the salmon are and changes the bus into a migrating salmon.

Website

US Fish and Wildlife Service: Life Cycle of Salmon
This website provides a detailed description of each stage of the salmon life cycle.

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Name Date Period

Salmon Life Cycle

Directions: Write the name of the salmon life cycle stage and a short description about each stage. In the circle, draw a simple picture about the salmon life cycle stage.

Stage 1: _____

Description: _____

_____

_____

Stage 2: _____

Description: _____

_____

_____

Stage 3: _____

Description: _____

_____

_____

Stage 4: _____

Description: _____

_____

_____

Stage 5: _____

Description: _____

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Stage 6: _____

Description: _____

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Stage 7: _____

Description: _____

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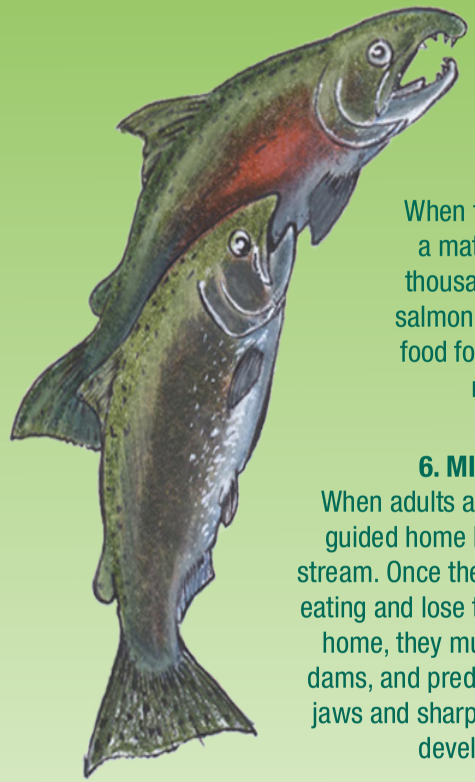
Salmon Life Cycle



1. EGGS
Under the gravel, thousands of eggs develop in nests called redds.

2. ALEVIN
Alevin hatch and remain under the gravel for protection against predators until their yolk sac is fully absorbed.

3. FRY
Once alevin have absorbed their yolk, they become fry. They head for protected spots, like under logs and behind boulders. They dart out to catch tiny insects that come their way.

4. SMOLTS
When they feel the urge, young salmon begin migrating toward estuaries where they begin adapting to saltwater in a process called smoltification.

5. OCEAN ADULTS
Salmon enter the ocean as juveniles and leave it as mature adults. In the ocean, salmon travel thousands of miles and feed on other fish, squid, eels, and shrimp.

6. MIGRATING ADULTS
When adults are ready to spawn, they are guided home by the smells of their home stream. Once they reach freshwater, they stop eating and lose their silver color. On their way home, they must battle rapids, waterfalls, dams, and predators. Males develop hooked jaws and sharp canine teeth; some species develop humped backs.

7. SPAWNING ADULTS
When they reach the spawning grounds, they find a mate. Females dig nests in the gravel and lay thousands of eggs that are fertilized by milt. Most salmon die after spawning and their bodies provide food for other wildlife including bald eagles, bears, minks, river otters, and invertebrates.

At every life stage, salmon need abundant cold, clean water.

Name Date Period

A Salmon's Journey

Part I. Background Research

Directions: Before creating your storyboard, you will need to research more information about salmon in your community. Use the Internet to find answers to the following questions.

1. What is the name of a river or stream near your school that has salmon?

2. To which ocean do the salmon migrate?

3. What are some routes they might take from the stream or river to the ocean?

4. List at least two predators a salmon might encounter during its migration.

5. In addition to predators, what other natural challenges might a salmon face?

6. List at least one human-made challenge a salmon might encounter during its migration.

7. Use Google Maps to estimate the number of miles salmon might travel from the river to the ocean.

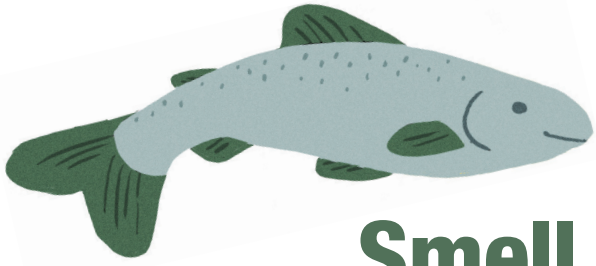
Part II. Storyboard

Directions for the narration column: Imagine you are a salmon. Write 2-3 sentences for each life cycle stage that describe your experiences. Consider including things like sights, smells, sounds, predators, prey, and potential obstacles to migration.

Directions for the photo/illustration column: Describe what the salmon might be seeing during the different stages of its life cycle. Consider including fellow salmon, predators, prey, habitat, and potential obstacles a salmon might face during its journey.

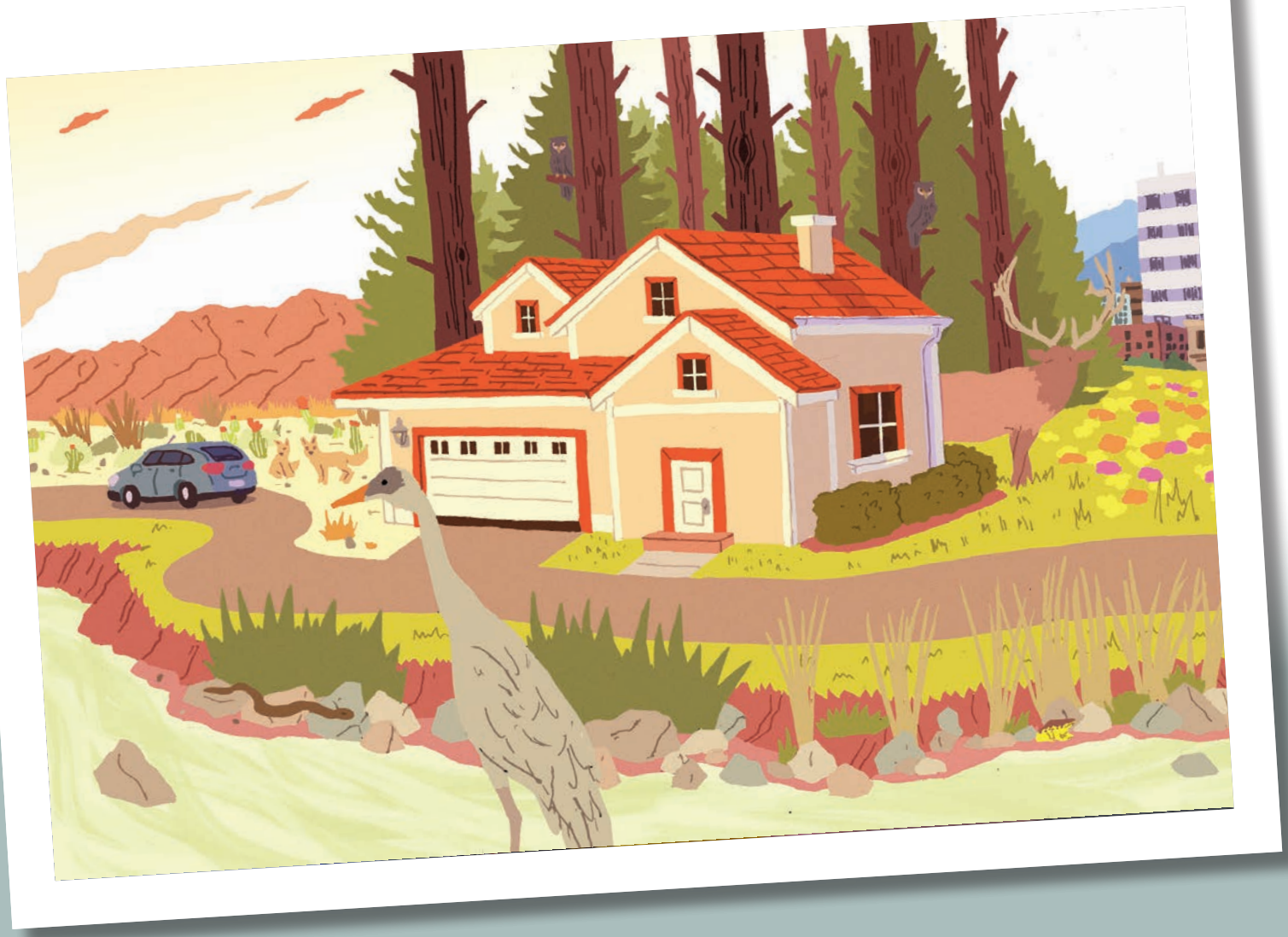
A Salmon's Journey, Page 2

Life Cycle Stage	Narration	Photos/Illustrations
Egg		
Alevin		
Fry		
Smolt		
Ocean Adult		
Migrating Adult		
Spawning Adult		



Lesson 2

Smell Your Way Home



After a short discussion about migrations, students hypothesize how salmon can find their way from the ocean all the way back to their natal stream. The class learns that salmon navigate using their sense of smell, and then act out a salmon's migration by blindly following their sense of smell from a mock ocean to a natal stream. After the students successfully complete one migration, pollutants—which interfere with a salmon's sense a smell—are introduced into the activity. Students must again find their way home, but this time with an impaired sense of smell.

Objectives

Students will:

- Predict how salmon find their way from the ocean to their natal stream.
- Act out the migration of salmon from the ocean to their natal stream.
- Discuss how pollution can impair a salmon's ability to migrate.
- Describe the experience of using their sense of smell to navigate.

Students will understand:

- Salmon use their sense of smell to find their natal stream.
- Pollution can impair a salmon's sense of smell.
- Pollution can affect a salmon's ability to find its natal stream.

Time Required

Approximately 1.5 hours

Preparation

□ Strong scents
Gather 1 different strong scent (e.g., peppermint oil, vanilla extract, citrus oil, etc.) per group of 4-5 students. Bottles with eyedroppers are the easiest to use.

□ Small cups
Gather at least 6 small cups, vials, or canisters per group of 4-5 students.

□ Signs
Write 1 sign that says "ocean" and another that says "natal stream." Post them on opposite sides of the room.

□ Permanent markers
Gather 1 marker per group of 4-5 students.

□ Blindfolds
Gather 1 blindfold per group of 4-5 students.

□ Stopwatch or timer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Keywords

Migration—The relatively long-distance movement of individuals, usually on a seasonal basis.

Natal stream—A salmon's home stream; where a salmon hatched.

Pollution—The release of substances into the environment that adversely affect the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Supporting Vocabulary

Homing—An animal's ability to return to a place or territory after traveling a distance away from it.

Imprint—Rapid learning that occurs during a brief receptive period and establishes a long-lasting behavioral response to a specific individual or object or location.

Nares—Fish nostrils which are used for smelling, not breathing.

Olfaction—The sense of smell.

Pollutant—Any substance introduced to the environment that adversely affects the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Background Information

Smell, or olfaction, is an important sense for salmon and many other fish. The little holes above a fish's mouth that look like nostrils are called **nares**. Nares do not lead to the throat the way nostrils do in mammals. Instead they open up into a chamber where the smell receptors are located. These smell receptors are

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so sensitive that they make a salmon's sense of smell one million times more sensitive than a human's.[5]

When they enter the smolt stage (when they begin migrating to the ocean), salmon are particularly sensitive to the odors of their local waterways. Each waterway has a unique scent from a combination of rotting vegetation, insects, fish, and dust released from local rocks and soils. These odors are imprinted on the smolt's brain and help provide the salmon with direction-finding cues years later.

Salmon spend a few years feeding in the ocean—travelling hundreds or thousands of kilometers—before returning to spawn in their natal stream. Some salmon even spawn in the same section of stream in which they were born. It is estimated that 90-99% of salmon return to their natal streams, while the remaining 1-10% stray into other streams.

While we know how salmon navigate after they find the river mouth, it is not completely understood how salmon return to the correct coastline. To find their way to the correct coastline, it is believed that salmon use many different environmental cues including day length, the sun's position, Earth's magnetic field, water salinity, and temperature gradients. Once salmon reach freshwater, they are guided largely by their sense of smell and the odors that were imprinted on their brains during the smolt stage.

Lesson

Introduction

1. Remind the class that salmon can migrate hundreds and even thousands of kilometers in their lifetime. But salmon are not the only animals to make long migrations.
2. In popcorn style, ask the class to list different animals that migrate. Write these examples on the board.
3. Share with the class that many different kinds of animals migrate. Monarch butterflies migrate nearly 5,000 km (3,000 mi) from Southern Canada to Northern Mexico. Leatherback sea turtles will cross the entire Pacific Ocean every year—approximately 16,000 km (10,000 mi)—in search of food. In Africa, millions of migrating wildebeest travel 1,600 km (1,000 mi) along with hundreds of thousands of zebra and gazelles. Around the world, animals fly, swim, and walk thousands of kilometers without using maps, GPS, or smartphones.
4. In think-pair-share format or through a free write, ask students to:
   - Describe how people use their senses to navigate.
   - Predict how salmon migrate from the ocean all the way back to their natal (home) streams.
5. After students have shared their ideas, tell the class that salmon are very dependent on their sense of smell. During their smolt stage (when they begin migrating to the ocean), salmon are particularly sensitive to the smells of the water. These smells are imprinted on the salmon's brain. When salmon are ready to return from the coast to their home stream, their sense of smell guides them home.

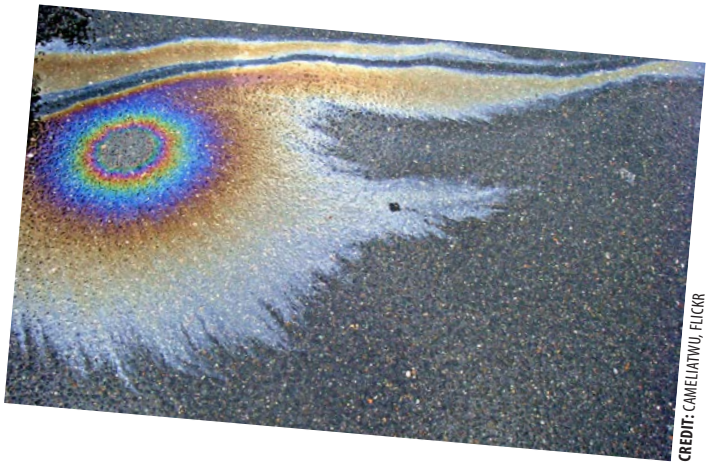
Activity

1. Tell the class they will act as salmon and try to use their sense of smell to find their way to their natal stream.
2. Have students move their desks, tables, and chairs to the perimeter of the room.
3. Place the "ocean" and "natal stream" signs on opposite sides of the room.
4. Divide the class into groups of 4-5.
5. Give each group a set of small cups, a scent, and a marker.
6. Ask groups to label each of their small cups with the same letter, number, or symbol.
7. Instruct each group to add a few drops of their scent to each small cup.
8. Ask the group to choose one member of the group to be the salmon.

9. The salmon should sniff the scent of their natal stream and try to remember it.
10. Ask all of the salmon to move to the side of the room with the "ocean" sign.
11. Give each salmon a blindfold and instruct them to put it on.
12. The rest of the group should create a trail of small cups from the "ocean" side of the room to the "natal stream" side of the room. Their small cups should not be in a straight line and may intersect with another group's vials.
13. The groups should sit near their last small cup near the "natal stream" sign.
14. Tell students that on your command the salmon should try to find their home stream/group by crawling along the floor and sniffing the small cups. Remind the class that salmon cannot talk. Any salmon caught talking will be sent back to the ocean to start over.

    Option: Assign each salmon a guide to help them make their way from one vial to another. The guide should not lead the salmon directly to vials from their own stream.
15. Get ready to mark the time it takes the salmon to get from the ocean to their natal stream. When a salmon makes it back to its natal stream, note the time on the board. If a salmon returns to the wrong group, note this on the board.
16. Tell the salmon to begin migrating to their home stream.

    Option: If the salmon are having trouble finding their way to their home stream, you may allow the salmon's group to guide their salmon home using nonverbal cues (e.g., snapping fingers, tapping on the floor, adding extra scents to the trail, etc.).
17. When all of the salmon have reached their natal stream, have students remove their blindfolds.
18. Lead a class discussion using the following prompts:
    - What did this experience feel like to the salmon? Was it easier or harder than you expected? Why?
    - What did this experience feel like to the rest of the group?
    - How was this experience like a real salmon migration?
    - How was this experience different than a real salmon migration?



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19. Tell the class that sometimes pollutants can enter rivers or streams. Pollution can come from cleaning supplies, paints, pesticides, leaky cars, factories, and more.
20. Ask student to describe how might pollution affect a salmon's sense of navigation?
21. Ask the groups to choose a different salmon.
22. The salmon should return to the "ocean" and put on their blindfolds.
23. Ask the remainder of the group to retrieve their small cups.
24. Give each group a different scent than they had the first round.
25. Have each group place a drop or two of the "pollutant" in each vial.
26. Repeat Steps 12-18.
27. Have students pick up their small cups and return the classroom to its original configuration.
28. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:
    - How is this activity like a real salmon migration? How is it different?
    - How did pollution impair the salmon's sense of navigation?

Discussion Questions

1. Besides navigation, how else might salmon use their sense of smell?
2. Why do different streams and rivers have a distinct smell?

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3. How can our actions at home or school affect the smells of streams or rivers? What can we do to reduce this impact?
4. In the wild, do all salmon make it to the right natal stream? Why or why not?
5. Since salmon navigate using their sense of smell, how might fish born in hatcheries be at a disadvantage?

Action Project

Do families in your community know how to properly dispose of hazardous household waste? Waterways can become polluted—and affect a salmon's sense of smell—when common household products such as household cleaners, paints, fertilizers, and pesticides are not disposed of properly. Have students research the closest household hazardous waste disposal site and create posters or other advertisements that let the community know how to properly dispose of this waste. Students can also **research eco-friendly alternatives** to common hazardous products and inform the community of safer alternatives.

Extensions

Art

As a class, create a mural that depicts the smells salmon might encounter throughout their migration. Have students incorporate natural smells as well as products from homes, cars, and industries.

Civics

Have students write a letter to companies that produce household cleaning products and encourage them to use more eco-friendly ingredients.

Science

Through a salmon dissection, students can learn about the form and function of a salmon's anatomy. The ***Salmonid Anatomy and Dissection Workshop Handbook*** guides educators through the dissection process and provides descriptions of a salmon's anatomy.

Writing

Students can write a short story about the smells salmon might encounter while migrating through different types of ecosystems and rural or urban areas.

Additional Resources

Articles

KUOW: Salmon are losing their sense of smell.
Salmon are starting to lose their sense of smell and their fear of predators, according to research from federal and university scientists in Seattle.

Books

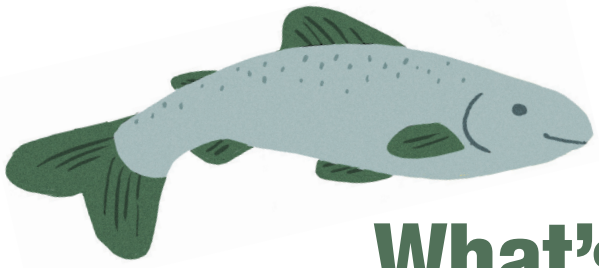
Marianne Berkes: *Going Home: The Mystery of Animal Migration* (32 pages, AD790L)
Students will discover how animals from around the globe migrate by air, land, and sea.

James Cheshire: *Where The Animals Go: Tracking Wildlife with Technology in 50 Maps and Graphics* (192 pages)
This book provides a comprehensive portrait of how creatures like ants, otters, owls, turtles, and sharks navigate the world.

Videos

How Do Animals Find Their Way Home Without GPS? (4:05)
Animals travel hundreds of kilometers without GPS, but how? Understanding the earth's magnetic field might be the ultimate travel tip.

Zinc stinks! Olfactory inhibition in juvenile coho salmon (2:49)
When a salmon's olfactory system is compromised, so is their ability to detect prey.



Lesson 3

What's a Watershed?

An introductory questionnaire tests students' basic understanding of watersheds. After watching a video clip about watersheds, students retake the questionnaire and define watershed in their own words. Students explore a local watershed online before constructing their own watershed model. Through a series of hypotheses and observations, students learn how water and pollutants move throughout the watershed. A class discussion reveals how pollutants from land might affect aquatic organisms and what students can do to prevent water pollution.

Objectives

Students will:

- Define watershed in their own words.
- Construct a watershed model.
- Brainstorm common products that might cause pollution.
- Hypothesize and observe how water and pollutants move through their watershed model.
- Predict how household products can affect salmon and other aquatic organisms.

Students will understand:

- Surface water in a watershed drains to a single point.
- Ecosystems are interconnected.
- Pollution can move from land to water.
- Pollution can affect aquatic organisms.

Time Required

At least 2 hours. Time will vary depending on the complexity of students' models.

Preparation

□ **Video clip:** ***Watersheds!*** or ***What is a Watershed?***
Project 1 of these videos during Step 3 of the introduction.

□ **Website:** ***Model My Watershed***
Project this website during Step 7 of the introduction.

□ **Handout:** ***Watershed Observations***
Print 1 copy per student or group of 3-4.

□ **Watershed base:** modeling clay or aluminum foil
Gather 1 grapefruit-sized lump of modeling clay or 1 sheet of aluminum foil approximately 20" long per student or group of 3-4.

□ **Watershed container:** dish basins, deep baking pans, or other large waterproof containers
Gather 1 container per student or group of 3-4.

□ **Rainmaker:** spray bottles, eye droppers, or small cups
Gather 1 rainmaker per student or group of 3-4.

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□ **Water source:** a nearby sink, drinking fountain, or a bucket of water

□ **Permanent markers**
Gather a few colors per student or group of 3-4.

□ **Pollutants**
Gather sprinkles and/or gelatin mixes of different colors for each student or group of 3-4.

□ **Watershed accessories** (optional)
To make this activity more realistic, provide each student or group of 3-4 with some or all of the following items:

- Small model houses, businesses, and farm buildings
- Small model people, animals, and trees
- Artificial turf
- Sponges cut into small pieces

Keywords

Pollutant—Any substance introduced into the environment that adversely affects the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Pollution—The release of substances into the environment that adversely affect the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Ridgeline—An area of higher ground separating two adjacent streams or watersheds.

Watershed—An area of land where surface water drains down to a single point.

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Supporting Vocabulary

Nonpoint source pollution—Harmful substances released from many different sources that cannot be individually identified.

Point source pollution—Harmful substances released from an identifiable source.

Stormwater runoff—Rainfall, melted snow, or irrigation water that flows across the ground's surface and is eventually returned to streams. Runoff can pick up pollutants from air or land and carry them to receiving waters.

Topography—The shape of the land.

Background Information

A watershed is an area of land where surface water drains down to a single point, such as a pond, lake, or ocean. The boundary of a watershed is the high land surrounding it, like the edge of a bowl. Water from hundreds, and often thousands, of creeks and streams flow from higher ground to rivers. This water eventually winds up in a larger body of water, such as larger rivers, lakes, or the ocean.

A watershed can be small, such as a single lake or a single county. Some watersheds encompass thousands of square kilometers and may contain streams, rivers, lakes, reservoirs, and groundwater. The largest watershed in the US is the Mississippi River Watershed. It drains nearly 3 million square km (1.15 million square miles) from 31 states and two Canadian provinces!

As rainwater and snowmelt run downhill, they carry whatever is on the land—such as oil from cars, trash and debris on streets, or exposed soil from construction—to the nearest body of water. These pollutants can concentrate in streams and rivers and can be carried down the watershed and into the ocean.

Rain and snowmelt from watersheds can take many routes to the sea. During periods of heavy rain and snowfall, water may run onto and off of impervious surfaces such as parking lots, roads, and buildings because it has nowhere else to go. These surfaces transport water, and pollutants, directly into storm drains.

When pollutants enter our waterways, they can cause a variety of adverse effects on aquatic species. Common contaminants can impair salmon health in a variety of ways. For example, certain metals and pesticides are toxic to the salmon nervous system, thereby disrupting feeding and predator avoidance.[6] Pesticides and petroleum-derived compounds suppress the immune system, rendering salmon more vulnerable to pathogens that cause lethal diseases.[7] Petroleum-derived compounds are also known to depress growth of juvenile salmon, which can decrease their chances of survival.[8] Other compounds target the cardiovascular system, causing heart failure or permanent heart defects.[9]

Wetlands can act as an important runoff filter. They trap sediments and excess nutrients from runoff before it reaches open water. Plant roots can absorb nutrients from fertilizers, manure, and sewage. Other pollutants may stick to soil particles. In many cases, the wetland filtration process removes much of the water's nutrient and pollutant load by the time it leaves a wetland, allowing cleaner water to enter the ocean.

There are many ways that people can minimize water pollution:

- Walk, bike, and use public transportation whenever possible.
- Fix leaks from vehicles as soon as possible.
- Use environmentally-friendly household products.
- Minimize the use of pesticides and fertilizers.
- Properly dispose of household hazardous wastes, such as oil, paint, and pesticides.

Lesson

Introduction

1. Tell the class that you are going to read a few statements. Students should put their thumbs up if they agree and put

their thumbs down if they disagree.

Option: Have students put their heads down on their desk to ensure they are answering the questions independently.

2. Read the following statements one at a time. Give students time to each statement before moving on. At this time, do not correct their answers.
   - Ecosystems are connected. ***Yes***
   - A watershed is a shed where water is stored. ***No***
   - Water flows uphill. ***No***
   - A watershed is another name for a bathroom. ***No***
   - You live in a watershed. ***Yes***
   - All water in a watershed drains down to a single spot. ***Yes***
   - Water can move between different ecosystems. ***Yes***
3. Show students the video clip ***Watershed!*** (5:22) from CoCoRaHS HQ or ***What is a Watershed?*** (1:18) from Battle River Watershed.
4. Repeat the questionnaire from Step 2. Be sure to note and address any misconceptions.
5. In their journals or science notebooks, have students write their own definition of a watershed.
6. Review the following definition of a watershed with the class: An area of land where surface water drains down to a single point.
7. Project ***Model My Watershed***.
8. Locate your school on the map.
9. Zoom out so that some local bodies of water are visible.
10. Turn on the Continental US Medium Resolution Stream Network layer. This is found under the  icon with three wavy lines.
11. Ask students to imagine that it has rained at your school. Point out the ridgelines surrounding your school.
12. Have students describe where the water would flow and the path it would take.

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Activity

1. Tell the class they will now make their own watershed model.
2. Break students into groups of 3-4 or allow students to work individually.
3. Give each group or individual a watershed base (clay or aluminum foil) and a watershed container (dish basins or baking pans).
4. Tell students their model must include hills or mountains; a stream or river; and a pond, lake, or ocean. To construct hills or mountains, students may wish to crumple paper and insert it under the clay or aluminum foil. If students need additional support, you may wish to build a demonstration model first.
5. After students have created their model, give them a permanent marker to trace the boundaries of their water sources.
6. **Option A:** Hand out the watershed accessories (buildings, people, trees, etc.). Instruct students to place the items on their model. Explain that the sponges represent wetlands and should be located near a pond, lake, or river.

Homes	Roadways	Farms
Cleaners	Antifreeze	Fertilizers
Fertilizers	Brake pad dust	Herbicides
Herbicides	Diesel	Insecticides
Insecticides	Gasoline	Manure
Pet waste	Oil	Oil

Option B: If you are not using the watershed accessories,

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ask students to draw homes, business, farms, and forests on their model using the permanent marker.

7. Give each student or group the handout ***Watershed Observations***.
8. Have students complete Part I of their handout.
9. Give each group a rainmaker and have them fill it up with water.
10. Ask students to make it rain by dropping some water on their model. Ensure that students have used enough water so that it collects in a waterway on their model.
11. Have students complete Part II of the handout.
12. Encourage a few students to compare their hypothesis to their observations.
13. Draw a three column table on the board with the headers: homes, roadways, and farms.
14. Give students a few minutes to silently think about potential sources of pollution from homes, business, and farms.
15. Invite students to write their suggestions on the board. Common examples include:
16. Give each student or small group pollutants (sprinkles and/or gelatin mixes).
17. Tell students that each different color will represent a different pollutant. Students may choose which pollutants they would like to represent in their model.
18. Have students complete Part III of the handout.
19. Tell students to place their pollutants on their watershed model.
20. Ask students to complete Part IV of their handout.
21. Ask students to make it rain by dropping a little water on their model. Ensure that students have used enough water to move the pollutants into the waterways on their model.
22. Ask students to complete Part V of their handout.
23. Encourage a few students to compare their hypothesis to their observations.
24. Ask students to complete Parts VI of their handout.
25. Bring the class back together and lead a class discussion or think-pair-share exercise using the following prompts.
    - How does water move through a watershed?
    - How does pollution move through a watershed?
    - How might watershed pollution affect salmon and other aquatic animals?
    - What can you do at home to protect our waterways?

Discussion Questions

1. How do watersheds connect ecosystems?
2. How could pollution in a river affect the ocean?
3. Why is it important to take care of watersheds?
4. How can pavement, such as roads and sidewalks, increase water pollution?
5. How can grass, wetlands, and other natural areas decrease water pollution?

Action Project

By adding plants and rain gardens to your schoolyard, you can reduce runoff and water pollution. Have students plot the location and names of plants on campus, the location of storm drains, and potential locations for additional plants. Work with your local gardening center, conservation district, or habitat restoration group to select and plant native plants. The ***Asphalt to Ecosystems***, ***Schoolyard Habitat Project Guide***, and

National Wildlife Federation's Schoolyard Habitats provide additional information about creating a thriving schoolyard.

Extensions

Engineering

Using commonly available materials (e.g., sand, cotton balls, gravel, sod, etc.), students can design a water filter that filters pollutants from runoff. Challenge students to design a filter that is both effective and low cost. Students should also think about how their filter would be installed in order to filter runoff. For more support, see the **Water Filtration lesson plan** from TeachEngineering.

Environmental Science

Visit Google Maps and locate your school. Zoom in so that only a few blocks are visible around the school. Print a copy of this map for each student. Take the class on a walk through the neighborhood and have students note potential sources of water pollution on their maps (e.g., leaks from pipes, litter, gas or oil on pavement, pesticides). Students could also repeat the same activity in their neighborhood.

Technology

Have students use **Model My Watershed** to identify their watershed, the major sources of pollution in the watershed, and how impervious pavement is contributing to runoff. Students can discover how to improve their watershed by adding plants, creating green roofs, and minimizing paved surfaces.

Topography

Give students graph paper and a ruler. Students can take detailed measurements of their watershed model, and plot the measurements on graph paper to create a topographic map. Using the topographic map, they can more accurately predict how water and pollutants will move through their model.

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Additional Resources

Activities and Curriculum

Healthy Waters Institute: 1000 Drops
This unit encourage students to develop a closer connection to their home waters. The unit is divided into 6 sections that build a foundation of understanding about how water moves through a watershed.

Save The Bay: Watershed Curriculum
The 29 activities in this curriculum provide students with a hands-on exploration of watersheds, topography, and wastewater. The curriculum was designed for the San Francisco Bay watershed, but can easily be adapted for other regions.

Northland NEMO Program: The Watershed Game
In this board game, teams of students apply practices, plans, and policies to decrease water pollution while balancing financial resources.

San Diego Zoo: Watershed Heroes Curriculum
The 7 activities in this unit encourage students to become stewards of their local watershed and think about how their actions might affect local and global waterways.

Interactives

Project Wet: Explore Watersheds
This interactive from Project Wet provides students with graphics, videos, and activities that help students better visualize watersheds.

Fernleaf Interactive: Watersheds
By hovering over different positions on a map, students can see how major rivers flow and into which ocean they drain.

Name Date Period

Watershed Observations

Part I. Water hypothesis
Describe how you think the water will move over your watershed model after a rainstorm.

Part II. Water observations
Describe how the water moved over your watershed model after the rainstorm.

Part III. Pollutant key
Create a key that shows the pollutants you will use in your model.

Part IV. Pollutant hypothesis
Describe how you think the pollutants will move over your watershed after a rainstorm.

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Part V. Pollutant observations

Describe how the pollutants moved over your watershed after a rainstorm.

Part VI. Pollution prediction

Describe what might happen if pollutants enter waterways. How might the pollutants affect aquatic animals?

Lesson 4

Ecosystem Interconnections

During a warmup exercise, students brainstorm the plants, animals, and other elements in local ecosystems. After defining the term ecosystem in their own words, small groups create a diagram that shows the interconnections between abiotic and biotic elements in one of six aquatic ecosystems. Using a graphic organizer, students discover the similarities and differences between the aquatic ecosystems upon which salmon depend.

Objectives

Students will:

- Describe the abiotic and biotic elements in a local ecosystem.
- Define "ecosystem" in their own words.
- Create a diagram that shows interconnections between different components of an aquatic ecosystem.
- Identify producers, consumers, decomposers, and abiotic factors in an aquatic ecosystem.
- Compare and contrast two aquatic ecosystems.

Students will understand:

- Ecosystems are made up of living and nonliving elements.
- Every ecosystem contains producers, consumers, decomposers, and abiotic factors.
- Salmon depend on multiple different ecosystems throughout their life cycle.

Time Required

Approximately 2 hours

Preparation

□ **Butcher paper**
Cut 6 pieces approximately 36" long.

□ **Handout: *Ecosystems***
Print 1 copy of each ecosystem.

□ **Handout**: ***Ecosystem Compare and Contrast***
Print 1 copy per student.

□ **Scissors**
Gather at least 6 pairs.

□ **Glue**
Gather at least 6 bottles or sticks of glue.

□ **Crayons, markers, or colored pencils**


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Keywords

Abiotic factor—A nonliving environmental medium (e.g., water, soils, nutrients) or nonliving environmental characteristic (e.g., light, temperature, pH, humidity).

Biotic factor—A living part of an ecosystem (e.g., animals, plants, and microorganisms).

Ecosystem—A community of organisms (plant, animal, and other living organisms) and the abiotic parts of their environment.

Supporting Vocabulary

Consumer—Organisms that must eat other organisms to obtain energy; consumers are also called heterotrophs.

Decomposer—An organism that breaks down organic material over time.

Economy—The system of production, distribution, and consumption of goods and services.

Food chain—A linear sequence of organisms through which nutrients and energy pass as one organism eats another.

Food web—Including many interconnected food chains, a food web is a more realistic representation of consumption relationships in ecosystems.

Producer—Organisms that can make their own energy from inorganic materials and an energy source such as sunlight; producers are also called autotrophs.

Photosynthesis—The process of using sunlight to synthesize foods from carbon dioxide and water.

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Background Information

An ecosystem consists of a community of organisms together with their physical environment. Ecosystems can be small, such as the tide pools found near the rocky shores of many oceans, or very large, such as the Amazon Rainforest. Aquatic ecosystems include oceans, estuaries, lakes, rivers, and streams and areas that might only be flooded with water for part of the year such as floodplains and wetlands.

A salmon's anadromous life cycle makes it a vital part of many different aquatic ecosystems. Their life begins in rivers, streams, and lakes. As they mature, salmon migrate to estuaries. As adults, salmon live nearshore and in the open ocean for several years before returning to their home stream or river to mate. While migrating through different ecosystems, salmon play a key role in many food webs. Salmon also play a vital role in fertilizing ecosystems since they carry many nutrients from the sea back to their natal streams.

Aquatic ecosystems perform many important environmental functions such as recycling nutrients, purifying water, attenuating floods, recharging groundwater, and providing habitats for wildlife. Aquatic ecosystems also provide many economic opportunities, including recreation, tourism, and fishing. Aquatic ecosystems are the lifeblood of coastal regions.

It is important to remember that the boundaries that we draw around an ecosystem are artificial. Both natural materials and human-made materials—including pollutants—can move throughout and in between ecosystems. Pollutants that are discharged on land may make their way into local streams and rivers and are ultimately swept out to sea.

Lesson

Introduction

1. Ask students to close their eyes and think about what kinds of plants, animals, or other natural things they might find outside your school or around their neighborhoods.

   Option: Show students a few photos of local ecosystems or give them a few minutes to look outside.

2. Invite students to write their ideas on the board.

3. Give students a minute to reflect upon the words on the board.

4. Ask the class if they know the word that describes a community of living things, such as plants and animals, and things that are not living, such as rocks, soil, sunlight, and water. ***Ecosystem***

5. In their science notebooks or journals, ask students to define the word "ecosystem" in their own words.

6. Ask a few students to share their examples.

7. Ask the class to list examples of different types of ecosystems. List these examples on the board. If students need extra support, suggest different types of animals (e.g., chipmunk, blue whale, orangutang, etc.) and ask where they might live (e.g., forest, ocean, rainforest, etc.).

Activity

1. Divide the class into 6 groups.

2. Give each group a different set of ecosystem cards and pair of scissors.

3. Instruct students to cut out the cards.

4. After all of the cards have been cut out, the group should read each card. Instruct the groups how to read the cards (e.g., choral reading, partner reading, echo, etc).

5. Tell the class they will now create a diagram that shows how the plants, animals, and abiotic factors in the ecosystem interact. Students can either glue their cards on the butcher paper or draw the plants, animals, and abiotic factors themselves.

6. Give each group a piece of butcher paper, a glue stick, and

crayons, markers, or colored pencils.

7. Once groups have completed their diagrams, ask students to color code the producers, consumers, decomposers, and abiotic factors. Students could also color code the groups of consumers (i.e., herbivores, carnivores, and omnivores). Advanced students could also identify the trophic levels of the consumers (i.e., primary, secondary, tertiary, and quaternary consumers).

8. After groups have finished their diagrams, call the class to attention.

Group A	Group B
River	Kelp forest
Wetland	Eelgrass meadow
Estuary	Open ocean

9. Give each student a copy of the handout ***Ecosystem Compare and Contrast*** and review the directions with the class.

10. Pair one ecosystem group with another ecosystem group.

11. Give the groups about 10 minutes to present their ecosystems to each other and complete their handouts.

12. Have a few groups summarize their handouts. Be sure that students have recognized the following similarities and differences.

    - Similarities: Every ecosystem is aquatic. Each of the ecosystems have humans, sun, salmon, producers, consumers, and decomposers.

    - Differences: Some of the ecosystems are saltwater others are freshwater. There are different plants/animals in each ecosystem.

13. Ask students to raise their hands if salmon live in their ecosystem.

14. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:

    - Why are salmon found in so many different ecosystems? ***Salmon live in different ecosystems throughout their lives. They are born in rivers and streams. As they mature, they move to estuaries. Adults spend a few years in the ocean before returning to their home stream or river.***

CREDIT: OLIVER.DODD, FLICKR

    - How do salmon benefit from living in so many different ecosystems? ***Salmon are able to find different sources of prey at different stages of their life cycle.***

    - Why might it be challenging for salmon to live in so many different ecosystems? ***There are new predators in different ecosystems. It takes a lot of energy to complete such long migrations.***

    - How do ecosystems benefit from salmon living in different ecosystems? ***Salmon are a key part of many food webs. Salmon transport important nutrients from the ocean to the forest. When the bodies of salmon decompose, they fertilize the forest.***

15. Save the ecosystem diagrams for Lesson 5.

Discussion Questions

1. How are abiotic factors (nonliving things) important to ecosystems?

2. How are terrestrial (land) and aquatic (water) ecosystems connected?

3. If one species declines or becomes overpopulated, how can this affect the larger ecosystem?

4. Why is it important to take care of ecosystems?

5. How are people part of ecosystems?

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Action Project

Invasive species are impacting terrestrial and aquatic ecosystems around the world. Invasive species can be any kind of living organism—animals, plants, fungi, bacteria, or even an organism's seeds or eggs—that are not native to an ecosystem and cause harm to the environment, the economy, or human health. In the US, roughly 50,000 non-native species have been introduced.[10] Every year, invasive species cost the US $137 billion.[11] Contact your local Stream Team or River Keepers to host an invasive species removal event. This will not only help salmon, but all native aquatic species.

Extensions

Art

Have students choose a species from their ecosystem and create a poster or trading card that highlights the defining characteristics of the species and its role in the ecosystem.

Environmental Science

Have students research a common invasive species that might inhabit their ecosystem. Students can describe how this invasive species will affect their ecosystem and how it might be eradicated without harming others species or the ecosystem.

Geography

Assign each student a different country. Students can research the dominant ecosystem in this country and its key plants and animals.

Music

Work with your school's music teacher to have the class practice the song ***Ecosystems by MindMuzic***.

Additional Resources

Interactive

PBS: Eekoworld
This interactive website provides an overview of 5 different ecosystems: tundra, forest, aquatic, grasslands, and desert.

Videos

Blue Carbon (5:47)
How do healthy coastal wetlands mitigate climate change? This video tells the story of how coastal wetlands reduce carbon pollution.

Ecosystem Interdependence: Managing Salmon for Healthy Forests (3:45)
This video explains how salmon are an important part of many Americans' diets—and how they deliver essential nutrients to a wide variety of habitats, especially through the "poop loop."

Exploring Ecosystems: Coastal Food Webs (4:14)
How do changes in the ecosystem affect the community? Enter an underwater forest of kelp and explore the various threads that connect species together that help maintain diversity and balance in food webs.

River

A river is a long body of moving water. Rivers provide a steady flow of fresh water. Rivers flow into bigger rivers and must rivers eventually flow into the ocean. Along the way, rivers pick up nutrients and carry them to the sea.

Many animals depend on rivers including fish, birds, snails, insects, bears, and more. People also depend on rivers. Rivers are used for water, food, transportation, and recreation. River valleys provide fertile soils for farms.

Unfortunately, people have been using rivers to dispose of trash. Pollution from yards, farms, and businesses also washes into rivers. Dams have also greatly changed river ecosystems.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: People eat fish from the river ecosystem. They also eat crayfish, mussels, lamprey, and caviar (fish eggs).

Other: Healthy rivers support the economy. Fish and fishing generate a lot of money. Recreation, like kayaking, canoeing, and boating, also generate income for people.

SIGNAL CRAYFISH (*Pacifastacus leniusculus*)

Diet: Signal crayfish will eat almost anything—including other crayfish. They regularly eat fish, frogs, aquatic insects, worms, and aquatic plants.

Predators: Otters, mink, predatory fish, eels, other crayfish, and humans.

Habitat: Crayfish dig burrows up to three feet long in river banks.

Other: When crayfish burrow, they help aerate (put oxygen into) the sediment.

GREEN ALGAE (*Chlorophyta SPP.*)

Diet: Green algae make their own food through photosynthesis.

Predators: Algae are eaten by young aquatic animals including frogs, fish, and insects. Algae are also eaten by filter feeders such as oysters, clams, and mussels.

Habitat: Algae float on the surface of the water and grow on rocks and other surfaces.

Other: Algae produce oxygen for animals living in the river.

GRAVEL

Gravel helps regulate the temperature of rivers by allowing surface water and ground water to mix. It also helps clean the water.

Some aquatic insects live and lay their eggs in gravel.

Salmon lay their eggs in gravel. After the eggs hatch, salmon are protected by the gravel.

AMERICAN BLACK BEAR (*Ursus americanus*)

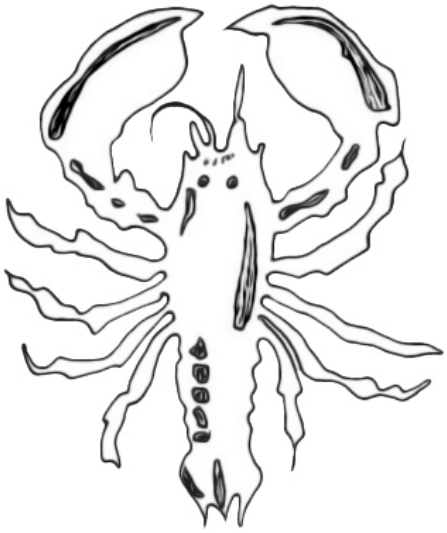
Diet: Fruits, nuts, grass, insects, and the flesh of dead animals like salmon. Sometimes they will eat rabbits and deer.

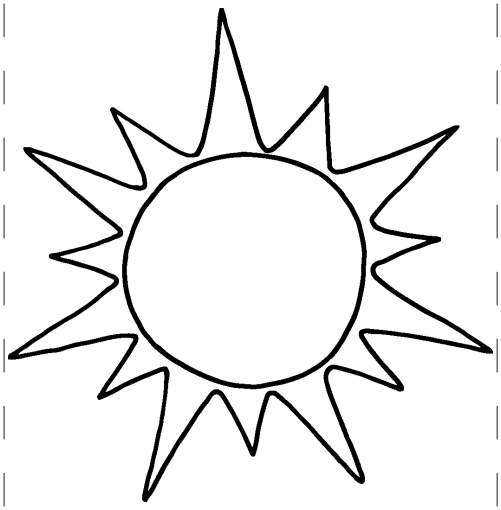
Predators: Wolves, mountain lions, and humans will hunt bears.

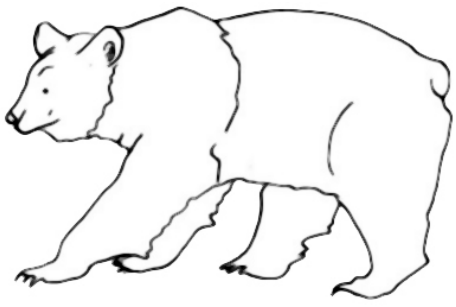
Habitat: They make beds from leaves on the forest floor. They will also sleep in rock crevices, hollow trees, or brush piles.

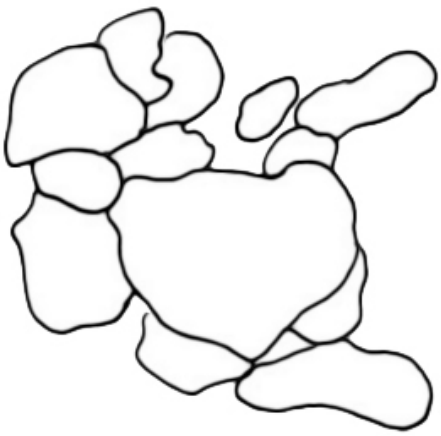
Other: Black bears help spread seeds through the forest. They also eat many insects, helping to keep populations under control.

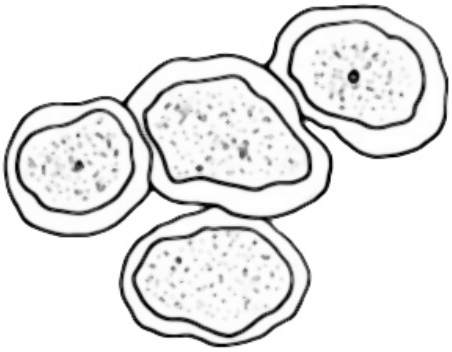
River











River

CADDISFLY (*Homoplectra SPP.*)

Diet: Some species of caddisflies eat algae and plants. Others eat insects.

Predators: Young caddisflies are aquatic and are eaten by fish, insects, and crayfish. Adults live on land and are eaten by birds, bats, frogs, and spiders.

Habitat: Female caddisflies lay eggs on plants near the water surface. When the larvae hatch from the eggs, they fall into water. Adults rest on tree trunks near freshwater.

Other: Some species of caddisflies are sensitive to pollution. A strong caddisfly population usually means good water quality.

LEECH (*Hirudinea SPP.*)

Diet: Fish, turtles, waterbirds, worms, snails, and aquatic insects.

Predators: Fish, turtles, and ducks.

Habitat: Leeches tend to live in shallower waters.

Other: Leeches thrive in poor water quality. Many leeches in one body of water, may indicate the water is polluted.

BELTED KINGFISHER (*Megaceryle alcyon*)

Diet: Typically eats small fish, crayfish, frogs, tadpoles, and aquatic insects. Occasionally they will eat small mammals, young birds, lizards, and berries.

Predators: Belted kingfishers have few natural predators. Hawks, eagles, kites, and falcons may eat kingfishers.

Habitat: Kingfishers live near streams, rivers, ponds, lakes, and estuaries. They nest in tunnels near water.

Other: A strong kingfisher population usually means a healthy environment.

TREES AND LEAVES

Shade from the tree canopy helps keep the water cool. Tree roots help prevent erosion.

When trees fall into the river they may block flows and create pools. These pools are important fish habitats. They prevent young fish from getting flushed downstream. The pools also help fish hide from predators.

Microscopic algae can attach to the dead tree and provide food for aquatic insects.

Leaves from the trees fall into the water. Aquatic invertebrates shred these leaves into tiny pieces. These tiny leaves become food for insects and other animals.

STRIPED SKUNK (*Mephitis mephitis*)

Diet: Skunks will eat almost anything, including insects, worms, birds, mice, frogs, eggs, dead animals, fish, snails, and crayfish.

Predators: Most predators typically avoid skunks. If cougars, coyotes, bobcats, owls, eagles, badgers, and foxes are really hungry, they may eat skunks.

Habitat: Skunks use hollow logs, brush piles, and the underground dens of other mammals. If necessary, they will dig their own dens.

Other: Skunks are important for controlling the populations of insects. They can also spread parasites and diseases.

WATER MOLD

Water mold is a group of different microorganisms. Microorganisms are tiny living things that can only be seen with a microscope.

Diet: Most water molds break down dead materials in the water. They decompose both dead plants and animals.

Habitat: Water mold can live in saltwater, freshwater, and moist soil.

COHO SALMON (*Oncorhynchus kisutch*)

Diet: Young coho eat zooplankton, insects, crustaceans, and fish. Spawning adults do not eat.

Predators: Fish, birds, and aquatic insects eat salmon eggs and young salmon. Bears, birds, and humans eat adult salmon.

Habitat: Newly hatched salmon live in gravel nests. Older salmon hide behind rocks and logs.

Other: Adults die after spawning. Their bodies provide food for many animals. When their bodies decompose, they release nutrients into the soil and fertilize plants and trees.

COMMON WATER MOSS (*Fontinalis antipyretica*)

Diet: Water moss makes its own food through photosynthesis.

Habitat: In fast flowing water, water moss attaches itself to rocks or logs. It can also be found floating in still water.

Other: This plant grows in large clumps. It provides shelter for fish eggs and fry. It also provides habitat for aquatic insects, larvae, and other microorganisms.

OREGON FLOATER (*Anodonta oregonensis*)

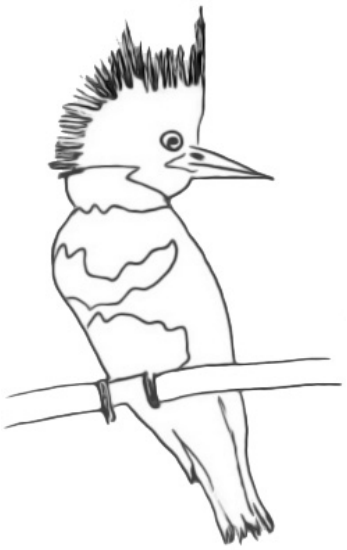
Diet: Freshwater mussels are filter feeders. They eat very small pieces of dead leaves. They also eat microorganisms like algae, bacteria, and zooplankton.

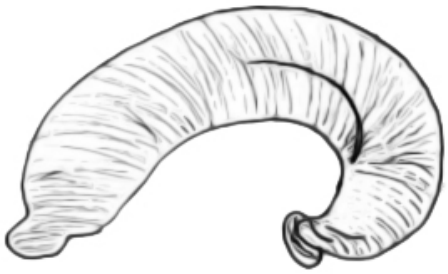
Predators: River otters, muskrats, raccoons, skunks, and waterbirds. Some fish may also eat young mussels.

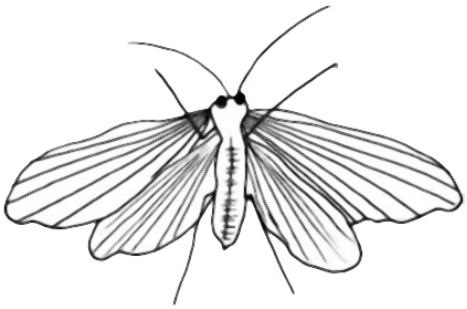
Habitat: Mussels bury themselves in their sediment.

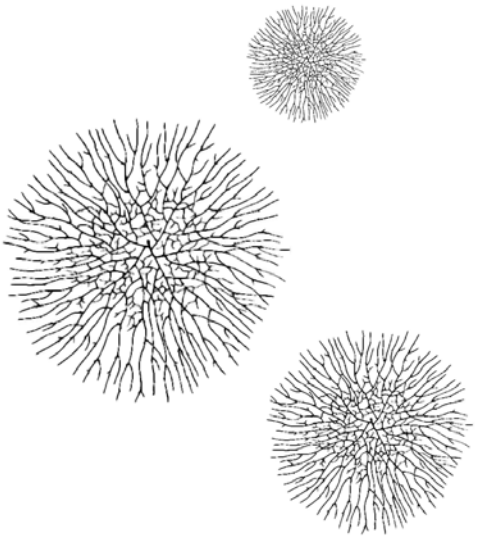
Other: Since mussels are filter feeders, they help keep the water clean.

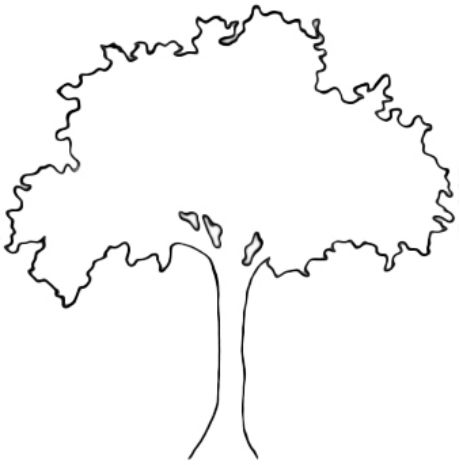
River

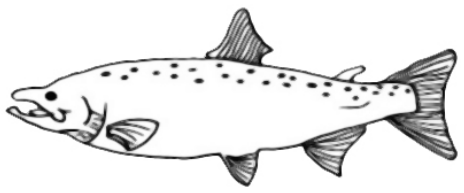












Wetland

A wetland is land that is saturated with water. The land can be saturated part of the year or all year. The water can be freshwater, brackish (a mixture of freshwater and saltwater), or saltwater.

Wetlands can be as small as a backyard pond or as large as the Florida Everglades. Swamps, marshes, and bogs are a few types of wetlands.

Wetlands are very important for the environment. They help purify water, control floods, and slow erosion. Wetlands are very biodiverse. This means that they are home to many different species of plants and animals.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: People eat clams, fish, and oysters from wetlands. Some indigenous cultures also eat harbor seals.

Other: Healthy wetlands support the economy. Forestry, fishing, and hunting support a lot of jobs. Recreation, such as birding and kayaking, also generate income for people.

AMERICAN WIGEON (*Anas americana*)

Diet: Wigeons mostly eat aquatic plants such as wild celery. They also eat aquatic insects such as damselflies and caddisflies.

Predators: Some predators include California gulls, American crows, striped skunks, red foxes, and American badgers.

Habitat: Wigeons create nests in the ground. The nests are lined with grasses and down (soft feathers). The nests are located in tall grass or shrubs.

BLUE DASHER (*Pachydiplax longipennis*)

Diet: Dragonflies are predators. They eat almost any insect they can catch. They are also known to eat small fish, freshwater shrimp, and tadpoles.

Predators: Birds, fishes, frogs, and water shrews will eat dashers.

Habitat: Blue dashers live near still, bodies of water. Dashers roost in trees at night.

DUNLIN (*Calidris alpina*)

Diet: This small bird eats insects, small crustaceans, snails, slugs, worms, and small fish.

Predators: Birds of prey such as harriers, falcons, merlins, kestrels, and owls will eat dunlins.

Habitat: Dunlins nest on dry islands of vegetation in wetlands.

Other: Strong populations of dunlins can indicate healthy wetlands.

GEODUCK CLAM (*Panopea generosa*)

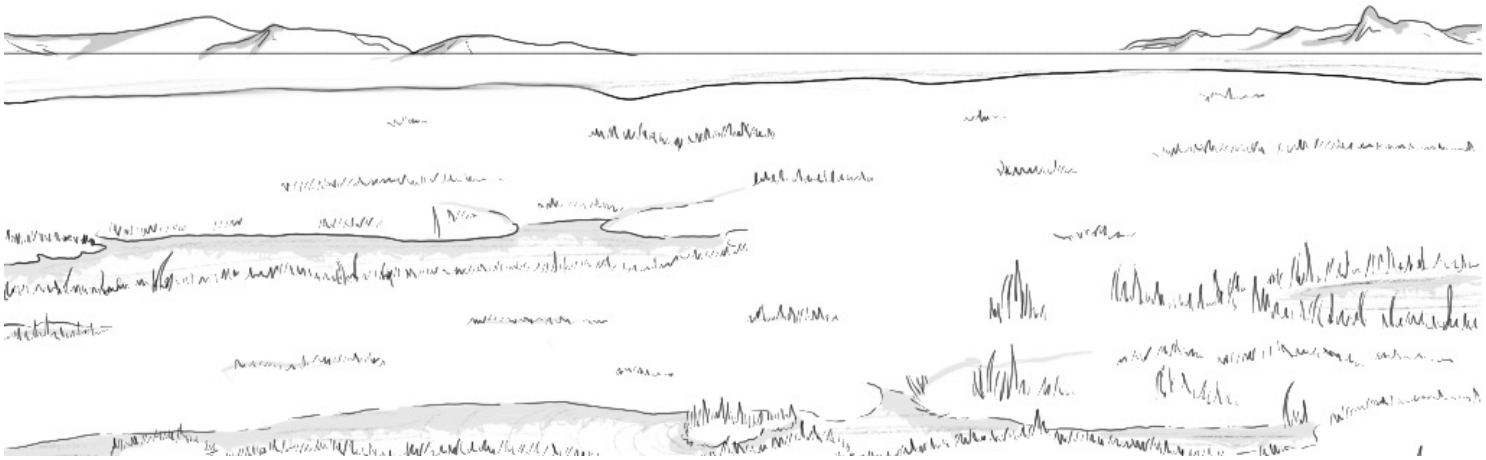
Diet: Geoducks are filter feeders. They stick their long necks (siphons) above ground to feed on phytoplankton.

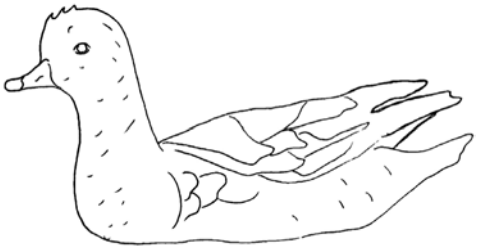
Predators: Humans and sea otters eat geoducks. Starfish will sometimes attack a geoduck when its siphon is above ground.

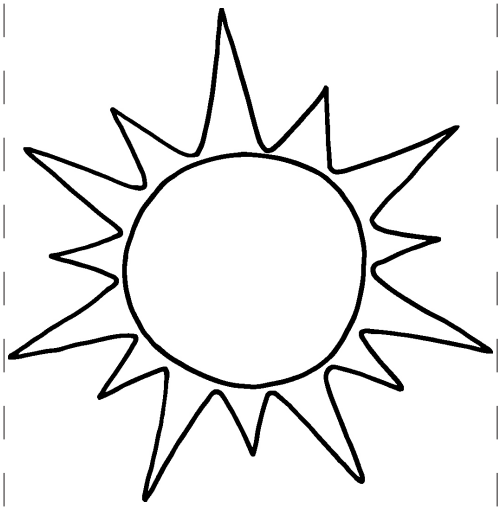
Habitat: Geoducks select a home about two feet deep in the sand. Once they pick a home, they do not move.

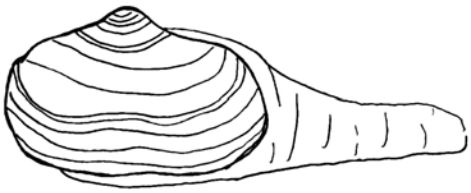
Other: Geoducks can live up to 168 years.

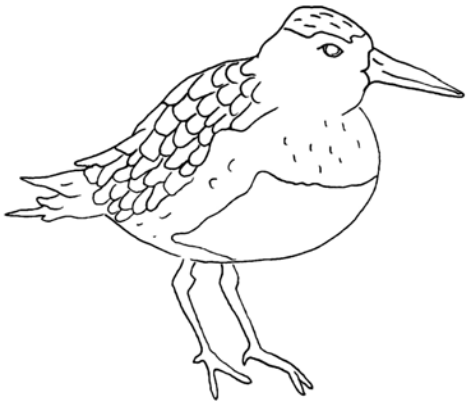
Wetlands

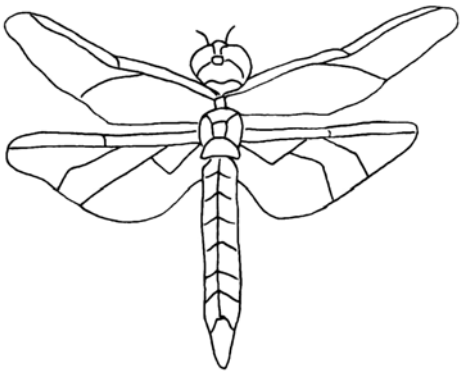












Wetland

GREEN HERON (*Butorides virescens*)

Diet: Green herons mainly eat fish. Sometimes they will eat frogs, insects, spiders, molluscs, and crustaceans.

Predators: Young birds are eaten by racoons. Adults are eaten by birds of prey, including eagles and falcons.

Habitat: Herons build nests in trees or bushes near water.

Other: Herons are one of the few animals to use tools. They commonly use bread crusts, insects, and spiders as fishing bait.

PACIFIC HARBOR SEAL(*Phoca vitulina*)

Diet: Fish such as cod, flatfish, and salmon. They also eat shrimp, crabs, mollusks and squid.

Predators: Sharks, killer whales, and humans hunt adults. Coyotes may eat pups.

Habitat: Pups spend much of their time resting on beaches while adults hunt for food. Adults sleep on land or in the water.

Other: Harbor seals are an important indicator species. The health of seal populations can tell us a lot about the health of predators and prey in the ecosystem.

OLYMPIA OYSTER (*Ostrea lurida*)

Diet: Olympia oysters filter the water and screen out phytoplankton.

Predators: Humans, birds, marine mammals, sea turtles, and some species of fish eat oysters.

Habitat: These oysters lie with their left valve on the substrate (gravel, sand, or old shells). They attach themselves to the substrate.

Other: One oyster can filter up to 30 gallons of water a day. This removes nitrogen and other pollutants from the water.

RIVER OTTER (*Lutra canadensis*)

Diet: River otters eat amphibians, turtles, fish, crayfish, and crabs.

Predators: While on land, they will occasionally be eaten by wolves or coyotes.

Habitat: They burrow under large tree roots, beneath rocky ledges, or under fallen trees. They often use old muskrat, beaver, or woodchuck burrows.

Other: River otters are a top predator. They help control the populations of small animals, which keeps the food web in balance.

OSPREY (*Pandion haliaetus*)

Diet: Fish make up 99% of an osprey's diet.

Predators: As adults, osprey are sometimes eaten by owls and eagles. Osprey eggs and chicks are eaten by raccoons and foxes.

Habitat: Ospreys nest on top of large trees not far from water. They often nest in trees with dead or broken tops. They also nest on human-made structures such as telephone poles.

Other: Osprey nests are used by smaller birds. Grackles, swallows, starlings, and sparrows build their nests inside osprey nests.

WILD CELERY (*Vallisneria americana*)

Diet: Wild celery makes its own food through photosynthesis.

Predators: All parts of the plant are eaten by wild ducks.

Habitat: It grows in fresh and slightly salty water.

Other: Wild celery provides shade and shelter for different species of fish.

PAINTED TURTLE (*Chrysemys picta*)

Diet: They commonly eat aquatic insects, fish, tadpoles, worms, dead animals, and water plants.

Predators: Garter snakes, ground squirrels, skunks, badgers, and foxes eat young turtles. Adults are eaten by raccoons.

Habitat: Painted turtles are found in freshwater ecosystems. Adults sun themselves on rocks and logs. Females dig nests in soft soil.

Other: The average temperature of the nest determines a turtles' sex. Warmer conditions produce more females.

PACIFIC GIANT SALAMANDER (*Dicamptodon tenebrosus*)

Diet: Small insects, fish, mice, shrews, snakes, and occasionally other amphibians.

Predators: Weasels, river otters, water shrews, garter snakes, and salmon.

Habitat: Juveniles live in water. Adults live in both water and on land in damp forests.

Other: Amphibians are environmental indicators. They are particularly sensitive to changes in water quality. They will not be found in areas with pollution.

RED FOX (*Vulpes vulpes*)

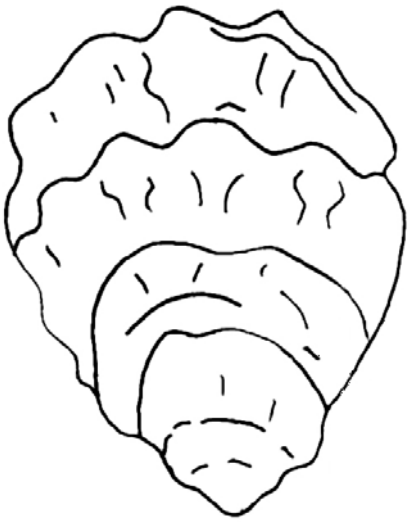
Diet: Foxes consume a variety of small animals, including rabbits, mice, birds, and insects. They will also eat a variety of berries and fruits.

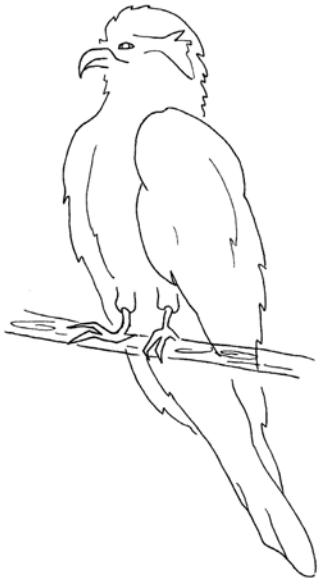
Predators: Humans, wolves, coyotes, bobcats, lynxes, and cougars will hunt foxes.

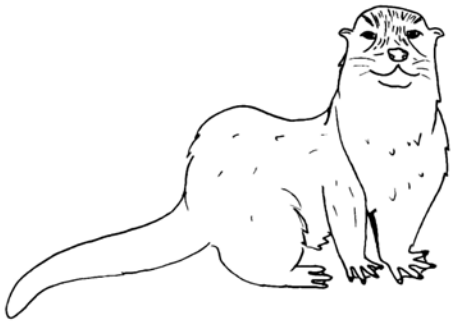
Habitat: In the winter, red foxes live in underground dens. The rest of the year, they rest in fields.

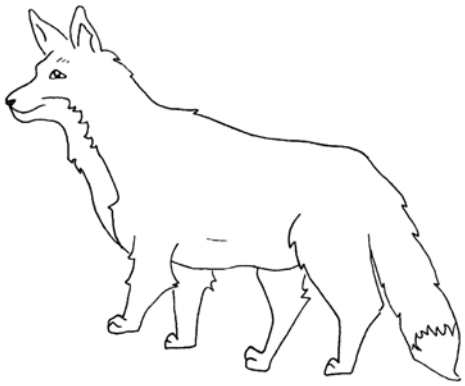
Other: Red foxes help control populations of prey animals, such as rodents and rabbits. They also help disperse seeds.

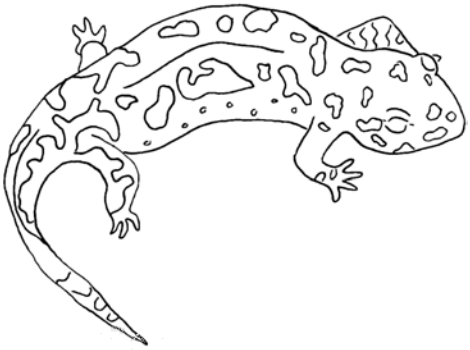
Wetland











Wetland

WATER SPIDER (*Argyroneta aquatica*)

Diet: Water spiders prey on aquatic insects.

Predators: Beetles, dragonfly larvae, frogs, and fish prey on water spiders.

Habitat: The water spider is the only spider that lives its life entirely underwater. It creates an underwater silk web.

Other: Water spiders need water plants to anchor their webs.

TAILED FROG (*Ascaphus truei*)

Diet: They eat aquatic and terrestrial insects. They also eat spiders and snails.

Predators: Garter snakes, shrews, Pacific giant salamanders, trout, and sculpins prey on tailed frogs.

Habitat: Tailed frogs are mostly aquatic. Adults may emerge during cool, wet conditions to hunt on land.

Other: Tailed frogs are an indicator species. Healthy populations of this species can mean a healthy ecosystem.

COHO SALMON (*Oncorhynchus kisutch*)

Diet: Young coho eat zooplankton, small fish, insects, crustaceans, and mollusks.

Predators: Ducks, seabirds, otters, mammals, seals, snakes, and larger fish prey on young coho.

Habitat: Juvenile coho salmon rely on forested wetlands. These calm waters protect salmon from currents.

Other: Adults die soon after spawning. Their decaying bodies fertilize rivers and streams. These nutrients enrich insects, fish, and other aquatic animals. They also provide nutrients for nearby plants and trees.

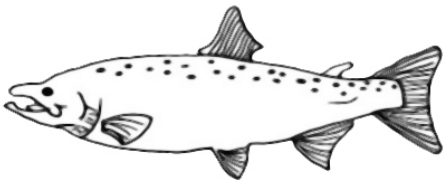
WATER MOLD

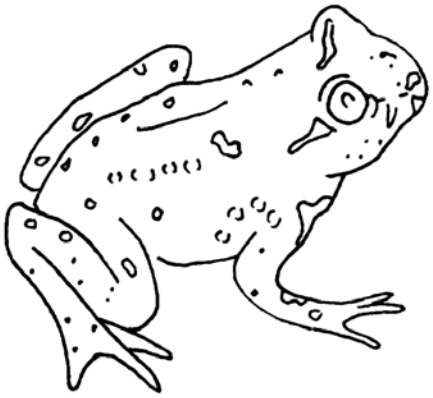
Water mold is a group of different microorganisms. Microorganisms are tiny living things that can only be seen with a microscope.

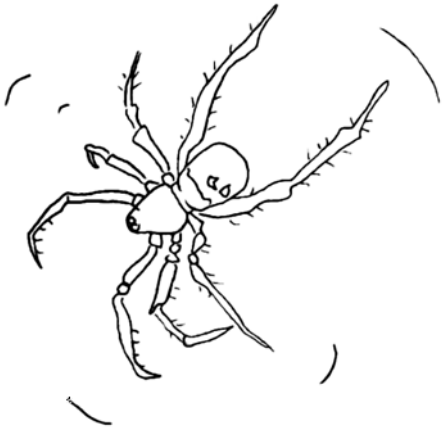
Diet: Most water molds break down dead materials in the water. They decompose both dead plants and animals.

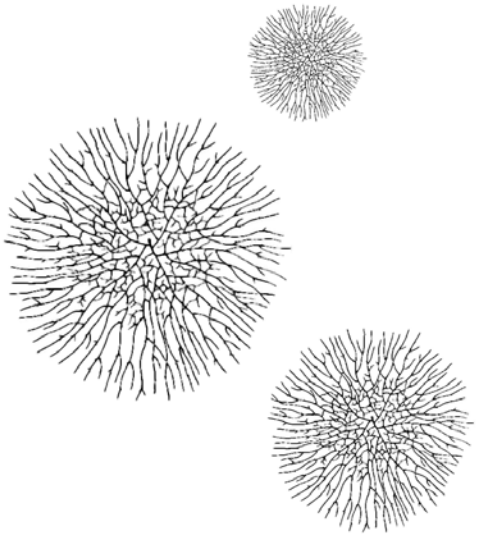
Habitat: Water mold can live in saltwater, freshwater, and moist soil.

Wetland









Estuary

Estuaries are bodies of water that sit between the land and the ocean. This ecosystem is created when freshwater rivers and streams meet and mix with the salt water. Estuaries are affected by the ocean's tides and waves. They are also affected by the flows of rivers and river sediment.

Estuaries receive a lot of nutrients from both seawater and freshwater. Estuaries are very productive ecosystems. This means that plants in the estuary produce a lot of vegetation. In turn, these plants support lots of animals.

Around the world, many people live near estuaries. About 60% of the world's population lives along estuaries and the coast. This means that estuaries are often affected by erosion, overfishing, pollution, and more.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: In this ecosystem, people eat coho salmon and littleneck clams. Some indigenous cultures also eat harbor seals.

Other: Estuaries are a big source of revenue (money). Seafood sales and recreation such as fishing, bird watching, and boating create a lot of jobs and money for the US economy.

COHO SALMON (*Oncorhynchus kisutch*)

Diet: Smolts eat zooplankton, small fish, insects, crustaceans, and mollusks.

Predators: Ducks, seabirds, otters, mammals, seals, snakes, and larger fish prey on smolts.

Habitat: Estuary plants, such as eelgrass and sedge, help salmon hide from predators.

Other: Adults die soon after spawning. Their decaying bodies fertilize rivers and streams. These nutrients enrich insects, fish, and other aquatic animals. They also provide nutrients for nearby plants and trees.

MUD SHRIMP (*Upogebia pugettensis*)

Diet: Mud shrimp are filter feeders. They filter detritus (waste and dead matter) and plankton out of the water.

Predators: Pacific staghorn sculpin eat mud shrimp. Mud shrimp are also used by people as fishing bait.

Habitat: These shrimp live in the intertidal zone. They make burrows in the mud or sand.

Other: Parasites have infected many mud shrimp populations. Some populations of have almost been wiped out from parasites.

GREEN DARNER (*Anax junius*)

Diet: Young darners eat tadpoles, small fish, and mosquito larvae. Adults eat butterflies, moths, flies, mosquitoes, and other dragonflies.

Predators: Freshwater fish, frogs, spiders, and birds will sometimes eat these dragonflies.

Habitat: Green darners can be found flying over water or far from it. At night, they rest in low grass and bushes near bodies water.

Other: There are several parasites that use green darners as hosts. The parasites are then spread to the predators of green darners.

LITTLENECK CLAM (*Leukoma staminea*)

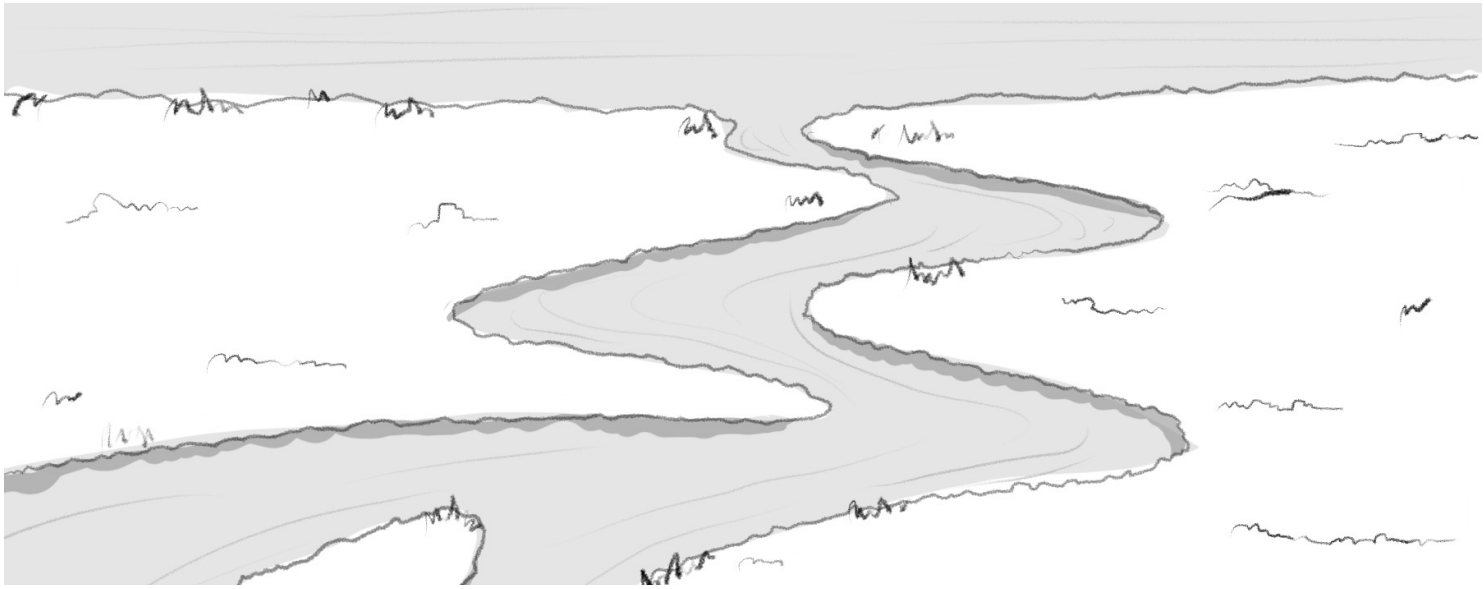
Diet: Clams are filter feeders. This species eats phytoplankton (microscopic algae or plants) and diatoms.

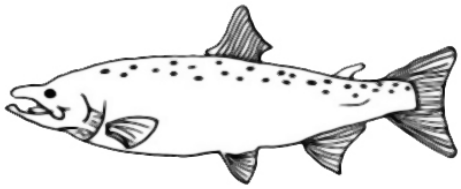
Predators: Littleneck clams are eaten by moon snails, octopus, sculpins, crabs, sea stars, and humans.

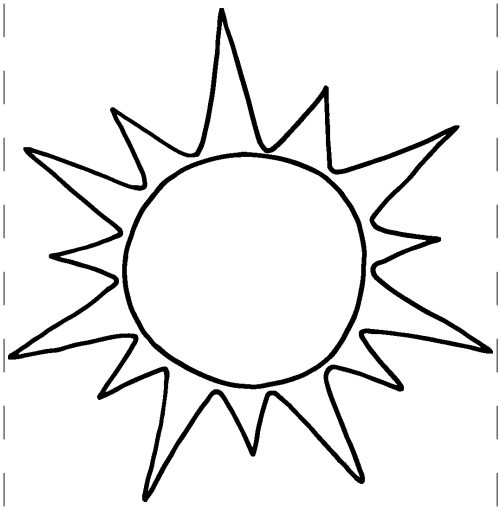
Habitat: They bury themselves in a mixture of sand, gravel, and mud in the tidal zone.

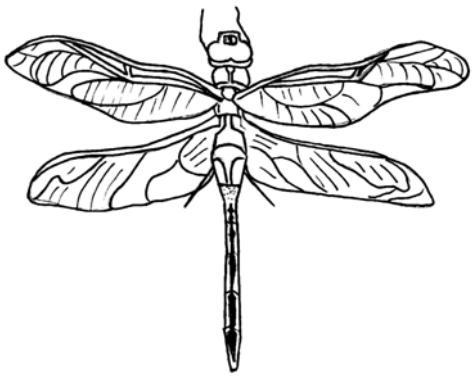
Other: A single littleneck clam can filter 4.5 gallons of seawater per day. This helps remove sediment and excess nutrients from the water.

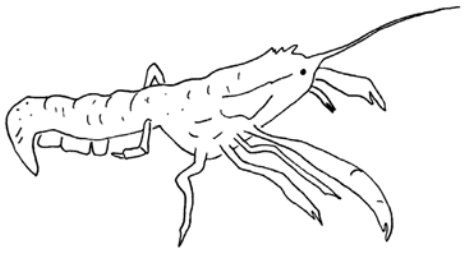
Estuary











Estuary

RACCOON (*Procyon lotor*)

Diet: Raccoons feed on nearly any available food. They often eat fruits, nuts, corn, fish, frogs, insects, bird eggs, rodents, and dead animals.

Predators: Hawks, owls, and humans are major predators. Snakes may eat young raccoons.

Habitat: Raccoons create dens in hollow trees, logs, or crevices.

Other: Raccoons are strong swimmers. However, they do not swim farther than they need because their fur is not waterproof.

ZOOPLANKTON

Zooplankton are tiny, free-floating animals such as jellyfish, krill, snails, slugs, and worms. Thousands of different species are part of the zooplankton community.

Diet: Zooplankton eat phytoplankton or zooplankton. Phytoplankton are algae that live near the surface of the water.

Predators: Fish, salamanders, and aquatic insects are common predators in estuaries.

Habitat: Zooplankton can be found in the oceans, seas, rivers and ponds. They are usually located near the surface of the water.

FIDDLER CRAB (*Uca pugnax*)

Diet: Fiddler crabs are scavengers. They mostly feed on dead animals they find in the sand.

Predators: Herons, egrets, and raccoons eat fiddler crabs.

Habitat: They make dens on sandy or muddy beaches.

Other: Fiddler crabs help keep beaches clean by eating dead plants and animals.

GREAT EGRET (*Ardea alba*)

Diet: Egrets mostly eat fish. They will also eat amphibians, small mammals, and invertebrates, including aquatic insects.

Predators: Their eggs and young are preyed upon by raccoons, vultures, and crows. Adults do not have predators.

Habitat: They nest in trees near wetlands, tidal flats, streams, and ponds. Egrets nest very close together, with up to 50 nesting in the same tree.

Other: They will only breed when there is enough water nearby.

PACIFIC SWAMPFIRE (*Sarcocornia pacifica*)

Diet: Pacific swampfire makes its own food through photosynthesis.

Predators: This plant is eaten by people, mice, and voles.

Habitat: Pacific swampfire likes to grow with other Pacific swampfire. They form fields in the low zone of the estuary.

Other: This plant absorbs salty water. The salt is pushed into the tips of the plant. The tips turn red when there is a buildup of salts. Eventually this part of the plant will dry up and break off.

MARINE FUNGI

Some fungi can live in saltwater. These fungi are known as marine fungi. Scientists estimate that there are more than 1,500 species of marine fungi.[12]

Fungi play a very important role in marine ecosystems. Some species decompose dead animals. Others decompose plants. Some can even decompose wood or breakdown oil.

HARBOR SEAL (*Phoca vitulina*)

Diet: Harbor seals eat squid, octopus, and many species of fish.

Predators: Transient killer whales, sharks, stellar sea lions, and some people eat adult and young seals. Bald eagles, dogs, and coyotes hunt pups.

Habitat: They are often found on rocks, beaches, and mudflats. Pups rest on the beach while their mothers hunt in the water.

Other: Harbor seals sometimes steal fish from fishers. Sometimes they can become entangled in fishing nets.

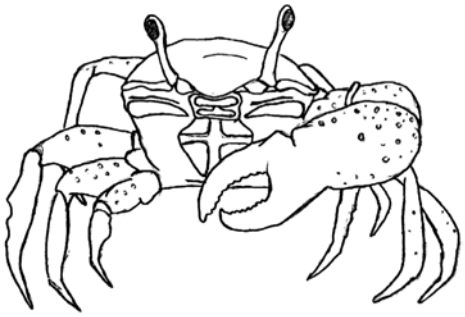
PACIFIC STAGHORN SCULPIN (*Leptocottus armatus*)

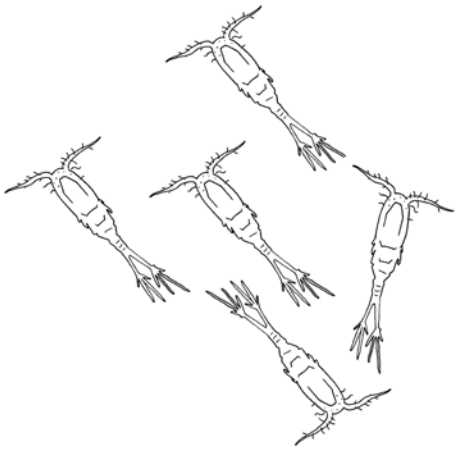
Diet: This fish typically eats small shrimps, crabs, and fish. It will also eat clams and frogs.

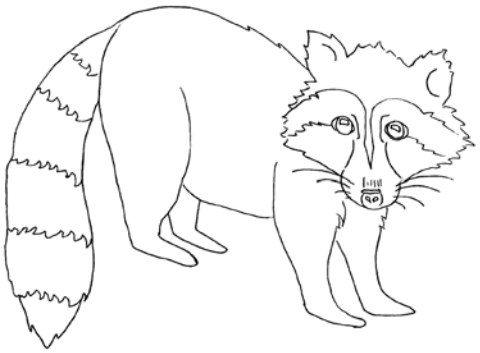
Predators: Herons, cormorants, kingfishers, sea lions, seals, striped bass, sharks, and humans eat this species.

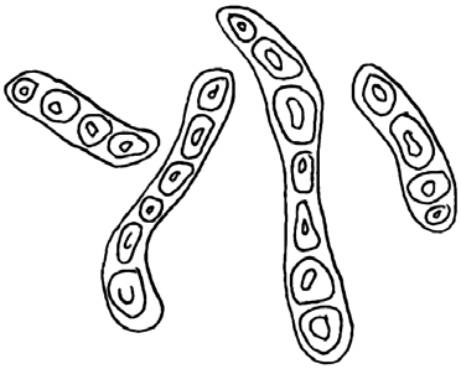
Habitat: Sculpins typically live near the shore in bays and estuaries. They prefer sandy bottoms.

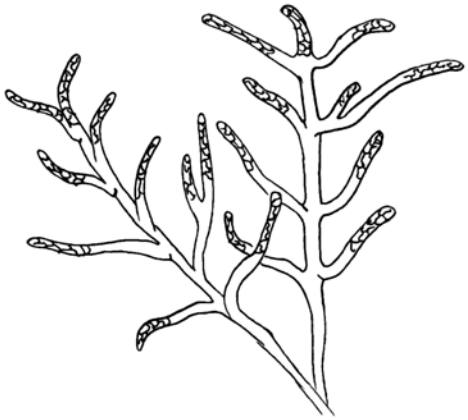
Estuary

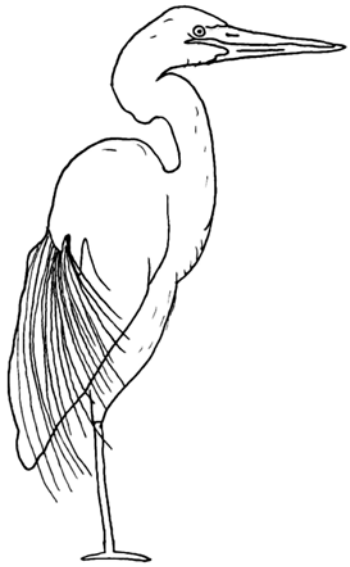


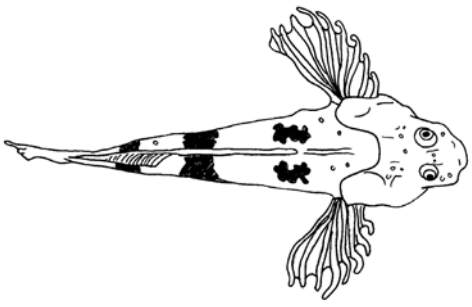












Kelp Forest

Kelp forests are underwater ecosystems. Like a forest of trees, giant kelp grow in large numbers together. Kelp forests grow faster than bamboo forests. One piece of giant kelp can grow 10-12 inches per day, and can grow up to 175 feet tall!

Kelp forests have layers like rainforests. They have a canopy on top and several layers below. Like forests on land, kelp forests provide shelter and habitat for many different animals. Kelp forests are home to fish, sea snails, worms, crabs, sea urchins, sea stars, sponges, and more. These forests provide spawning grounds for many small species of fish. Kelp also provides shelter from big waves, helping small larval fish survive.

Destructive fishing practices, pollution, and damage from boats negatively affect kelp forests.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: People eat lobsters, urchins, fish, abalone, and eels from kelp forests. Kelp is also harvested for different products.

Other: People kayak, snorkel, and scuba dive in kelp forests. These activities support recreation and tourism in local economies.

GIANT KELP (*Enhydra lutris*)

Diet: This algae makes its own food through photosynthesis.

Predators: Sea otters, urchins, and some fish eat kelp. People also harvest kelp for ice cream, toothpaste, cereals, and makeup.

Habitat: Kelp grows in shallow saltwater. It grows best in cold water with plenty of nutrients.

Other: A single kelp plant may have more than 10,000 individual snails, crabs, and other invertebrates living on it. Hundreds of fish swimming around kelp, in search of tiny prey.

CALIFORNIA SPINY LOBSTER (*Panulirus interruptus*)

Diet: These lobsters eat worms, urchins, snails, sand dollars, shellfish, and decaying matter.

Predators: Octopus, fish, rockfish, bass, humans eat spiny lobsters.

Habitat: They prefers waters with rocky shorelines. They live in holes and crevices during the day. At night, they venture out to hunt.

Other: These lobsters act as hosts. Sponges, barnacles, and other small animals live on their shells.

RED ROCK SHRIMP (*Lysmata californica*)

Diet: These shrimp are scavengers. They feed on scraps of dead animals. They also eat parasites that live on other animals.

Predators: People use these shrimp as fishing bait. Some fish and eels also prey on the shrimp.

Habitat: They live in the Eastern Pacific Ocean along rocky bottoms.

Other: Shrimp cluster in groups on the bottom of the kelp forest. They provide cleaning stations for other species such as garibaldi, moray eels, and spiny lobsters.

NORRIS' TOP SNAIL (*Norrisia norrisi*)

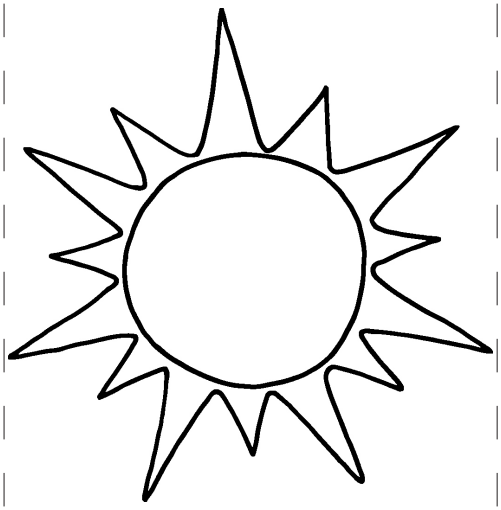
Diet: These snails prefer to eat kelp, and will also eat other types of algae.

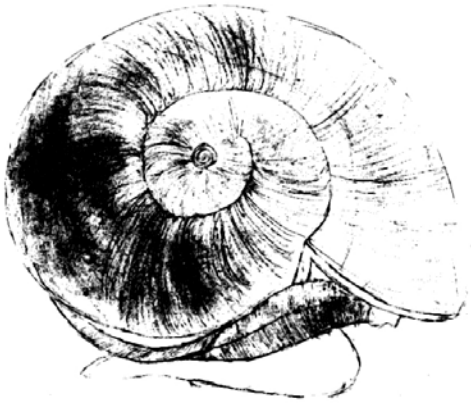
Predators: Sea stars, otters, starfish, moon snails, and the California spiny lobster hunt this species.

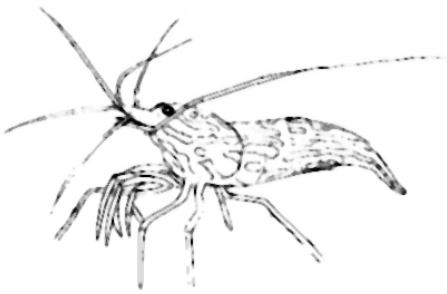
Habitat: These snails live in kelp forests. They migrate up the kelp at night, and down the kelp during the day.

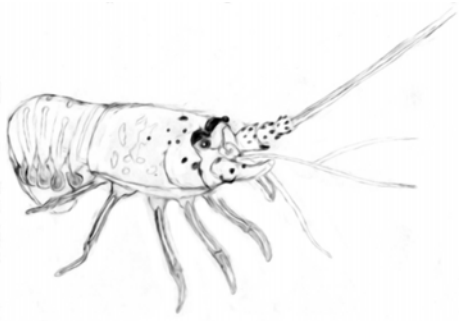
Other: Hermit crabs use empty Norris' top snail shells.

Kelp Forest









Kelp Forest

BAT STAR (*Asterina miniata*)

Diet: These stars prey on other sea stars, algae, and tunicate worms. They will also eat dead plants and animals.

Predators: Other sea stars, mollusks, and crustaceans eat bat stars.

Habitat: Bat Stars live on rocks, sandy bottoms, and surf grass. They can often be found in crevices and under rocks.

Other: It feeds by extending its stomach over its prey.

RED SEA URCHIN (*Mesocentrotus franciscanus*)

Diet: These urchins eat a lot of kelp. They also scrape seaweed and algae off the seafloor.

Predators: Crabs, large fish, sea otters, eels, birds, and humans eat these urchins.

Habitat: They prefer rocky, protected areas of the ocean. They are usually found in shallow water, but occasionally can be found 100 metres (328 feet) deep.

Other: Red sea urchins can form groups in kelp forests. These groups can eat too much kelp and damage the kelp forest.

GREEN ABALONE (*Haliotis fulgens*)

Diet: Green abalone feed on seaweed and algae including kelp.

Predators: People, seals, sea lions, sea otters, fish, octopus, and sea stars are predators of green abalone.

Habitat: The green abalone lives in shallow water. It is usually found in rock crevices.

Other: Red sea urchins protect young abalone from predators. When abalone are adults, they compete with urchins for food and habitat.

KELP ROCKFISH (*Sebastes atrovirens*)

Diet: They will eat crustaceans, such as shrimp and amphipods. Kelp rockfish will also eat small fish, particularly juvenile blue rockfish.

Predators: The juveniles are eaten by birds, pinnipeds, porpoises, and larger fish. Adults are eaten by sharks, dolphins, seals, and people.

Habitat: Kelp rockfish live in kelp beds and on rocky reefs.

CALIFORNIA MORAY EEL (*Gymnothorax mordax*)

Diet: They prey on crabs, lobsters, sea urchins, shrimp, reef fish, and octopuses.

Predators: Barracudas, sea snakes, humans, and groupers eat this species.

Habitat: They live in crevices in rocks. At night, they feed on reefs.

Other: These eels often live in the same crevice as red rock shrimp. The shrimp rid the moray of dead skin and parasites. The eel provides the shrimp with protection from predators.

GREEN SEA ANEMONE (*Anthopleura xanthogrammica*)

Diet: These anemones eat mussels, crabs, sea urchins, and small fishes.

Predators: Sea spiders, sea stars, and nudibranchs eat this anemone.

Habitat: They typically attach to substrate, mussel beds, and human-made structures. They prefer locations with cold water and lots of waves.

Other: This species has a symbiotic relationship with zoxanthellae. This is a type of algae that lives inside the anemone.

KELP CRAB (*Pugettia producta*)

Diet: These crabs eat kelp, sea cabbage, and rockweed. If algae is scarce, they will eat barnacles, mussels, hydroids, and bryozoans.

Predators: Sea otters, seagulls, octopus, and some fish will prey on these crabs.

Habitat: They are usually found in dense kelp beds. They also live in tide pools that are covered in surfgrass or algae.

Other: They are almost the same color as the kelp they eat and hide in.

SEA OTTER (*Enhydra lutris*)

Diet: Sea otters eat clams, mussels, urchins, crabs, sea stars, squid, octopus, and fish.

Predators: Sharks, killer whales, sea lions, and humans eat sea otters. Eagles and coyotes will prey on otter pups.

Habitat: They spend most of their active time foraging in giant kelp forests. They eat, rest, and groom themselves at the water's surface.

Other: Sea otters prey on sea urchins This prevents sea urchins from overgrazing the kelp forest. This allows the kelp forest to thrive.

HARBOR SEAL (*Phoca vitulina*)

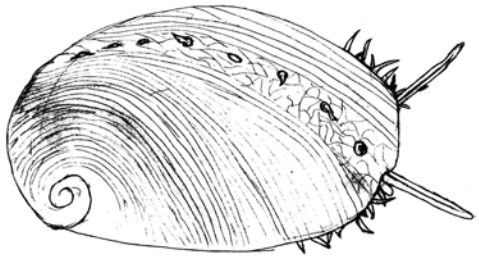
Diet: They mostly eat fish. Harbor seals will also eat octopus, squid, crabs, and shrimp.

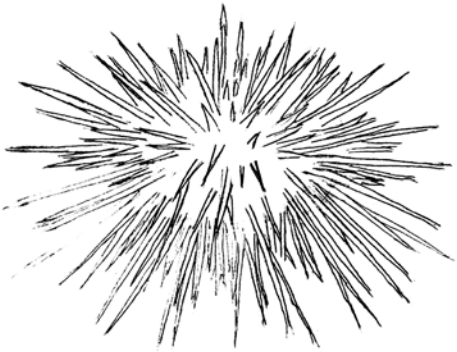
Predators: People, sharks, and killer whales will eat adults. Bald eagles, dogs, and coyotes will hunt pups.

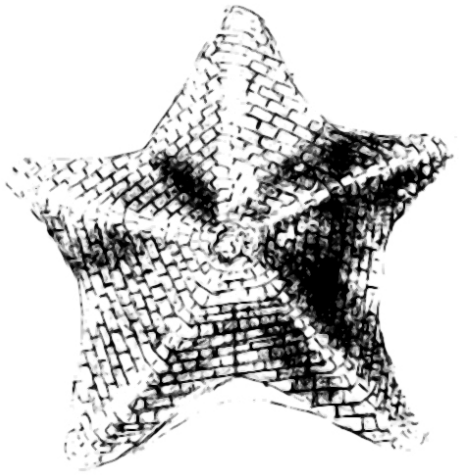
Habitat: Harbor seals live near shallow waters. They are typically seen near piers and beaches, as well as on intercoastal islands.

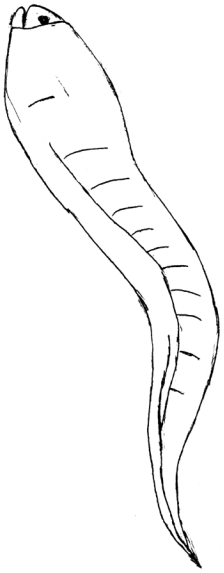
Other: People visit beaches to watch seals. Seals are a source of tourism for some communities.

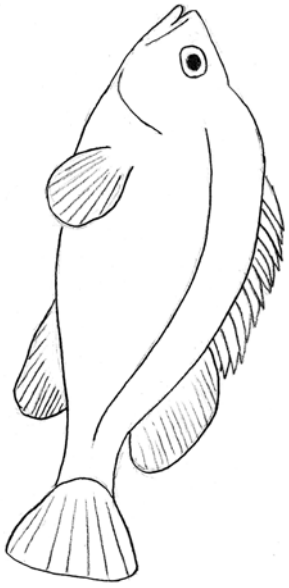
Kelp Forest

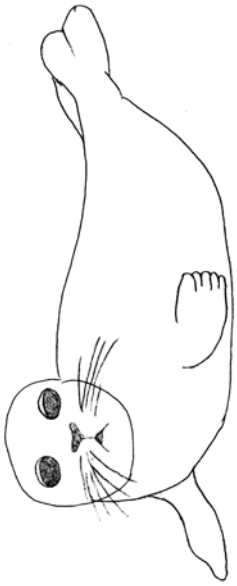












Kelp Forest

MARINE BACTERIA

Bacteria are a type of microbe. They are so small that they can only be seen with a microscope

Diet: These bacteria break down dead organisms as big as whales or as small as other microbes. This makes nutrients available to other organisms.

Habitat: In the ocean, bacteria are found at the surface and all the way to the floor. Some can even live inside underwater volcanoes.

Other: Some elements are rare but important in the ocean. Bacteria help recycle these rare elements.

CRUSTOSE CORALLINE ALGAE (*Calliarthron SPP.*)

Diet: They make their own food through photosynthesis, and pull elements from saltwater.

Predators: Chiton, some fish, abalone, and other sea snails will eat this algae.

Habitat: They live on coral, shells, under ledges, and on rocks where light is limited.

Other: This algae grow very slowly and can become covered in seaweed. Fish eat seaweed from the surface of the algae, and prevent it from smothering the algae.

COHO SALMON (*Oncorhynchus kisutch*)

Diet: While they live in the ocean, coho eat smaller fish, squid, and crustaceans.

Predators: Larger fish, birds, seals, sea lions, whales, and people will eat coho.

Habitat: Some fish migrate a short distance from the coast. Others fish migrate long distances.

Other: After spending 2-3 years in the ocean, salmon return to their home stream. They find their home stream using their sense of smell. Pollution in the water can reduce their sense of smell.

WESTERN GULL (*Larus occidentalis*)

Diet: At sea, they eat fish, krill, squid, jellies, and garbage. Sometimes they eat eggs and young birds. They will even steal fish from other birds and milk from sleeping seals.

Predators: Foxes, weasels, sharks, and predatory birds, such as hawk and falcons will prey on them.

Habitat: They use estuaries, beaches, fields, garbage dumps, and city waterfronts. Their nests are on rocky, sandy, or gravel islands or cliffs.

Other: Gulls are also scavengers. They help clean up carcasses on beaches.

PACIFIC HERRING (*Clupea pallasii*)

Diet: Young fish eat phytoplankton. Older fish eat zooplankton, small fish, and fish larvae.

Predators: Herring is a major food source for salmon, seabirds, seals, and other marine mammals. Humans, black bears, song birds, wolves, and small mammals will also eat them.

Habitat: Eggs and young herring live in eelgrass beds or kelp forests. Adults form schools and live along the shoreline or in shallow bays.

Other: Herring can make up more than half of the diet of Chinook and coho salmon.[13]

GARIBALDI (*Hypsypops rubicundus*)

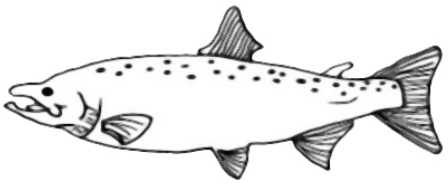
Diet: These fish eat shrimp, anemones, sponges, worms, nudibranchs, and bryozoans.

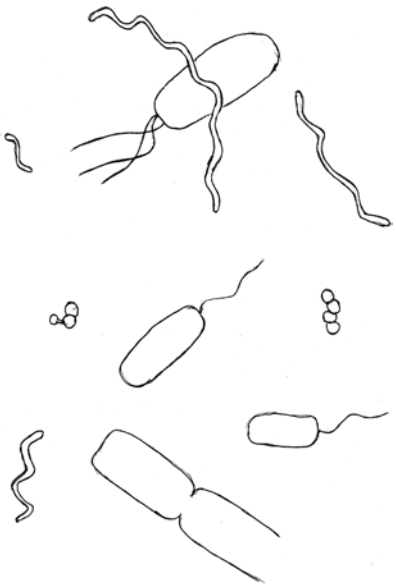
Predators: Seals, sea lions, and brown pelicans prey on garibaldi.

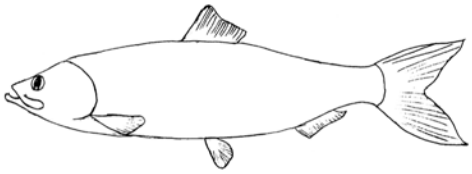
Habitat: Garibaldi live in rocky reefs and kelp forest in shallow water.

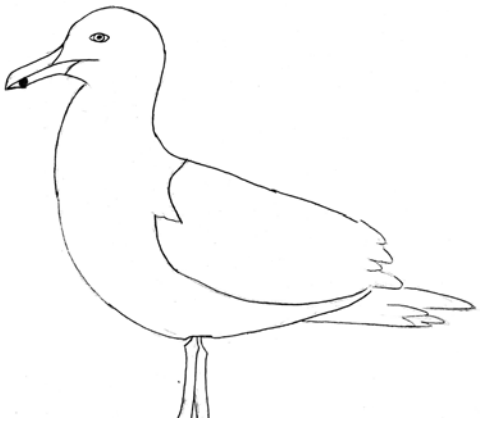
Other: They are known for their aggressiveness. Males are particularly territorial. They will even fight off bigger predators.

Kelp Forest









Eelgrass Meadow

Eelgrass is not a seaweed. It is a blooming underwater grass. Eelgrasses spread out and form meadows. These meadows build up in the spring and summer. They decay in the fall and winter. Eelgrass grows up to three feet tall.

Eelgrass meadows are very important ecosystems. They provide food and habitat for many different species. They also slow waves and currents, which slows erosion. These meadows also help keep animals cool during low tides. They even filter pollution out of the water. They also store carbon, a major cause of climate change.

Seagrass meadows are some of the most endangered ecosystems. In the US, 90% of eelgrass beds have been destroyed.[14] The remaining eelgrass meadows can be damaged by boats, invasive species, clamming, climate change, and pollution.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: People eat squid, herring, salmon, crab, and mussels from eelgrass meadows. People also harvest eelgrass for paper, insulation, roofing, and more.

Other: People kayak, snorkel, and scuba dive in eelgrass meadows. These activities support recreation and tourism in local economies.

GREEN SEA TURTLE (*Chelonia mydas*)

Diet: They eat eelgrass, algae, moss, seaweed, sea lettuce, and other aquatic plants.

Predators: Young turtles are eaten by jaguars, red foxes, feral dogs, crabs, crocodiles, and people. Juveniles and adults are eaten by sharks.

Habitat: They forage in coastal areas that have lots of algae and sea grass, and nest on beaches with slopes.

Other: Many countries have laws to protect sea turtles. But sea turtles are still poached for their eggs, meat, and shells.

SILVERSPOTTED SCULPIN (*Blepsias cirrhosus*)

Diet: These fish eat crabs, amphipods, worms, and small fish.

Predators: Larger fish, herons, otters, and raccoons eat these sculpins.

Habitat: The silverspotted sculpin lives in eelgrass beds.

Other: Silverspotted Sculpin eggs can take more than 250 days to hatch. Females lay their eggs inside sponges. Since sponges do not have many predators, the eggs are pretty safe.

CALIFORNIA SEA LION (*Zalophus californianus*)

Diet: Sea lions love eating fish. They will also eat squid, octopus, cuttlefish, and nautiluses.

Predators: Great white sharks, bull sharks, and killer whales prey on California sea lions.

Habitat: They live along coastlines and are often found on human-made structures such as jetties, piers, buoys and oil platforms.

Other: Trained California sea lions are used by the US Navy. They help during search and rescue missions. They are also used to detect underwater mines and intruders.

MARKET SQUID (*Loligo opalescens*)

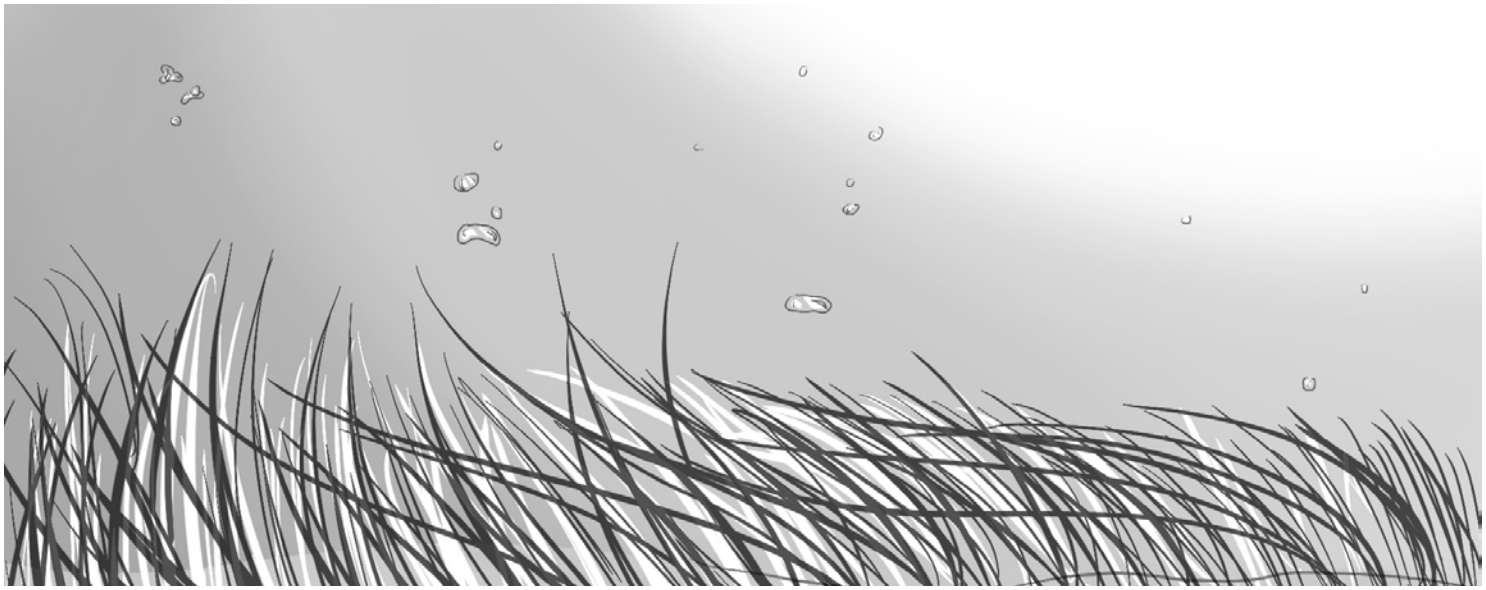
Diet: They eat crustaceans, other squid, sardines, herring, mackerel, and anchovies.

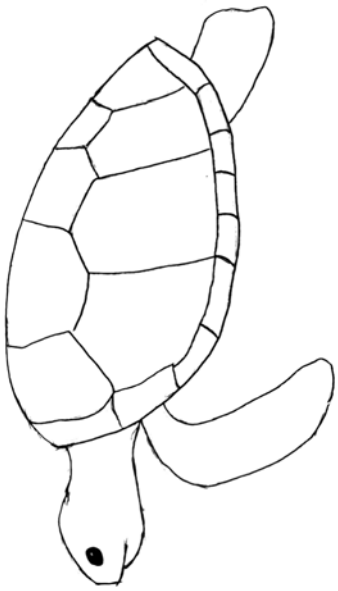
Predators: People, toothed whales, porpoises, sea lions, harbor seals, Chinook salmon, coho salmon, and many birds eat market squid.

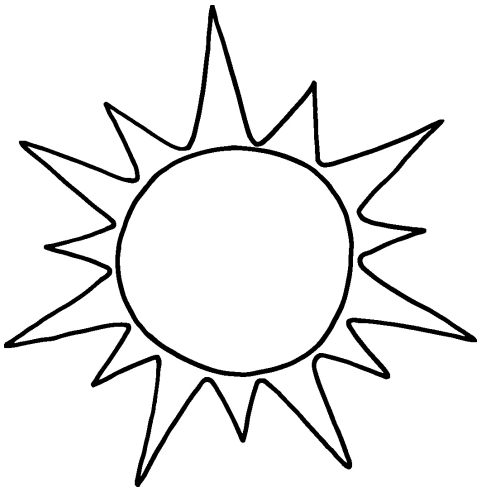
Habitat: These squid are found in the eastern Pacific Ocean. They usually stay near the coast.

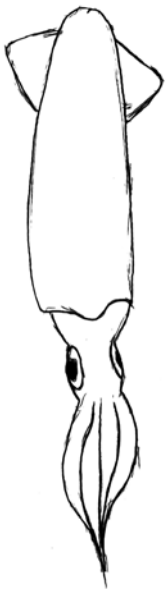
Other: Most people know them as calamari. More than $100 million worth of squid are caught in the US every year.[15]

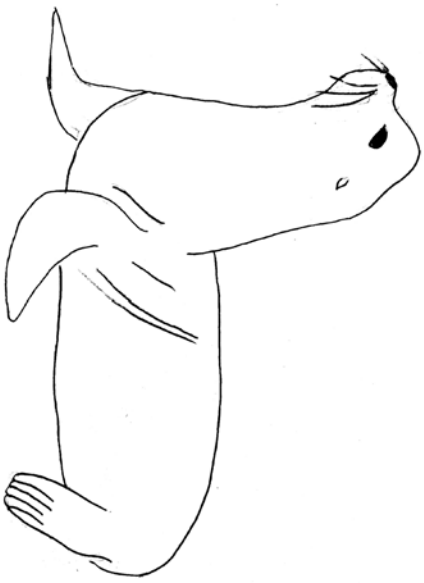
Eelgrass Meadow

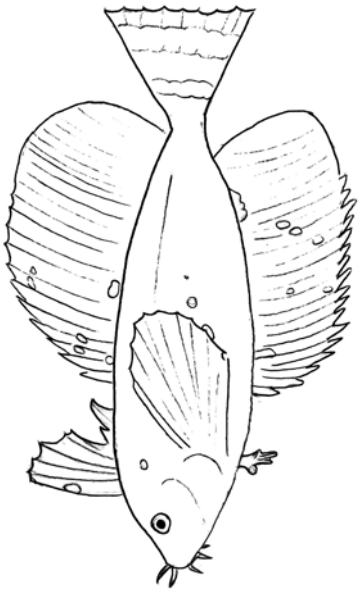












Eelgrass Meadow

PACIFIC HERRING (*Clupea pallasii*)

Diet: Young fish eat phytoplankton. Older fish eat zooplankton, small fish, and fish larvae.

Predators: Herring is a major food source for salmon, seabirds, seals, and other marine mammals. Humans, black bears, song birds, wolves, and small mammals will also eat them.

Habitat: Eggs and young herring live in eelgrass beds or kelp forests. Adults form schools and live along the shoreline or in shallow bays.

Other: Herring can make up more than half of the diet of Chinook and coho salmon.[16]

COHO SALMON (*Oncorhynchus kisutch*)

Diet: While they live in the ocean, coho eat smaller fishes, squid, and crustaceans.

Predators: Larger fishes, birds, seals, sea lions, whales, and people will eat coho.

Habitat: Some fish migrate a short distance from the coast. Others fish migrate long distances.

Other: After spending 2-3 years in the ocean, salmon return to their home stream. They find their home stream using their sense of smell. Pollution in the water can reduce their sense of smell.

COMMON EELGRASS (*Zostera marina*)

Diet: These plants make their own food using photosynthesis.

Predators: Green turtles, manatees, and birds eat eelgrass.

Habitat: It grows in shallow waters, along both coasts of North America.

Other: Seagrasses are known as the "lungs of the sea" because they generate so much oxygen. Eelgrass also helps protect crab, shorebirds, and young fish from predators. Snails and crustaceans eat algae off of eelgrass leaves, keeping the eelgrass clean.

OPALESCENT NUDIBRANCH (*Hermissenda crassicornis*)

Diet: This species eats hydroids, sponges, corals, other nudibranchs, barnacles, and anemones.

Predators: Nudibranchs are poisonous and are brightly colored. Most animals avoid eating them, except other nudibranchs and some fish.

Habitat: They can be found around tidepools, pier pilings, mudflats, and eelgrass beds.

Other: They lay their eggs on algae and eelgrass.

HELMET CRAB (*Telmessus cheiragonus*)

Diet: These crabs eat eelgrass. They also scavenge for dead invertebrates and fish. Sometimes they will attack and eat other crabs.

Predators: Seabirds, sea otters, fishes, and octopuses will eat helmet crabs.

Habitat: Helmet crabs live on rocky or sandy bottoms. They often live in or near eelgrass beds or kelp forests.

BAY PIPEFISH (*Syngnathus leptorhynchus*)

Diet: Pipefish eat small crustaceans, small fish, and zooplankton.

Predators: Pipefish have few predators since they imitate blades of eelgrass. Large fishes, otters, and crabs will sometimes eat them.

Habitat: These fish are common in eelgrass beds, bays, and estuaries.

Other: Because this species depends on eelgrass habitats, it can be used as an indicator species. Healthy pipefish populations usually indicates healthy eelgrass habitats.

MARINE BACTERIA

Bacteria are tiny microbes that can only be seen with a microscope.

Diet: Some bacteria are decomposers. They break down dead organisms as big as whales or as small as other microbes.

Habitat: In the ocean, bacteria are found at the surface and all the way to the ocean floor. Some can even live inside underwater volcanoes.

Other: Some elements are rare but important in the ocean. Bacteria help recycle these rare elements.

EELGRASS SEA SLUG (*Phyllaplysia taylori*)

Diet: This species feeds on algae, sponges, diatoms, and other small organism that live on eelgrass blades.

Predators: Sunfish and some sea stars prey on these slugs.

Habitat: They live among eelgrass meadows, and range from British Columbia to Southern California.

Other: This slug is only found on eelgrass.

DUNGENESS CRAB (*Cancer magister*)

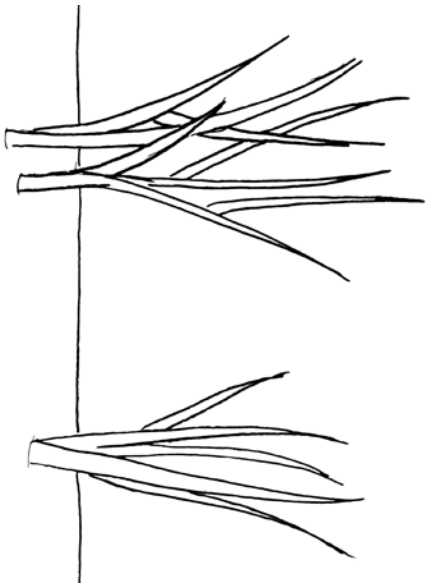
Diet: Juveniles feed on fish, shrimp, molluscs, and crustaceans. Adults feed on bivalves, crustaceans, and fishes.

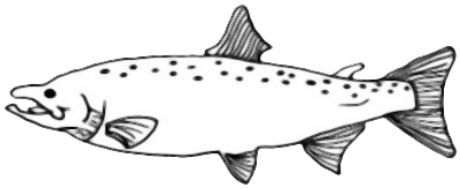
Predators: Rockfishes, coho salmon, and Chinook salmon eat larvae. Seals, fishes, and octopuses prey on adults.

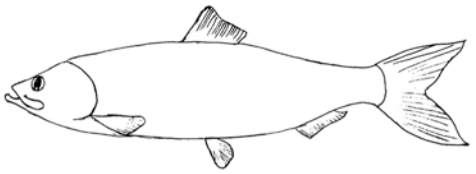
Habitat: Dungeness crabs are found on the Pacific coast where eelgrass is plentiful.

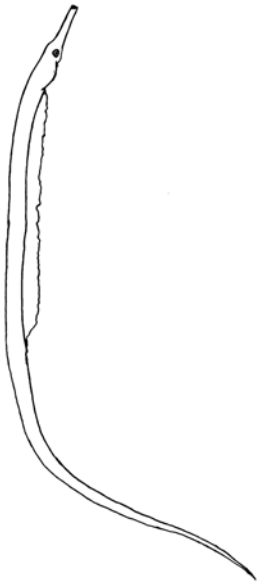
Other: Dungeness crabs are economically important. In the US, the Dungeness fishery is worth tens of millions of dollars.

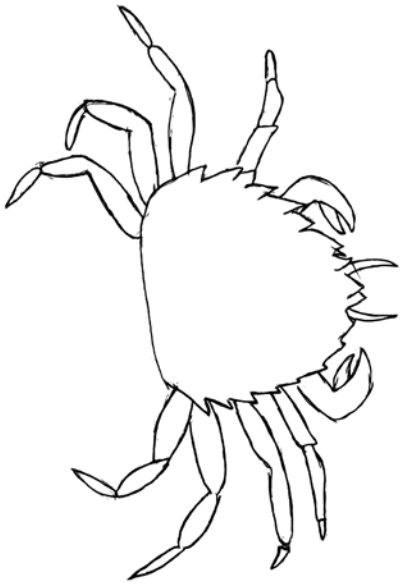
Eelgrass Meadow

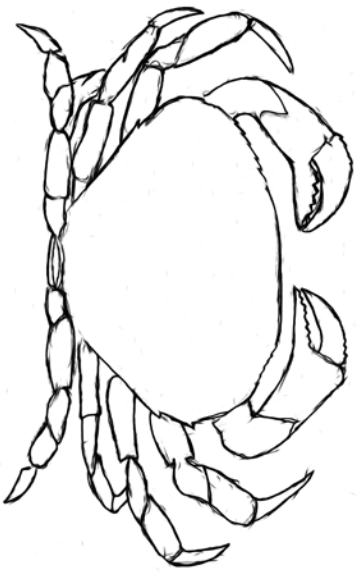


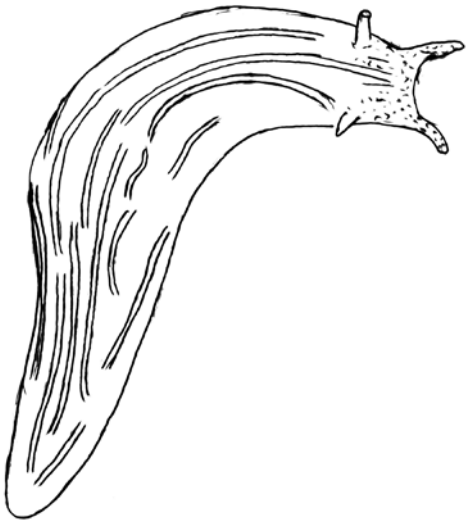


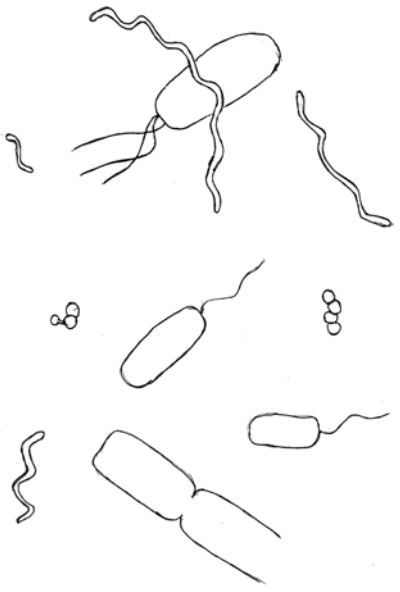












Eelgrass Meadow

SEA OTTER (*Enhydra lutris*)

Diet: Sea otters eat clams, mussels, urchins, crabs, sea stars, squid, octopus, and fish.

Predators: Sharks, killer whales, sea lions, and humans eat adults. Eagles and coyotes eat pups.

Habitat: Sea otters live in giant kelp forests. They spend most of their active time foraging below the canopy. They eat, rest, and groom themselves at the water's surface.

Other: Sea otters eat many crabs. With fewer crabs, sea slugs are more likely to survive. Sea slugs feed on the algae that grows on eelgrass. This helps keep eelgrass healthy.

CRESCENT GUNNEL (*Pholis laeta*)

Diet: This eel-like fish eats crustaceans, algae, marine worms, and mollusks.

Predators: They are preyed upon by seabirds, river otters, mink, and other fishes.

Habitat: The crescent gunnel seeks shelter in eelgrass beds, under rocks, and in algae.

Other: Gunnels spent the summer in eelgrass beds. In the winter, when eelgrass dies back, gunnels move offshore.

PACIFIC SEAHORSE (*Hippocampus ingens*)

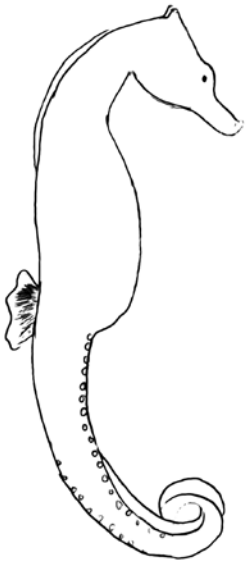
Diet: This species eats phytoplankton, crustaceans, and brine shrimp.

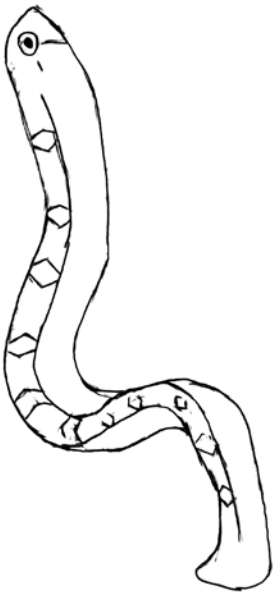
Predators: Pacific seahorses do not have many predators since they are camouflaged. Tuna, urchins, anglerfish, skates, people, and rays will hunt them.

Habitat: They can be found among eelgrass meadows where they wait for prey.

Other: Many seahorse species are fished. They are dried and used in traditional Chinese medicine. Some populations have declined because of overfishing.

Eelgrass Meadow





Open Ocean (epipelagic zone)

The open ocean is what exists beyond the coastal areas. The open ocean contains the largest ecosystem on Earth. It is so large that it is divided into four zones. Each zone has unique communities of organisms.

The epipelagic zone is the top layer of the ocean. It stretches down from the surface to about 200 meters (656 feet). In this zone, there is enough light for photosynthesis to take place. Phytoplankton are the foundation of this ecosystem. Because phytoplankton are so abundant, many animals live in the epipelagic zone.

The epipelagic zone can be affected by people. Pollution and trash from land can be washed out to sea. Oil spills can threaten the plants and animals that live in the water. Overfishing can cause species to become threatened or endangered. People around the world are working together to solve these problems.

SUN

The sun supports most of Earth's ecosystems. Producers (plants, algae, and phytoplankton) use sunlight to make usable energy. This process is called photosynthesis. Sunlight is the foundation of most food chains.

The sun also provides energy to warm Earth's atmosphere.

HUMAN (*Homo sapiens*)

Diet: People eat fish, octopus, and squid from the open ocean. Some indigenous cultures also eat whales, seals, and sea lions.

Other: People kayak, snorkel, scuba dive, and boat in the ocean. These activities are a major source of tourism. People also fish for many different species in the ocean. Fishing is very important to our economy.

BLUE WHALE (*Balaenoptera musculus*)

Diet: Blue whales mostly eat krill. They also eat zooplankton, crustaceans, and small fish.

Predators: Since adult blue whale are so large, they do not have many predators. Calves may be eaten by killer whales and large sharks.

Habitat: Blue whales are found in the open ocean. They live in temperate, tropical, and polar regions.

Other: Although hunting for these whales was banned in 1966 by the International Whaling Commission, blue whale populations are still recovering.

KILLER WHALE (*Orcinus orca*)

Diet: They eat seals, sea lions, smaller whales, dolphins, fish, sharks, squid, octopus, sea turtles, seabirds, sea otters, river otters, and more.

Predators: Adult killer whales have no natural predators. Young killer whales may be attacked by other killer whales or large sharks. Some cultures also hunt them.

Habitat: Killer whales are found in all oceans. Some stay in shallow waters along coasts, others live offshore.

Other: In 1989, the US banned capturing killer whales for marine parks.

LAYSAN ALBATROSS (*Phoebastria immutabilis*)

Diet: These birds mainly eat squid. They also eat fish, fish eggs, mollusks, and crustaceans.

Predators: Whales, sharks, dogs, and mongooses eat adults. Rats will eat babies.

Habitat: These birds live in temperate and tropical waters. They spend most of their time flying above the sea. They only land on water to feed or sleep. During nesting season, they stay on land.

Other: Albatross are a source of tourism. When on land, bird watchers visit breeding colonies.

COHO SALMON (*Oncorhynchus kisutch*)

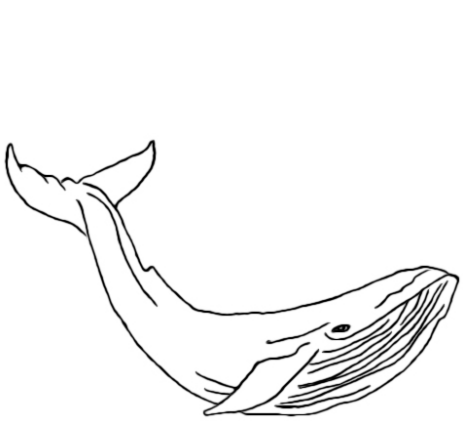
Diet: While they live in the ocean, coho eat smaller fishes, squid, and crustaceans.

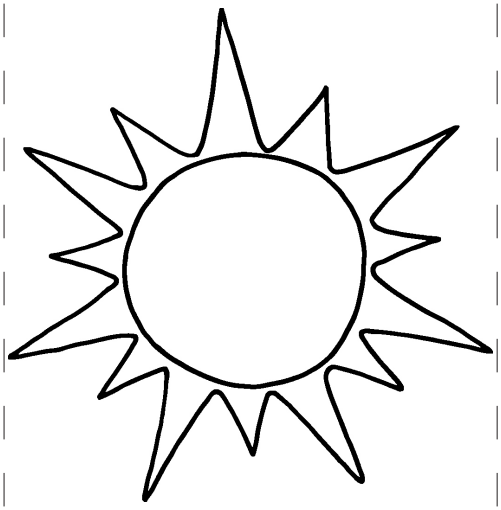
Predators: Larger fishes, birds, seals, whales, and people eat coho.

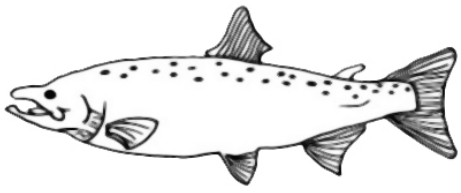
Habitat: Most coho spend 2-3 years in saltwater. Some fish migrate only a short distance into good feeding areas. Others fish migrate long distances.

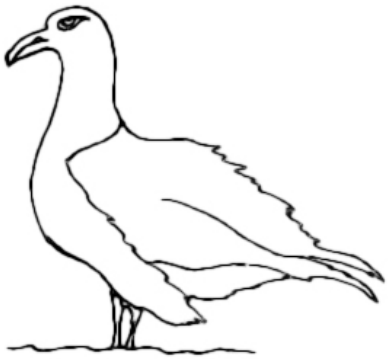
Other: After spending 2-3 years in the ocean, salmon return to their home stream. They find their home stream using their sense of smell. Pollution in the water can reduce their sense of smell.

Open Ocean (epipelagic zone)









Open Ocean (epipelagic zone)

BROWN PELICAN (*Pelecanus occidentalis*)

Diet: These birds mostly eat fish, but they will also eat small invertebrates and crustaceans.

Predators: Fish, crows, bobcats, cats, dogs, iguanas, alligators, fire ants, and raccoons will eat young. Adults are eaten by seal lions, sharks, and some people.

Habitat: These pelicans live in tropical waters, marshes, and swamps. They roost offshore at night. To nest, they move to small, predator-free islands.

Other: Human disturbance, fish hooks and lines, oil spills, and hunting threaten brown pelican populations.

CRYSTAL JELLY (*Aequorea victoria*)

Diet: This jelly feeds on plankton and larval fish. It will also eat other jellies.

Predators: Since jellies sting, they do not have many predators. Crystal jellies are eaten by others jellies, sea turtles, crabs, and other large crustaceans.

Habitat: This species lives both nearshore and offshore in the eastern Pacific Ocean.

Other: Crystal jellies can expand their mouth to eat prey half their size!

PACIFIC KRILL (*Euphausia pacifica*)

Diet: Krill mainly feed on phytoplankton. They will also eat zooplankton.

Predators: Krill feed hundreds of different animals including fish, seabirds, baleen whales, seals, and squid.

Habitat: This species of krill ranges from southeast Alaska to northern Baja California. It is found in colder waters.

Other: Although krill are only about 3 cm (1.2 inches) long, they are a major part of the food chain.

WHALE BARNACLE (*Cryptolepas rhachianecti*)

Diet: Whale barnacles eat plankton. As the whale swims through clouds of plankton, the barnacles also get a meal.

Habitat: Whale barnacles attach themselves to the bodies of baleen whales. This species lives on gray whales.

Other: Barnacles are typically harmless to the whale. When too many barnacles attach to one whale, it can slow their swimming. Too many barnacles can also make the whale more susceptible to parasites.

GREAT WHITE SHARK (*Carcharodon carcharias*)

Diet: Young eat squid, stingrays, and small sharks. Adults eat seals, sea lions, dolphins, whale carcasses, turtles, and seabirds.

Predators: Great whites are at the top of the food chain (apex predators). Only people, killer whales, and larger sharks pose a risk.

Habitat: They live in temperate and tropical waters near the coast and offshore.

Other: Boaters and dive operators can earn a living from shark tourism. Shark tourism allows visitors to see great white sharks safely in their natural habitat.

CALIFORNIA SEA LION (*Zalophus californianus*)

Diet: Sea lions love eating fish. They will also eat squid, octopus, cuttlefish, and nautiluses.

Predators: Great white sharks, bull sharks, and killer whales prey on California sea lions.

Habitat: They live along coastlines but have been found in rivers. They are often found on human-made structures such as jetties, piers, buoys and oil platforms.

Other: California sea lions are used by the US Navy. They help during search and rescue missions. They are also used to patrol areas in search of threats.

PELAGIC STINGRAY (*Pteroplatytrygon violacea*)

Diet: This species mainly eats small fishes, such as herring and mackerel. They also eat squid, jellies, and shrimp.

Predators: Sharks eat this species.

Habitat: Many stingrays spend most of their time buried on the sandy seafloor. Pelagic stingrays spend their time in open waters.

Other: To pelagic rays, plastic bags can look like jellies. If the stingray accidently eats a plastic bag, it can be a deadly mistake.

PACIFIC SARDINE (*Sardinops sagax*)

Diet: Young sardines eat phytoplankton. Adults eat zooplankton.

Predators: Sardines are eaten by sharks, dolphins, sea lions, seabirds, and whales.

Habitat: Sardines live in the open ocean, and travel in large schools.

Other: Sardines are very fatty. These fats are important for sea lion mothers that are nursing their pups.

LEATHERBACK SEA TURTLE (*Dermochelys coriacea*)

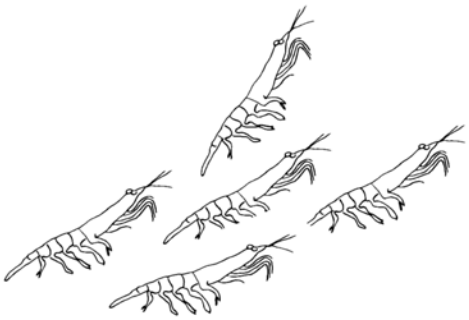
Diet: They mostly eat jellies. They will eat fish, mollusks, marine worms, and zooplankton.

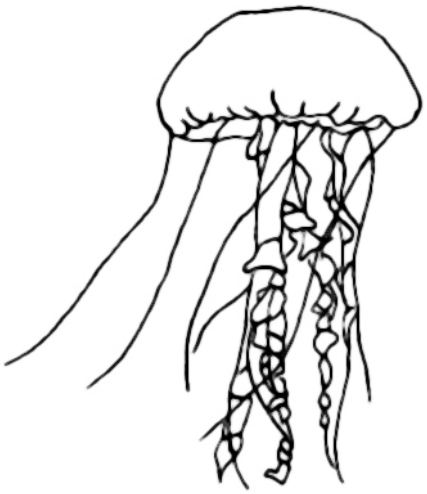
Predators: Eggs are eaten by crabs, raccoons, birds, dogs, humans, and pigs. Sharks, fish, and killer whales eat adults.

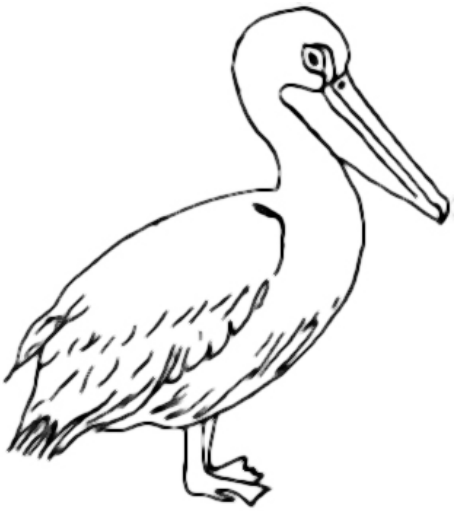
Habitat: They live in tropical, temperate, and some subarctic oceans. Females only come on land to lay eggs.

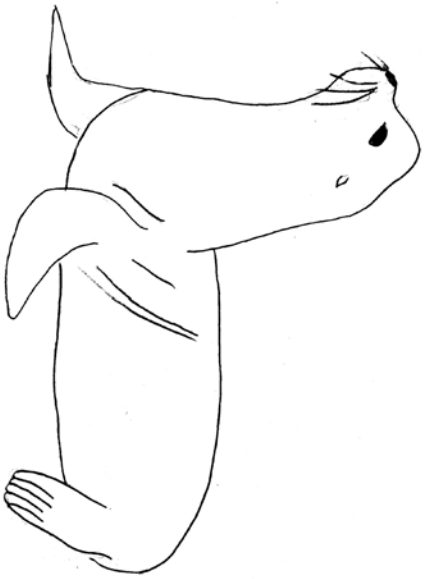
Other: Temperature influences the sex of the turtles. Warmer temperatures produce more female turtles. Cooler temperatures produce more males.

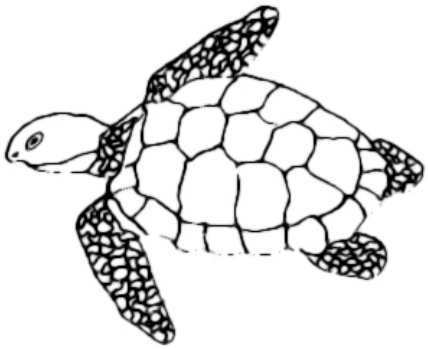
Open Ocean (epipelagic zone)

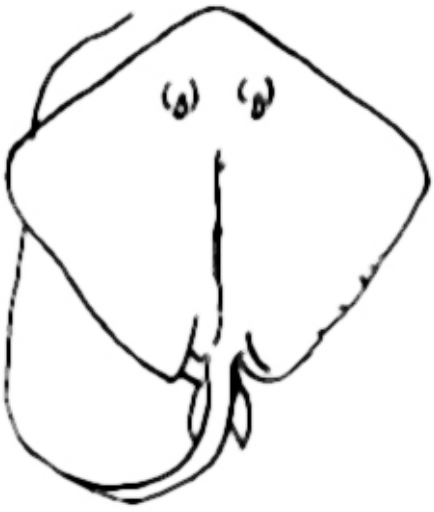












Open Ocean (epipelagic zone)

GIANT PACIFIC OCTOPUS (*Enteroctopus dofleini*)

Diet: They eat crabs, clams, fish, abalone, scallops, fish eggs, and octopuses.

Predators: Young are eaten by lingcod, seals, sea otters, mink, diving birds, and other octopuses. Adults have few predators other than humans and great white sharks.

Habitat: This species is found nearshore and far off the coast. They live in tide pools, under boulders, and in rock crevices.

Other: Octopuses are very intelligent animals. They can learn to open jars, play with toys, and interact with people.

PACIFIC MACKEREL (*Scomber japonicus*)

Diet: Mackerel eat krill, squid, and young fish.

Predators: These fish are eaten by porpoises, California sea lions, brown pelicans, larger fish, and sharks.

Habitat: This species ranges from Mexico to the Gulf of Alaska.

Other: Pacific mackerel are used for pet food and fishing bait.

ZOOPLANKTON

Diet: Zooplankton eat phytoplankton. Phytoplankton are algae that live near the surface of the water.

Predators: Fish, salamanders, and aquatic insects are common predators in estuaries.

Habitat: Zooplankton can be found in the oceans, seas, rivers and ponds. They are usually located near the surface of the water.

Other: Zooplankton is a type of plankton. It consists of tiny, free-floating animals. Thousands of different species are part of zooplankton.

PHYTOPLANKTON

Phytoplankton are many tiny algae living together.

Diet: Algae make their own food using photosynthesis.

Predators: Zooplankton, snails, coral, fish, shrimp, jellies, and krill are just some of the many predators.

Habitat: Phytoplankton live near the surface of the water.

Other: They are the first course in the food chain. They also produce more than half of the oxygen that we breathe on Earth.

MARINE BACTERIA

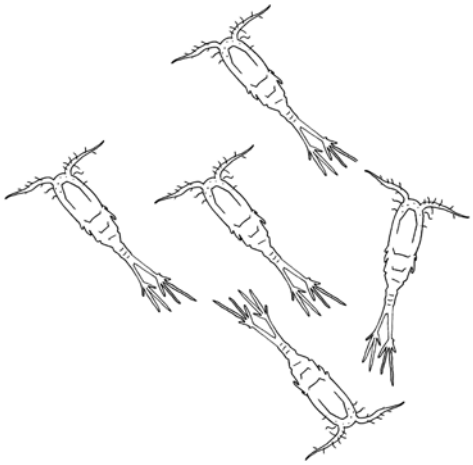
Bacteria are a type of microbe. They are so small that they can only be seen with a microscope.

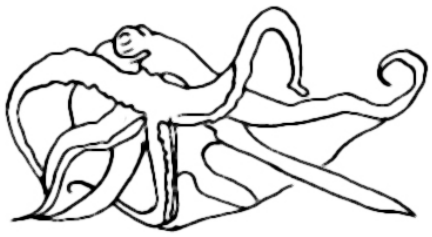
Diet: Some bacteria are decomposers. These bacteria break down dead organisms as big as whales or as small as other microbes. This makes nutrients available to other organisms.

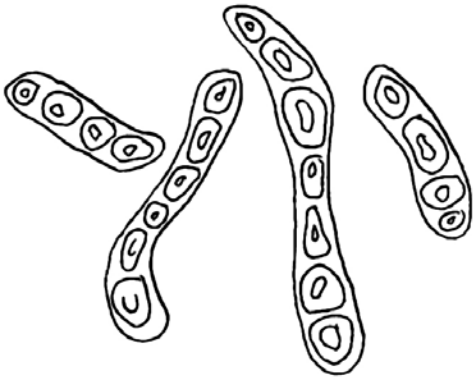
Habitat: In the ocean, they are found at the surface and all the way to the ocean floor. Some even live inside underwater volcanoes.

Other: Some elements are rare but important in the ocean. Bacteria help recycle these rare elements.

Open Ocean (epipelagic zone)







Name Date Period

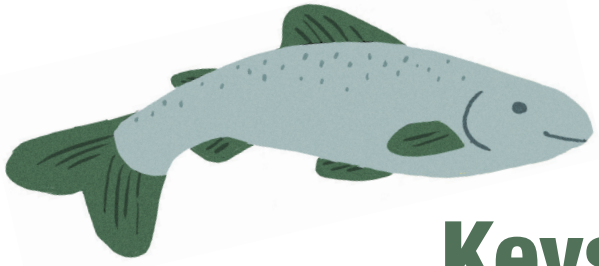
Ecosystem Compare and Contrast

Directions: Your group will present your ecosystem to one other group. The other group will also present their ecosystem to your group. While the other group is presenting, you should listen for similarities and differences between the ecosystems. Write these similarities and differences below.

Ecosystem 1: _____ **Ecosystem 2:** _____

How are they alike?

How are they different?



Lesson 5

Keystone Species

Students examine a Roman arch and discover that the keystone holds up the whole arch. Students then compare the keystone of the Roman arch to the characteristics of a keystone species. Students return to their small groups from Lesson 4 to identify a keystone species from their ecosystem diagram. After learning that salmon are a keystone species in each of their ecosystems, students describe ways their ecosystem might be affected if salmon populations decline.

Objectives

Students will:

- Define and describe characteristics of keystone species.
- Identify a keystone species from the ecosystem diagram.
- Explain how salmon are a keystone species.
- Hypothesize how changes in salmon populations might affect an ecosystem.

Students will understand:

- Changes to the population of a keystone species can have major affects throughout the ecosystem.
- Keystone species can be any living organism, not just animals.
- Keystone species can be large or small; predators or herbivores.
- Salmon are a keystone species.

Time Required

Approximately 90 minutes.

Preparation

□ Diagrams: *Ecosystem from Lesson 4*

□ Handout: *Keystone Species*
1 copy per student

Keywords

Ecosystem—A community of organisms (plant, animal, and other living organisms) and the abiotic parts of their environment.

Keystone species—A species on which other species in an ecosystem largely depend, such that if it were removed, the ecosystem would change drastically.

Supporting Vocabulary

Biodiversity—The variety of life in a particular habitat or ecosystem.

CREDIT: MARNEEJILL, FLICKR

Ecosystem engineer—Organisms that create, modify, destroy, or maintain a habitat in which they live or frequent. Examples include prairie dogs and beavers.

Foundation species—Organisms that play a major role in creating or maintaining habitat. Coral is one example.

Keystone host—Producers that provide food and/or shelter for keystone species.

Keystone mutualists—Two or more species that engage in mutually beneficial interactions. These species are often pollinators.

Nutrient vector—Organisms that transfers nutrients from one habitat to another.

Background Information

As the name implies, keystone species play key roles in their ecosystem. Many other plant and animal species depend on keystone species. Because keystone species are so important, the removal of one often results in a significant loss of biodiversity. Well-known examples include sea otters as managers of urchin populations, bees as pollinators, red mangroves as coastline protectors, and wolves as apex predators.

Keystone species can be any type of organism, including animals, bacteria, fungi, or plants. They can be producers, herbivores, omnivores, or carnivores. Keystone species are not always the largest or most abundant species in their ecosystem.

While salmon are not the classic textbook example of a keystone species, they are a very important one. From grizzly bears to killer whales, at least 137 different species depend on salmon.[17]

CREDIT: EAGLE WING TOURS

Returning salmon transport millions of tons of nutrients from marine environments to wetlands, rivers, and streams. Salmon predators and scavengers transport marine nutrients deep into the forest. Not only are salmon vital for many animals and people, but they also help ensure healthy forests by providing nutrients for plants and trees.

Lesson

Introduction

1. On the board, draw or display a picture of a Roman arch.

   Option: Have students construct their own Roman arches using **paper trapezoidal blocks**. Each arch will need at least 11 paper blocks.

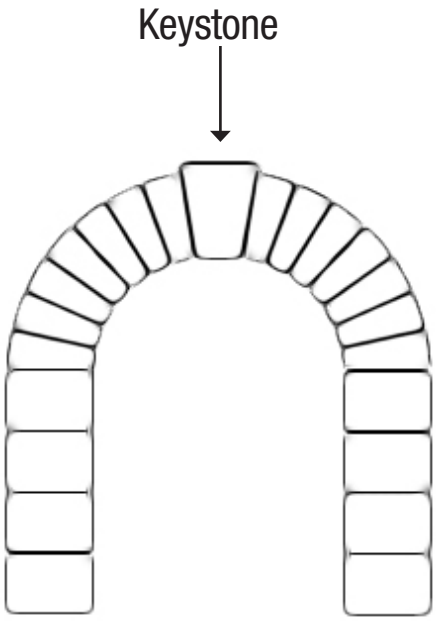
2. Point out the keystone (the stone at the top of the arch).

3. Ask students to guess what might happen if the keystone is removed.

4. Share the following excerpt with the class: The keystone is important because it holds up the arch. If a keystone is removed, the arch would collapse. Even though the keystone is under the least pressure of any of the stones in a Roman arch, the arch will collapse without it. Keystone species in an ecosystem are very similar. An ecosystem may experience dramatic changes if a keystone species is removed.

   Option: Show the video clip ***Keystone Roman Arches.***

5. Give the class a quick questionnaire. Ask students to put their thumbs up if they agree with the following statements and their thumbs down if they disagree. Pause after each statement and discuss the correct answer.



- Keystone species may be big. ***Yes***
- Keystone species can be tiny. ***Yes***
- Only animals can be keystone species. ***No***
- Keystone species must be carnivores (only eat meat). ***No***
- Keystone species can be herbivores (only eat plants). ***Yes***

6. In think-pair-share format, ask students to create their own definition for the phase "keystone species."

7. Ask a few groups to share their definitions.

8. Write the following definition on the board: Keystone species—A species on which other species in an ecosystem largely depend, such that if it were removed, the ecosystem would change drastically.

9. Ask students to record the definition in their science notebooks or journals.

Activity

1. Have students return to their groups from Lesson 4 (e.g., river, wetland, estuary, etc.).

2. Give each group their ecosystem diagram from Lesson 4 and give students time to review it.

3. Ask for each group to identify one keystone species from the diagram and explain why it is a keystone species.

4. Tell the class that each of their ecosystems has a common keystone species—salmon.

   Option: Display the ***Some Food Web Beneficiaries*** infographic on page 15 of the ***Pacific Salmon and Wildlife report*** from the Washington Departments of Fish and Wildlife and Natural Resources.

5. Share with the class that they will now examine how salmon act as a keystone species in their ecosystem.

6. Give each student a copy of the handout ***Keystone Species*** and review the directions with the class. Students may work in their groups or individually.

7. While groups are working, draw the following table on the board:

Ecosystem	Plants affected	Animals affected	Other impacts

8. Circulate around the room to answer questions and review answers. Be sure to pay particular attention to students' graphs.

9. After groups have completed their handouts, have one student from each ecosystem list the plants, animals, and other affects of reduced salmon populations on the board.

10. Share with the class that more than 137 species depend on salmon for their survival.

    Option: Display pages 116-124 of the ***Pacific Salmon and Wildlife*** report from the Washington Departments of Fish and Wildlife and Natural Resources.

11. Bring the class back together to discuss the characteristics of salmon and its life cycle that make it a keystone species. ***Salmon are a crucial part of many food webs, they live in many different ecosystems, they are eaten by many different animals, their decomposing bodies fertilize soil, they bring nutrients from the ocean to the stream and surrounding forest, etc.***

12. Ask the class to brainstorm ways that people might be affected by salmon populations that are declining or have become extinct.

Discussion Questions

1. Why are keystone species important?

CREDIT: JERRY MCFARLAND, FLICKR

2. Why is it important to protect keystone species?
3. How might a keystone species' population indicate the health of an ecosystem?
4. Are humans a keystone species? Why, or why not?
5. Why might it be problematic to label some species as keystone species and not others?

Action Project

Ask students to choose a keystone species that is threatened or endangered. Students can research key information about the species; why its population is declining; how the ecosystem is affected by a decline in this keystone species; and what individuals can do to help. Students can create a poster or social media campaign to educate others about this species or a fundraising campaign to assist in recovery efforts.

Extensions

Art

Have students create a food web, mural, or other piece of art that highlights the 137 species that depend on salmon for their survival. The entire list of species can be downloaded from the ***Pacific Salmon and Wildlife*** report from the Washington Departments of Fish and Wildlife and Natural Resources.

Debate

When funding for conservation projects cannot meet the needs of all species, how should we decide where the conservation dollars are spent? Share the ***Should We Let Pandas Go Extinct?*** (3:07) video with the class, and have students develop criteria for prioritizing conservation with a limited budget.

CREDIT: LYNNE BARRE, NOAA FISHERIES

Math

Provide students with the following statistics and ask them to calculate the number of chum salmon needed to supply 1 hectare forest with sufficient nitrogen and phosphorus for one year.

- The average adult chum salmon contributes approximately 130 grams of nitrogen and 20 grams of phosphorus to the forest.[18]
- Mature coniferous forests uptake approximately 39 kg/ha of nitrogen and 5 kg/ha of phosphorus every year.[19]

Science

To reinforce the idea that keystone species can be many different types and sizes of organisms, break the class into seven groups. Assign each group one of the following categories: plant, fungi, bacteria, herbivore, omnivore, carnivore, decomposer. Have each group research an example of a keystone species from their assigned category. Students should describe how the ecosystem depends on this organism and potential affects if its population declines.

Sustainability

Using the ecosystems they were assigned in class, have students research why salmon populations are declining in their particular ecosystem. Students should also suggest ways that people can help salmon in this ecosystem. Have groups present their ideas to the class, and then lead a class discussion to find common ways that people can help salmon in all ecosystems.

Writing

Have students write an essay about what the phrase "salmon need forests, and forests need salmon" means.

Additional Resources

Activities and Curriculum

Purdue University: Eco-llapse
This lesson plan and Jenga-based game demonstrates how organisms depend on one another.

Salmonids in the Classroom: How Salmon Fertilize Trees
This classroom experiment helps students understand how salmon decompose and act as an important fertilizer for forests.

Soil Science Society of America: K-12 Resources
Help students better understand the connection between salmon returns and forest health with these free lesson plans and PowerPoint presentations.

Book

David Suzuki: Salmon Forest (32 pages, AD640L)
From adventures along a river in the Pacific rain forest, Kate discovers how the forest and the salmon need each other.

Poster

Salmonids in the Classroom: Salmon: The Vital Link
This poster shows the salmon life cycle and illustrates how salmon carry rich nutrients from the sea to the forest

Videos

Some Animals Are More Equal than Others (19:28)
This video explores early studies were that investigated keystone species and trophic cascades, as well as ongoing studies into the regulation of population sizes and species numbers.

There's Something Very Fishy About These Trees (4:37)
Salmon make a perilous voyage upstream past hungry eagles and bears to mate in forest creeks. When the salmon die, a new journey begins –with maggots.

Website

Monterey Bay Aquarium: Sea otters—gardeners of the eel grass
This website illustrates how one keystone species, sea otters, helps maintain kelp forests.

Name Date Period

Keystone Species

Directions: Review your ecosystem diagram before answering the questions below.

1. In your ecosystem, salmon is one example of a keystone species. List at least two reasons why salmon are a keystone species.

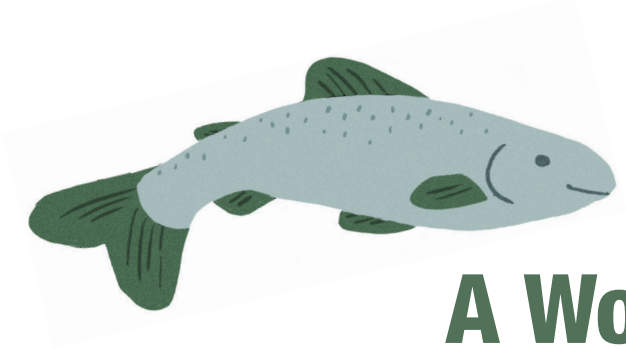
2. If salmon populations decrease, what might happen to their prey? List specific examples from your ecosystem diagram.

3. If salmon populations decrease, what might happen to their predators? List specific examples from your ecosystem diagram.

4. What other plants and animals in your ecosystem might be affected if salmon populations decrease or go extinct?

Keystone Species, Page 2

5. Create a graph that shows the relationship between salmon and two other species in your ecosystem. Be sure to label the axes and title the graph.



Lesson 6

A World of Salmon

After brainstorming different examples of culture, such as language, art, and food, students write about and draw their favorite family recipe. Individuals share their favorite recipe and then discuss how food is a part of culture. Small groups read profiles from 10 different regions and learn how salmon are important to each of these cultures. After locating each of these regions on a map, students discuss how the migration of salmon has affected cultures around the world.

Objectives

Students will:

- Draw and write about a recipe that has special meaning to their family.
- Describe connections between food and culture.
- Read and synthesize information about salmon food traditions from around the world.
- Draw connections between cultures with salmon food traditions and the migration of salmon.

Students will understand:

- Food is an important part of every culture.
- Salmon play an important part of cultures around the world.
- When salmon populations decline, they can affect cultural traditions.

Time Required

Approximately 60 minutes.

Preparation

□ Slideshow: *Examples of Culture* (Optional)
Project this during Steps 1-3 of the Introduction.

□ Display copy: *Favorite Family Food*
Project this during Step 5 of the Introduction.

□ Butcher paper
Cut 1 piece per student, approximately 12" long.

□ Markers, colored pencils, or crayons
Gather 1 set per student.

□ Cards: *Salmon Culture Around the World*
Print 1 copy of each card. Cut the cards out before class.

□ Handout: *A World of Salmon*
Print 1 copy per student.

□ Display copy: *World Map*
Project this during Step 4 of the Activity.

CREDIT: EDSEL LITTLE, FLICKR

Keywords

Culture—The behaviors, beliefs, arts, and products (things) of a community or group of people.

Tradition—The handing down of statements, beliefs, legends, customs, information, etc., from generation to generation.

Supporting Vocabulary

Custom—An action or way of behaving that is usual and traditional among the people in a particular group or place.

Cuisine—a style or manner of cooking food or presenting food; often related to a particular country or culture.

Society—A community, nation, or other group of people who have common interests, institutions, or culture.

Background Information

When we take a bite of our favorite meal, we are often flooded with memories of our favorite holidays, family celebrations, and our cultural heritage. Coming together and sharing a meal is a tradition that binds many families, communities, and countries together. Food plays a pivotal role in our culture.

For thousands of years, fishing for, cooking, and eating salmon, has been intertwined with cultures around the world. From salmon soup in Finland to fish cakes in Japan, and from salmon stuffed pie in Russia to cured salmon in Sweden—salmon dishes have been the centerpiece of birthdays, holidays, ceremonies, and religious occasions.

As salmon populations decline—and in some cases disappear—how might festivals, ceremonies, and feasts

CREDIT: MID-ATLANTIC CENTER FOR THE ARTS & HUMANITIES, FLICKR

designed around the annual migration of salmon be affected?

Lesson

Introduction

1. Share the following excerpt with the class:

   As we have already learned, salmon are incredible fish. They travel thousands of miles in their lifetime—from freshwater to saltwater and back again. Salmon are a keystone species in many different ecosystems. Not only do salmon support the food web of many ecosystems, but they are a vital part of human culture.

   Culture is everything that makes up the way a group of people live, including how they talk, eat, and celebrate. Food is one very important part of culture. Food brings families together for daily meals and brings communities together for rituals and celebrations.

2. Write the following definition of culture on board: The behaviors, beliefs, arts, and products (things) of a community or group of people.

3. In popcorn format, ask for the class to brainstorm different examples of culture. ***Language, music, clothing/fashion, beliefs, mannerisms, art, dance, etiquette/customs, food, etc.***

   Option: Project the presentation *Examples of Culture*.

4. Tell the class that today you are going to explore the most delicious part of culture—food!

5. Project the display copy ***Favorite Family Food***.

6. Ask students to think about the prompts and write down some notes on a piece of paper.

7. As students are silently brainstorming, give each student a piece of butcher paper and set of markers, colored pencils, or crayons.

8. Ask students to draw their favorite meal in the center of the butcher paper. Around their drawing, they should respond to the prompts from the display copy.

9. Have the class conduct a gallery walk or ask for a few student volunteers share their examples.

10. Lead a class discussion or think-pair-share exercise using the following prompts:

    - What role does food play in people's lives?
    - How does food play a part of your family's culture?
    - How does food play a part in our community's culture?

Activity

1. Share the following excerpt with the class:

   Around the world, many families share a family meal to celebrate birthdays, holidays, ceremonies, and religious occasions. Food connects us all—from different families and different cultures to billions of people around the world.

   Salmon are a centerpiece of cultural celebrations around the world. From salmon soup in Finland to fish cakes in Japan, and from salmon stuffed pie in Russia to cured salmon in Sweden—food, and salmon in particular, is deeply tied to culture.

2. Prepare the ***Salmon Culture Around the World*** cards.

   Option A. For a station option, tape the cards along the perimeter of the classroom or place them on different desks around the classroom. Students will circulate around the room and visit each of the 10 cards.

   Option B. For the jigsaw option, divide the class into 10 evenly-sized groups. Give each group a different card.

3. Give each student a copy of the ***A World of Salmon*** handout and let students know how you would like them to complete the handout (i.e., stations or jigsaw).

   Extension: Have students research additional information

about their assigned region's holidays, dinner etiquette, cooking methods, etc.

4. After students have completed the handout, project the display copy ***World Map***. Have students locate each of the locations on the map.

5. After each of the countries/regions has been located, have students summarize how salmon is important to each of these locations. If you have chosen the jigsaw option, ensure that students are filling in the remainder of their worksheets while others are presenting.

6. Ask students to look at the map. Guide a class discussion using the following prompts.

   - Do you notice any patterns?
   - How might these locations be related to the salmon life cycle?
   - Why is it surprising to see salmon in Hawaii? ***Salmon do not live near Hawaii. They must be imported to the island.***

7. Ask students to think about their favorite family dish. Lead a class discussion, think-pair-share exercise, or free write using the following discussion questions:

   - Why might salmon be the centerpiece of so many traditional dishes?
   - How might the decline or extinction of salmon affect cultural traditions?
   - How would you feel if you could no longer eat your favorite family meal because a key ingredient was no longer available?

Discussion Questions

1. Besides survival, how is food an important part of people's lives?
2. How does our culture or ethnic background affect the way we eat?
3. How might salmon migration have influenced culture?
4. How might geography, or where people live, influence culture?
5. Why do some of the practices of other cultures seem comforting or odd to us? How might some of our customs seem odd to other cultures?

CREDIT: US FOREST SERVICE REGION 5

Action Project

Ask students to collect oral histories from elder family or community members about how food culture has changed during their lifetime. If students do not have many elders in their family or community, consider partnering with a local retirement home.

Work with the class to design a questionnaire that each student will use with their interviewee. ***Our Changing Food Traditions*** from the American Museum of Natural History provides a comprehensive framework for this type of interview.

Combine the oral histories in a book that will be displayed at your school or local library. Consider inviting the interviewees to speak with the class and share some of their favorite recipes.

Extensions

Cooking

Host a food festival, and have each student bring in a different dish. Alternatively, students can create a class cookbook based off their families' recipes.

Culture

Share the ***Hungry Planet: What the World Eats*** profiles with the class. Ask students to share their reactions to the different profiles. Have students categorize foods that they recognize and ones they do not recognize. Ask students to discuss some reasons why people eat different kinds and amounts of food.

CREDIT: GARRETT ZIEGLER, FLICKR

Environmental Studies

Food often travels thousands of miles before reaching a grocery store. Have students pick an ingredient from their favorite family meal and research the resources required to produce this ingredient and how far it travels from the farm to the grocery store.

Health

Choose MyPlate can help students design a healthy menu on a budget, learn how to improve their current diet, and discover new, healthy recipes. Use the website to help students assess their current diet and make improvements where needed.

History

In the 1900s Atlantic salmon from Maine were so highly valued that the first one caught in the Penobscot River each spring was presented to the US President. The last Presidential salmon was caught in May 1992 for President George H.W. Bush. Have students create a timeline that shows the history of this tradition and the salmon that were caught for each president.

Technology/Communication

Use *Narrative Atlas* to connect your students with their counterparts around the world. Students can share favorite family and cultural traditions.

Additional Resources

Books

Bobbie Kalman: *What is Culture?* (32 pages, IG700L)
Introduce your students to different aspects of culture, such as costumes, dances, holidays, celebrations, and food.

Kristin Petrie: *Food Culture: Celebrating Diverse Traditions* (32 pages, 800L)
Bright, colorful photos will engage readers as they learn about the role food plays in daily life as well as different celebrations, festivals, feasts, and holidays.

Peter Menzel: *What the World Eats* (160 pages, 1150L)
Cultural geographers visited 25 families in 21 countries to illustrate what people around the world eat in a week.

Websites

Global Grocery

Find out where in the world many foods come from.

What the World Eats

This interactive from National Geographic shows how diets from 22 different countries have changed over 50 years.

What's on the Menu

Over 15,000 historical restaurant menus, dating back hundreds of years and searchable by dish.

Traditional Foods Project

This project from the Centers for Disease Control and Prevention chronicles traditional diets of 17 tribes from around the US.

Videos

Around the Table (2:49)

Chefs and authors discuss the importance of the communal meal.

How Food Connects Us (2:03)

What is one language humanity has in common? Food!

Kids Try (varies from 2:00-8:00)

This series shows kids trying food from around the world.

Outdoor Idaho: Idaho's Salmon (26:49)

This video explores the cultural and economic importance of salmon and what is being done to bring them back.

CREDIT: ANGELA, FLICKR

CREDIT: JESSICA FIESS-HILL, FLICKR

Favorite Family Food

What is your favorite food from family holidays or celebrations?

Why is it your favorite?

What ingredients are used to make this dish?

How does it smell?

How does it taste?

How do you feel when you eat this dish?

What is its significance in your family?

What celebrations or holidays do you make this recipe for?

How is this recipe part of your culture?

CREDIT: MATTHEW OLIPHANT, FLICKR

CREDIT: RICK WONG, FLICKR

Salmon Culture Around the World

First Salmon

Around North America, many tribes celebrate the return of salmon with a First Salmon Ceremony. The First Salmon Ceremony is one of the most important celebrations for tribes that live along the West Coast, including those living in the Columbia Basin. The Columbia Basin stretches from British Columbia south to Oregon and east to the border of Montana.

First Salmon Ceremonies differ from tribe to tribe, but many have some things in common. According to tribal religions, salmon were a gift from the Creator. In honor of this gift, Native Americans treated the annual arrival of the salmon with great reverence and a ceremony. The ceremony must take place before that year's fishing can occur. The salmon chief of the tribe selects a fisher to catch the first salmon. This is an honor, and before entering the river the fisher undergoes a blessing or a purification. Once a fish is caught, it is brought to shore and carefully prepared. The way the salmon is cooked and distributed varies between tribes. Traditionally, the head of the fish is kept and is pointed upriver to show the salmon's spirit the way home. The bones are carefully cleaned and returned to the river, where it is believed the salmon continue their journey.

According to tradition, if the first salmon caught each season is treated with respect, its spirit will return to the salmon village under the sea, where he will gather his relatives and lead them back to the rivers and streams. If the salmon is not treated with proper respect, its people will not return. In the spring of 1806, Lewis and Clark witnessed a first salmon ceremony at Celilo Falls on the Columbia River on their return journey home.

Photo credit: Pat Kruis, Oregon Public Broadcasting

Lohikeitto

The Finnish word for Finland is "Suomi," which means marshland. The country has more than 60,000 lakes, and less than 8% of the country's land is arable (farmable). While crops are limited—mainly potatoes, wheat, barley, and oats—the country has an abundance of fish.

In Finnish, lohi means "salmon" and keitto means "soup". Lohikeitto is a traditional salmon soup that uses two of Finland's most abundant resources: potatoes and salmon. The salmon is cooked and removed from the pot. Chunks of potatoes and onions are added to the salmon soup stock. Once the potatoes are soft, the salmon is added back to the pot along with some cream.

Lohikeitto is often served during brunch with some dill, butter, and bread. Traditional breads are a part of every meal in Finland. In western Finland, the bread is Ruisleipä, a sour rye bread that is flat and crispy and has a hole in the middle. In eastern Finland, the bread is round and thick.

In Finland, food is tied to the seasons. Market stalls are filled with seasonal produce and local delicacies. Festivals mark the arrival of favorite foods throughout the year.

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Salmon Culture Around the World

Galette with Salmon

Playing pranks on April 1 is a tradition in the US. What many people do not know is that the holiday started in France. Those who are fooled on April 1 are called the "Poisson d'Avril" (the April Fish). A common prank among French schoolchildren is to tape a paper fish to the back of a friend, and shout "Poisson d'Avril!" when the fish is discovered.

While it is not clear why fish are associated with April 1, many think the correlation is related to zodiac sign of Pisces (a fish), which falls near April.

Of course, no French tradition is complete without food to commemorate it. Eating your fill of fish is also an important part of celebrating le Poisson d'Avril in France. Many restaurants offer fish specials throughout the day. One popular le Poisson d'Avril dish is galettes with salmon. Galettes are like crusty pancakes made from buckwheat flour. The salmon galettes are often topped with dill, green onions, lemon, and creme fraiche. People also exchange fish-shaped candies, pastries, and cakes.

Photo credit: ilolab, Shutterstock

Lomi-lomi Salmon

This dish gets its name from the Hawaiian word lomi-lomi which means "to massage". The ingredients are mixed, or massaged, together gently by hand. Lomi-lomi is typically made with tomatoes, Maui onions or green onions, and salmon. Sometimes flakes of red chili pepper or crushed ice are added to the dish. It is always served cold. Even though lomi-lomi salmon is a very popular Hawaiian dish, salmon does not live in Hawaiian waters. Salmon was introduced to the island by whalers in the 1800s.

Lomi-lomi salmon is served at many luaus. A luau is a traditional Hawaiian party or feast that is usually accompanied by Hawaiian music and hula. Hula is a Polynesian dance form accompanied by chants or songs. Many of the dishes at a luau offer a blend of Hawaiian, Polynesian, and Asian-influenced flavors.

The traditional luau was eaten on the floor or ground over lauhala (leaves of the hala tree) mats. Attendees enjoyed poi (mashed taro root), dried fish, and pork cooked in the traditional Hawaiian imu (underground oven), sweet potatoes, and bananas. Everything was eaten with one's fingers. Traditional luaus were typically a very large gathering with hundreds and sometimes over a thousand people. Today, people still get together with families and friends at a luau to celebrate special events.

Photo credit: AS Food studio, Shutterstock

Salmon Culture Around the World

Sabzi Polo

Sabzi Polo is often served during Nowruz. Nowruz is the Iranian New Year, which is celebrated on the first day of spring. Nowruz has been celebrated for over 3,000 years. This celebration includes many traditions such as spring cleaning, purchasing new clothes, and visiting friends to renew bonds.

Almost every home has a haftseena, which is a ceremonial table. During Nowruz, the table is decorated with seven items since seven is considered a lucky number. Each item begins with the letter sin (s) in Persian. Each item that is placed on the ceremonial table is a symbol of spring and renewal. Some common items include apples (seeb), garlic (seer), hyacinth flowers (sonbol), pudding (samanu), grass (sabze), sumac (somaq) and coins (sekeh).

During Nowruz, families get together and share traditional meals. One of the main courses is Sabzi Polo Mahi. This main course is usually rice with green herbs served with fish. Fish symbolizes life and good luck. The green herbs symbolize fruitfulness or productiveness.

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Kamaboko

Kamaboko (かまぼこ) is a Japanese dish that is made of a fish cake topped with salmon roe (eggs). This rubbery fish cake is naturally white. During holidays, kamaboko is often served with white and pink-dyed slices, which is considered a very lucky color combination.

Kamaboko is often served during New Year's day in Japan. It is found in a box of osechi ryori (おせち 料理). Osechi ryori is an assortment of colorful dishes packed together in special boxes. These special wood boxes filled with treats are called jubako. Each dish in the jubako (樹箱) is a traditional food that has special meaning for the New Year. For example, the shape of kamaboko is said to resemble the first sunrise of the New Year.

The entire family shares one jubako on New Year's day and the foods are eaten using special chopsticks. The chopsticks are rounded on both ends. One side is for humans to use, the other side is for the gods.

Photo credit: PG_Payless, Shutterstock

Salmon Culture Around the World

Salmon and Peas

New Englanders often celebrate Fourth of July by serving salmon, peas, and baby potatoes. New England includes the states of Maine, Vermont, New Hampshire, Massachusetts, Connecticut and Rhode Island. This New English tradition has been around as long as the US has been a country.

So how did this dish become a tradition? On the first Fourth of July in 1776, it was rumored that Abigail Adams served Atlantic salmon, fresh garden peas, and baby potatoes to John Adams. John Adams is very important historical figure. He helped convince Congress to declare independence from Britain. He also helped Thomas Jefferson write the Declaration of Independence. He later became the second President of the US (1797–1801).

It is more likely that this dish became a tradition because of the timing of the salmon migration. Historically, salmon migrated from the Atlantic Ocean up New England's rivers in late June and early July. This is around the same time that garden peas and baby potatoes were ready to harvest.

While peas and potatoes are still grown in New England, wild Atlantic salmon populations are nearly extinct. Today, this dish is made using farmed salmon or wild salmon from the Pacific Ocean.

Photo credit: MShev, Shutterstock

Salmon kulebyaka

Russian cuisine is prided on baked goods, especially traditional savory pies. Kulebyaka (Кулебяка) is one type of Russian savory pie. It is a symbol of Russian hospitality and a bountiful table. The word came from old Russian verb – 'kulebyachit', which means to make with hands.

The pies can have many different fillings, but the most popular are salmon with buckwheat; ground meat with boiled eggs and rice; or cabbage with mushrooms and onions. The pie is baked in a pastry shell, and the filling layers are separated by thin pancakes. It is often served with soup, but can also be served as a main dish or as an appetizer. It was so popular in pre-revolutionary Russia, that the recipe was exported into France.

Kulebyaka is very popular during Lent in Russia. Lent is the 48 days of fasting and prayer before Easter. Before Lent begins, many Russians celebrate Maslenitsa, a week-long pancake holiday. Maslenitsa symbolizes the end of winter.

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Yu sheng

Chinese New Year festivities involve practicing many different traditions. One common tradition in Singapore is the tossing of the yu sheng for good fortune. Yu sheng is a raw fish salad. The salad is made up of white and green radish, carrots, bell peppers, turnips, red pickled ginger, slices of raw fish (commonly salmon), and crackers. The dish is usually served as an appetizer.

The dish symbolizes an abundance of wealth and a long life. It is customary to gather your family and friends to toss the ingredients. While the ingredients are being tossed, people say well-wishes to bring good luck. It is popularly believed that the higher the toss, the better your fortune in the upcoming year.

Before the tossing begins, the dish needs to be prepared. This is usually the job of one person. This person adds the ingredients one-by-one in a specific order. While they add the ingredients, they say wishes. Each ingredient is associated with a different meaning of good luck.

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Gravadlax

In Sweden, Christmas Eve is the culinary high point of the Christmas season. On Christmas Eve, families and friends gather in each other's homes for Julbord, the most lavish meal of the year. Traditionally, this feast begins with fish, and almost every table has gravadlax—salmon cured in sugar, salt, and dill.

Gravadlax means "buried salmon" or "grave salmon." During the Middle Ages, gravadlax was made by fishers, who salted the salmon and lightly fermented it by burying it in the sand above the high-tide line.

Today, the salmon is cured with salt and sugar and infused with fresh dill and sometimes other spices. It is usually served as an appetizer. It is sliced thinly and served with a sauce and bread or boiled potatoes.

Swedish food tends to be influenced by the seasons. The way it is spiced and cooked often reflects the storage needs of the old days. Typically, fish is pickled, meat is salted or smoked, and dairy products are curdled, boiled, or left to age.

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Name Date Period

A World of Salmon

Part I. Summary
Directions: Complete the table below.

Location	Dish	Holiday/Celebration	One other fact about food culture in this county/region
Columbia Basin 			
Finland 			
France 			
Hawaii 			
Iran 			

A World of Salmon, Page 2

Location	Dish	Holiday/Celebration	One other fact about food culture in this county/region
Japan 			
New England 			
Russia 			
Singapore 			
Sweden 			

Name

A World of Salmon, Page 3

Part II. Explanation
Directions: After completing the table in Part I, answer the questions below using complete sentences.

1. Which dish(es) would you like to try? Why?

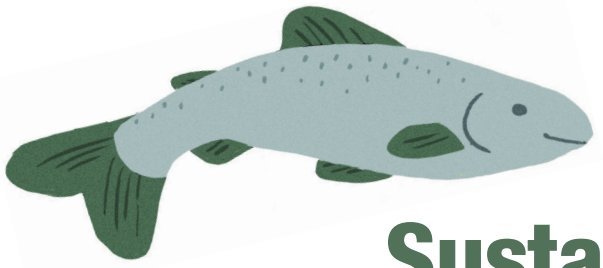
2. Which traditions remind you of your own family's traditions?

3. How is Finland's food shaped by its geography?

4. How is Hawaii's relationship with salmon different than other regions?

5. Which holiday/celebration would you be most excited to participate in? Why?


Finland
Russia
Sweden
Columbia Basin
France
New England
Japan
Hawaii
Iran
Singapore



Lesson 7

Sustainable Seafood

In Part 1, students compare and contrast three types of fishing: commercial, recreational, and subsistence. A discussion about the characteristics of sustainability sets up a simulation in which students demonstrate the implications of overfishing and bycatch. In optional Part II, students use the data from their fishing simulation to discuss the economic and environmental affects of bycatch. After reading about different types of commercial fishing gear and common bycatch, students redesign the fishing gear to reduce affects on the environment and marine animals.

Objectives

Students will:

- Compare and contrast commercial fishing, subsistence fishing, and recreational fishing.
- Discuss the importance and characteristics of sustainable fishing practices.
- Conduct a simulation that demonstrates overfishing, incidental catch, and bycatch.
- Redesign commercial fishing gear in order to reduce bycatch.

Students will understand:

- Major differences between commercial, recreational, and subsistence fisheries.
- Different types of fishing have different affects on the environment.
- Commercial fishing supports many jobs and diets around the world.
- While fishing for a specific species (target catch), other species can accidentally be caught (bycatch).
- Technology, regulation, and education can help reduce bycatch.

Time Required

Approximately 2 hours.

Preparation

Part I

□ Slideshow: *Fishing Types*
Project the slideshow during Step 4 of the Introduction.

□ Handout: *Compare and Contrast*
Print 1 copy per student.

□ Oceans
Create one "ocean" per 4-5 students. Use a mixing bowl, baking sheet, or roasting pan for each ocean. In the ocean, place 30 goldfish crackers (target catch), 20 gummy fish candies (retained incidental catch), and 20 oyster crackers (bycatch). These may be substituted with other small snacks or tokens (e.g., popcorn, marbles, pebbles, etc.). Label each ocean with a different name (i.e., Pacific, Atlantic, Indian, Arctic, Southern). Save the extra snacks/tokens, which will be used to replenish the oceans.

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□ Fishing Gear
For each student, gather one small Dixie (drinking) cup and one spoon. For each group of 4-5, gather one serving spoon and one pair of tongs.

□ Timer or stopwatch

□ Handout: *Fishing Log*
Print 1 copy per student.

Part II (optional)

□ Cards: *Fishing Gear*
Print and cutout 1 card per student or pair.

□ Handout: *Fishing Gear Redesign*
Print one copy per student or pair.

□ Internet access (optional)
For additional student research.

Keywords

Bycatch—The species that fishers accidentally catch. Sometimes this catch is discarded because fishers do not want it, cannot sell it, or are not allowed to keep it.

Commercial fishing—Catching fish for commercial profit. The fish is often sold to fish markets, restaurants, or fish processors.

Recreational fishing—Harvesting fish for personal use, sport, or challenge (e.g. as opposed to profit or research). Recreational fishing does not include sale, barter, or trade of all or part of the catch.

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Retained incidental catch—The species that fishers accidentally catch and keep.

Subsistence fishing—Fishing to feed one's family or community.

Sustainable—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

Target catch—The species that fishers are trying to catch.

Supporting Vocabulary

Discard—To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel.

Economy—The system of production, distribution, and consumption of goods and services.

Environment—The physical surroundings in which we live, including living (biotic) and nonliving (abiotic) factors.

Fish farming—Raising fish commercially in tanks or enclosures, usually for food.

Fish hatchery—A place for artificial breeding, hatching, and rearing fish through the early stages of their lives.

Ghost fishing—The accidental capture of aquatic organisms by fishing gear that has been lost or discarded into the sea and which continues to entangle or trap aquatic animals.

Society—A community, nation, or other group of people who have common interests, institutions, or culture.

Background Information

There are three types of fishing:

1. **Commercial fishing** is catching fish to make money. If done on a large scale, it is also called industrial fishing. The fish that are caught by the fishers are sold to seafood markets, grocery stores, and restaurants. Commercial fishing uses equipment such as trawlers, nets, pots, and large boats or factory ships. Factory ships can immediately process and freeze seafood. In 2013, commercial fishers in the US landed 9.9 billion pounds of seafood valued at $5.5 billion.[20] Globally, commercial fishing is major source of food and jobs for hundreds of millions of people.
2. **Recreational fishing** is catching fish for personal use, sport, or challenge. It is also known as sport fishing or angling. Recreational fishing does not include selling or trading fish. Rods, reels, hooks, baits, and small boats are typically used to catch the fish. In the US, as many as 33 million people aged 16 or older participate in recreational fishing, and spend $48 billion annually on equipment, licenses, trips and other fishing-related items or events.[21] License fees and taxes on fishing tackle and motorboat fuel are used by State governments to help support conservation projects around the country.
3. **Subsistence fishing** is catching fish to feed one's family or community. It is also known as traditional or artisanal fishing. Subsistence fishing is important for the economies and cultures of some indigenous peoples. Subsistence fishers typically use traditional fishing techniques such as rod and tackle, fishing arrows and harpoons, cast nets, and sometimes small fishing boats. Beyond indigenous communities, low-income and immigrant communities may rely on subsistence fishing to feed themselves or their families.

While there are many positive benefits associated with fishing, such as supporting jobs, diets, and conservation programs, there can also be negative consequences, such as overfishing, habitat destruction, and **bycatch**. Bycatch are the species that fishers accidentally catch, and sometimes toss back into the sea, because they do not want them, cannot sell them, or are not allowed to keep them.

While bycatch is declining in the US, it is still a major global issue. In the US, approximately 17% of catch is bycatch[22] and

around the world about 40% of catch is bycatch.[23] Each year, millions of tons of fish and hundreds of thousands of seabirds, seals, dolphins, whales, turtles, and other marine species are unintentionally killed as bycatch. In some fisheries, particularly those that use gear that scrapes across the ocean floor, the percentage of bycatch can outweigh the percentage of target catch.

Regulations, voluntary programs, and new technologies are being developed to minimize bycatch. Dolphin-safe labels, a voluntary program, were developed to help consumers identify companies that minimize dolphin fatalities during the harvest of tuna. Turtle excluder devices, a new technology, help sea turtles escape fishing nets. FishWatch and similar programs help people choose the most sustainable seafood options.

Part I

Introduction

1. Share the following excerpt with the class:

   We've been talking a lot about salmon—how they migrate, why they are a keystone species, and how people all around the world like to eat them. Where do all of these salmon come from? The last time you had fish sticks in the school cafeteria or grilled fish with your family, did you stop to think about where that fish came from? Many of us forget that our seafood must be caught, transported, and processed before it makes its way to restaurants, grocery stores, and cafeterias. Just like there are many methods of farming, there are also many methods of fishing. Around the world, there are many types of fishing and fishing gear are used to catch salmon.

2. Ask the class to brainstorm the different ways people might harvest salmon. ***Nets, poles, spears, farming/aquaculture, commercial boats, trawlers, etc.***

3. Give each student a copy of the handout ***Compare and Contrast*** and review the directions with the class.

4. Project the ***Fishing Types*** slideshow.

5. Advance each slide after students have completed their corresponding part os their handout. Pause when you reach Slide 6.

6. In popcorn format, ask students to share their answers from questions 1-3.

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7. Advance to Slide 7 and review the answers with the class.

8. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:

   - Which fishing method would catch the most fish?
   - Which method of fishing seems the most sustainable? Why?
   - What does sustainability mean?
   - How do we know if something is sustainable?

9. Share with students the definition of sustainability: Meeting the needs of the present, without compromising the ability of future generations to meet their own needs.

10. Ask the class to brainstorm reasons why it is important to know whether or not something is sustainable. ***To leave resources for future generations; to preserve the environment; to prevent polluting natural resources like air, water, and soil; to prevent species from going extinct; etc.***

    Extension: Explain that a common way to determine whether an activity or product is sustainable is to evaluate how it affects the economy, environment, and society. Ask for students to give examples of how fishing can affect our economy, environment, and society.

Activity[24]

1. Share the following excerpt with the class:

   Commercial fishing is major source of food and jobs for hundreds of millions of people around the world. Decisions about food—how and where it is grown, how

CREDIT: WHOLOGWHY, FLICKR

it is processed, and how it is transported—all relate to sustainability. Today we are going to conduct a fishing simulation to explore some of these sustainability issues.

2. Give each student a copy of the handout ***Fishing Log***.
3. Review the directions with the class and instruct students how to complete the key.
4. Divide the class into groups of four or five.
5. Give each group one ocean.
6. Give each student one Dixie (drinking) cup and one spoon.
7. Tell the class that when you say "start fishing" they will have 20 seconds to fish using their spoon, not their hands.
8. **Season 1:** say "start fishing" and give the class about 20 seconds to fish. If students are not depleting their oceans, extend the time until the oceans are fairly empty.
9. Have each fisher count their catch and complete the corresponding row in their ***Fishing Log***.
10. In order to survive to the next fishing season, fishers must have caught at least two of the target species. Fishers who did not catch the minimum must sit out for the following seasons.
11. For every 2 items remaining in the ocean (i.e., 2 goldfish crackers) add 1 more of the same item (i.e., 1 goldfish crackers). Explain to the class that the organisms reproduced in between the seasons.

    Option: Create a spreadsheet to record each ocean's data. At the end of each round add the data to the spreadsheet. After students have completed their handout, project this graph and use it to lead a class discussion.

12. **Season 2:** Give one student in each group a serving spoon. The serving spoon represents a different fishing technology. The remaining students will use their teaspoons from the first season. Repeat Steps 8-11.
13. **Season 3:** Have students put aside the serving spoon. Give one student in each group a pair of tongs. The tongs represents a different fishing technology. The remaining students will use their teaspoons from the first season. Repeat Steps 8-11.
14. **Season 4:** In each group, allow one student to use a serving spoon and another student to use a pair of tongs. The remaining students will use their teaspoons from the first season. Repeat Steps 8-11.
15. Ask the class how fishers might survive if their ocean runs out of target species? ***Start fishing in a new ocean or change jobs.***
16. When an ocean runs out of fish, allow students to move to another ocean. Repeat steps 8-11 until most, or all, of the oceans are depleted.
17. Give the class time to complete their handout.
18. Ask for a few students to share their answers to questions 1-3.
19. Lead a class discussion using the following prompts:
    - Did everyone in your group try to take as many fish as possible? Why, or Why not?
    - How did you feel when others took more fish than you?
    - What are the consequences of some people taking too many fish?
    - What rules or technologies could be developed to ensure fisheries are sustainable?
20. Move on to Part II or collect the handouts and save them for when you return to Part II.

Part II

Introduction

1. Give students a few minutes to review their ***Fishing Log*** data from Lesson I.
2. While students are reviewing their data, draw the following table on the board. Leave enough space for every student

to add their data.

	Target Catch	Incidental Catch	Bycatch
Total			

3. Invite students to the board to write their information in the table or fill out the table as students call out their numbers.
4. As a class, add up the total target catch, total incidental catch, and total bycatch.
5. Have the class calculate the percentage of bycatch [bycatch/(target catch + incidental catch + bycatch)]*100. Write these numbers on the board.
6. Share the following excerpt with the class:

   In addition to overfishing, bycatch is another major problem around the world. Bycatch occurs when fishers catch animals that they did not mean to catch, or when fishing gear harms or kills marine animals like dolphins, whales, seals, seabirds, or turtles. In the US, approximately 17% of catch is bycatch.[25] Around the world, about 40% of catch is bycatch.[26]

7. Have students write their own definition of bycatch.
8. Review the following definition with the class:

   Bycatch—The species that fishers accidentally catch. Sometimes this catch is discarded because fishers do not want it, cannot sell it, or are not allowed to keep it.

9. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:
   - Why can bycatch be a problem?
   - How is bycatch related to sustainability?
   - How could fishers decrease bycatch?

Activity

1. Share the following excerpt with the class:

   Most bycatch occurs because fishing gear can cover a large area—longlines can be 80 km (50 mi) long—and it is often unselective. Unselective means that fishing gear catches not only the target species but many other types animals as well. Bycatch can also happen when nets are lost at sea. Lost nets can continue to capture animals. In order to reduce bycatch, scientists, engineers, and fishers are working together to design better gear that more selectively targets species.

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2. Give each student or pair of students a ***Fishing Gear Redesign*** handout and a ***Fishing Gear*** card.
3. Review the handout directions with the class.

   Option: Give students string and sticks to test out different methods. Students might also research different animal deterrent methods online (e.g., what methods might repel seabirds).

4. Encourage students to be creative. As long as their redesign demonstrates that it might reduce bycatch, there are no right or wrong answers.
5. If students are having a hard time redesigning their device, give them some of the following prompts:
   - Could the shapes or sizes of the nets or hooks be changed?
   - Could anything be added to or removed from the gear?
   - What methods might deter non-target species (e.g., noises, lights, scents, etc.)?
   - How might gear only attract the target species (e.g., prey, scents, lights, etc.)?
   - What digital technology could fishers use to avoid bycatch (e.g., apps to track marine mammals and sea turtles)?

   Option: Print and share pages 51-53 of the ***Fishing Techniques to Reduce the Bycatch of Threatened***

CREDIT: ROBERT COUSE-BAKER, FLICKR

Marine Animals paper with the class or have students explore the awardees of the *Bycatch Reduction Engineering Program*.

6. Once students have finished their handout, bring the class back together.

7. Tell students that they will have 1-2 minutes to describe their fishing gear and the improvements that they made. During the presentation, the audience should think about the redesign and be prepared to offer constructive feedback.

8. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:

   - Besides improving fishing gear, what other ways could we make fishing more sustainable?
   - What role to consumers—people like you and me who buy seafood—play in sustainable fisheries?

Discussion Questions

1. How might a subsistence fisher and a commercial fisher be affected differently by declining fish populations?
2. How can technology affect fisheries?
3. How can we better manage common resources (resources that belong to everyone), such as air, drinking water, or ocean resources?
4. The earth's resources are finite. How can we ensure that people today and in the future have enough fish in the sea?
5. In addition to changing fishing gear, how else could fishers, engineers, or governments minimize bycatch?

Action Project

Is the fish in your cafeteria sustainable? Have students interview cafeteria workers to see what types of fish is being served and where it comes from. Students can use *FishWatch* or *Seafood Watch* to find more sustainable choices and recommend them to the cafeteria.

Extensions

Debate

Some people have proposed using aquaculture, or fish farming, as a way to reduce pressures on wild fish populations. Have students research the pros and cons of aquaculture. Host a class debate in which students most support their position.

Geography and Culture

Around the world, subsistence farming, fishing, hunting, and gathering is still an important part of some cultures. Assign each student a different country and have them research the subsistence resources and methods of one culture within their assigned country.

Government

Many countries have developed guidelines and regulations to help reduce overfishing and bycatch. Have students choose a country and one of their major fisheries. Students can research current regulations, what is working well, and what could be improved.

Math

Governments around the world enact catch limits to help reduce overfishing. Have students decide which variables they would include to determine catch limits.

Policy

In the US, dolphin-safe standards and turtle excluder devices have been promoted to reduce bycatch. Have students research the effectiveness of these programs and make recommendations for improvements.

Writing

Have students respond to the following quote from J. Clarence Davies in regards to fishing: "Today's world is one in which the age-old risks of humankind - the drought, floods, communicable diseases - are less of a problem than ever before. They have been replaced by risks of humanity's own making..."

Additional Resources

Book

Bruce McMillan: *Salmon Summer* (32 pages, 710L)
This book follows the summer journey of nine-year-old Alex. Alex, a Native Aleut living on Kodiak Island in Alaska, helps his family catch, clean, and preserve salmon, halibut, and Alaskan king crabs.

Case Studies and Profiles

Emmonak: A Modern-Day Eskimo Town Fights for Subsistence
This photo essay chronicles Emmonak, a Yup'ik Eskimo town on the western coast of Alaska, where families are struggling to maintain the subsistence lifestyle of their ancestors.

People of the Big Water
The Xikrin are a subsistence culture in Brazil whose livelihoods are being affected by the world's third-largest dam.

Voice from the Fisheries
This database contains oral history interviews from commercial, recreational, and subsistence fishers.

Websites

Ending Seabird Bycatch
This website provides an overview of seabird bycatch and different technologies that are being used to address this problem.

FishWatch
This website contains a database of the most sustainable seafood.

Smart Gear International Competition
This competition hosted promotes innovative ideas that reduce bycatch and more selectively target fish species.

Videos

Make Better Seafood Choices (4:49)
Learn how to make more sustainable seafood choices.

Save the oceans, feed the world! (11:06)
Learn how sustainable fisheries help feed the planet, provide jobs for fishers, and help marine ecosystems thrive.

Subsistence (2:55)
Find out why subsistence is so important to Native Alaskans.

Yukon Kings (7:15)
Follow a Yup'ik fisherman as he teaches his grandkids how to fish during the summer salmon run.

CREDIT: JPELLGEN (@1179_JP), FLICKR

Name Date Period

Compare and Contrast

1. Describe what is happening in the Commercial Fishing slide.

2. Describe what is happening in the Recreational Fishing slide.

3. Describe what is happening in the Subsistence Fishing slide.

4. Read the Fishing Types slide before completing the following table.

Fishing Type	What is the purpose of this type of fishing?	What happens to the fish that are caught?	What tools are used?
Commercial Fishing			
Recreational Fishing			
Subsistence Fishing			

Compare and Contrast, Page 2

5. What is the difference between commercial fishing and recreational fishing?

6. What is the difference between recreational fishing and subsistence fishing?

7. How do you imagine life differs between a subsistence fisher and a commercial fisher? How might their lives be similar?

Name Date Period

Fishing Log

Part I: Fishing Key
Directions: Complete the key below by writing or drawing the corresponding items in the left-hand column.

	Target catch Fish you are trying to catch. These fish will be sold at the market or eaten by your family.
	Retained incidental catch These are animals that you are not trying to catch. Even though you catch them accidentally, you can still sell them at the market or eat them.
	Bycatch These are animals that are not trying to catch. Unlike retained incidental catch, you cannot sell or eat bycatch.

Part II. Fishing
Directions: In this activity, you will act as a fisher. Your livelihood depends on catching fish. You must catch at least two target species to feed your family and move on to the next round. If you catch extra fish, you can sell them at the local market.

When the fishing begins, you will use your "net" (teaspoon) to catch "fish" from the "ocean" (bowl) and deposit them into your "boat" (cup). You may not put any animals back into the ocean, even if they are unwanted. After each fishing season, complete the corresponding row in the table below.

Season	Fishing Tool	# Target Catch	# Retained Incidental Catch	# Bycatch	# Fish Left in the Ocean	Observations
1	Teaspoon					
2						
3						
4						
5						
6						

Fishing Log, Page 2

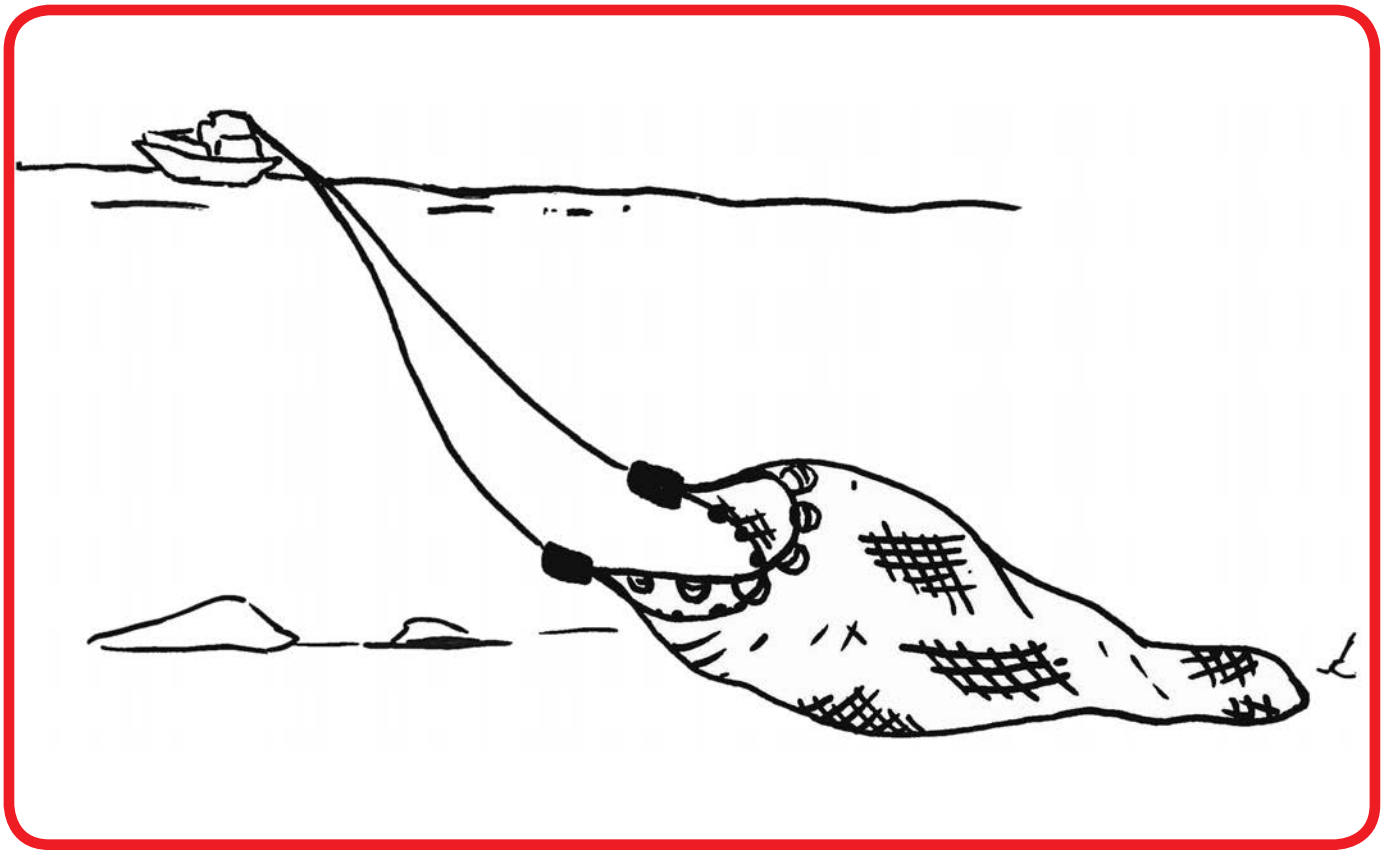
Part III. Analyzing
Directions: Answer the following questions using complete sentences.

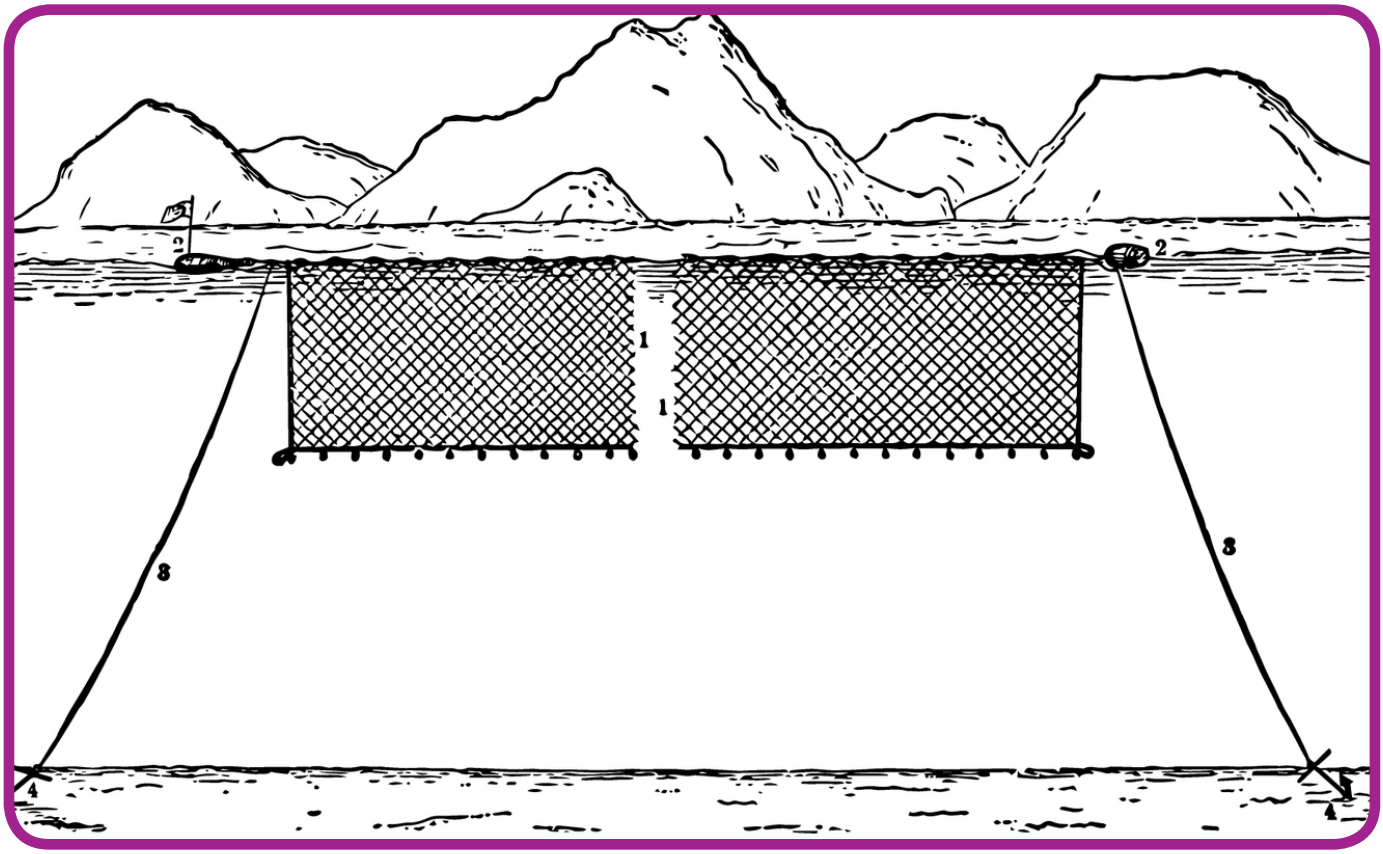
1. How does this activity relate to real ocean and fishing issues?

2. How did you feel when your ocean had fewer and fewer fish?

3. Do you think the fishers in your ocean were fishing sustainably? If not, how could the fishers in your ocean have acted more sustainably?

Fishing Methods Cards





Bottom Trawl

Overview
Bottom trawling is an industrial fishing method where a large net with heavy weights is dragged across the seafloor. When it is dragged across the seafloor, it scoops up everything in its path.

Target Catch
Fishers use bottom trawls to catch shrimp, crabs, and groundfish such as halibut and sole.

Bycatch
Before the net reaches the ocean floor, it filters a lot of water. On its way to the ocean floor, it can catch other fish or invertebrates, such as squid or jellyfish. Animals can also be caught as the net is hauled back up to the ship. Many sea turtle species rest and forage on the bottom and are at risk of being captured in bottom trawls. Marine mammals can become entangled by trawl gear when swimming. Pilot whales and common dolphins are particularly susceptible to being caught.

Bycatch reduction
A turtle excluder device is a grid of bars with an opening either at the top or the bottom of the trawl net. Small animals such as shrimp pass through the bars and are caught in the bag end of the trawl. When larger animals, such as sea turtles and sharks, are captured in the trawl, they strike the grid bars and are ejected through the opening.

Video
https://youtu.be/BcJFSl_YJHk

Credit: Food and Agriculture Organization of the United Nations

Gill Nets

Overview
Gillnetting uses curtains of nets. The nets are suspended by a system of floats and weights. Fish can only get their head through the netting, not their body. The fish's gills then get caught in the mesh as the fish tries to back out of the net. As the fish struggles to free itself, it becomes more and more entangled.

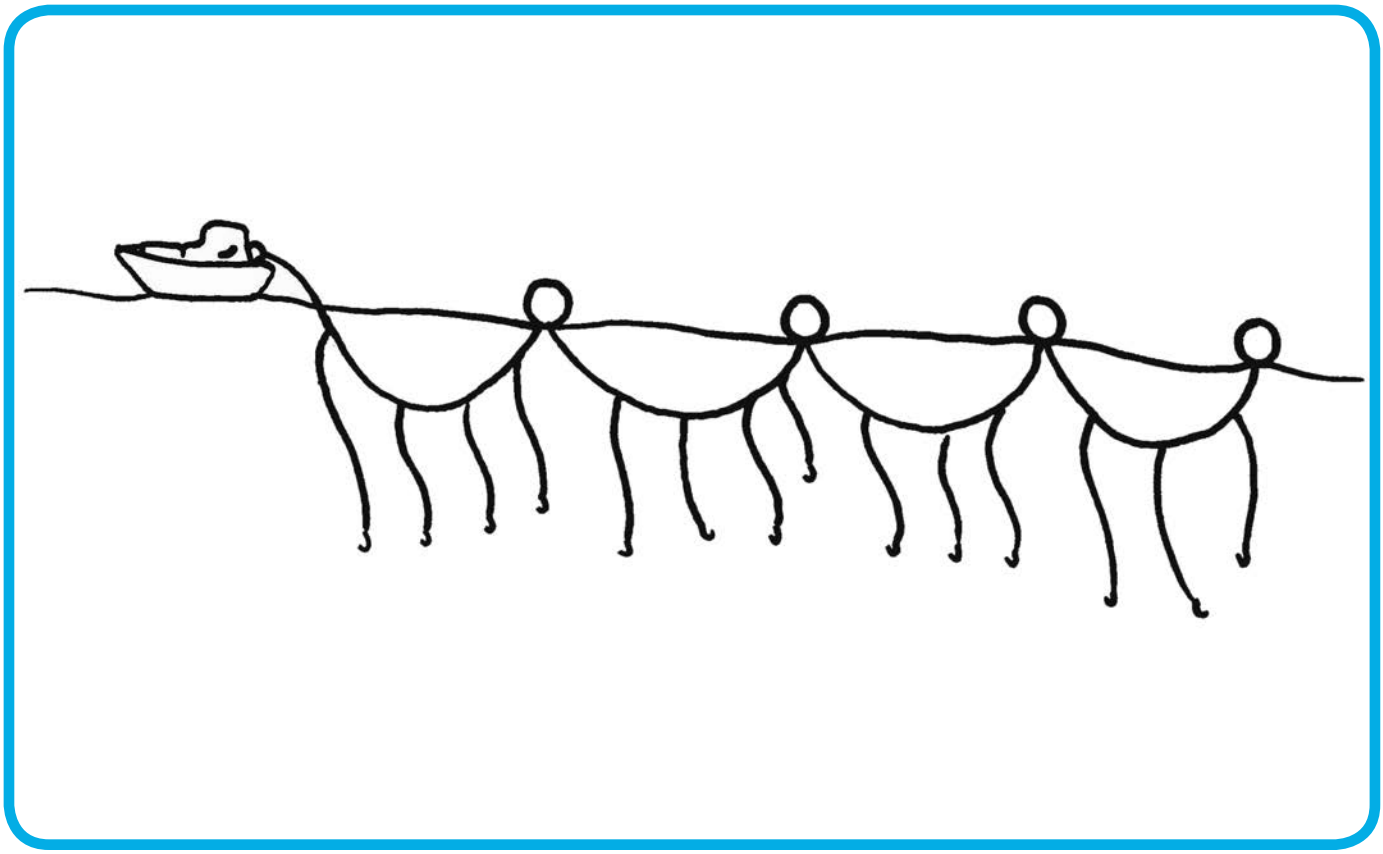
Target Catch
Gill nets are often used to catch cod, salmon, sturgeon, and tuna.

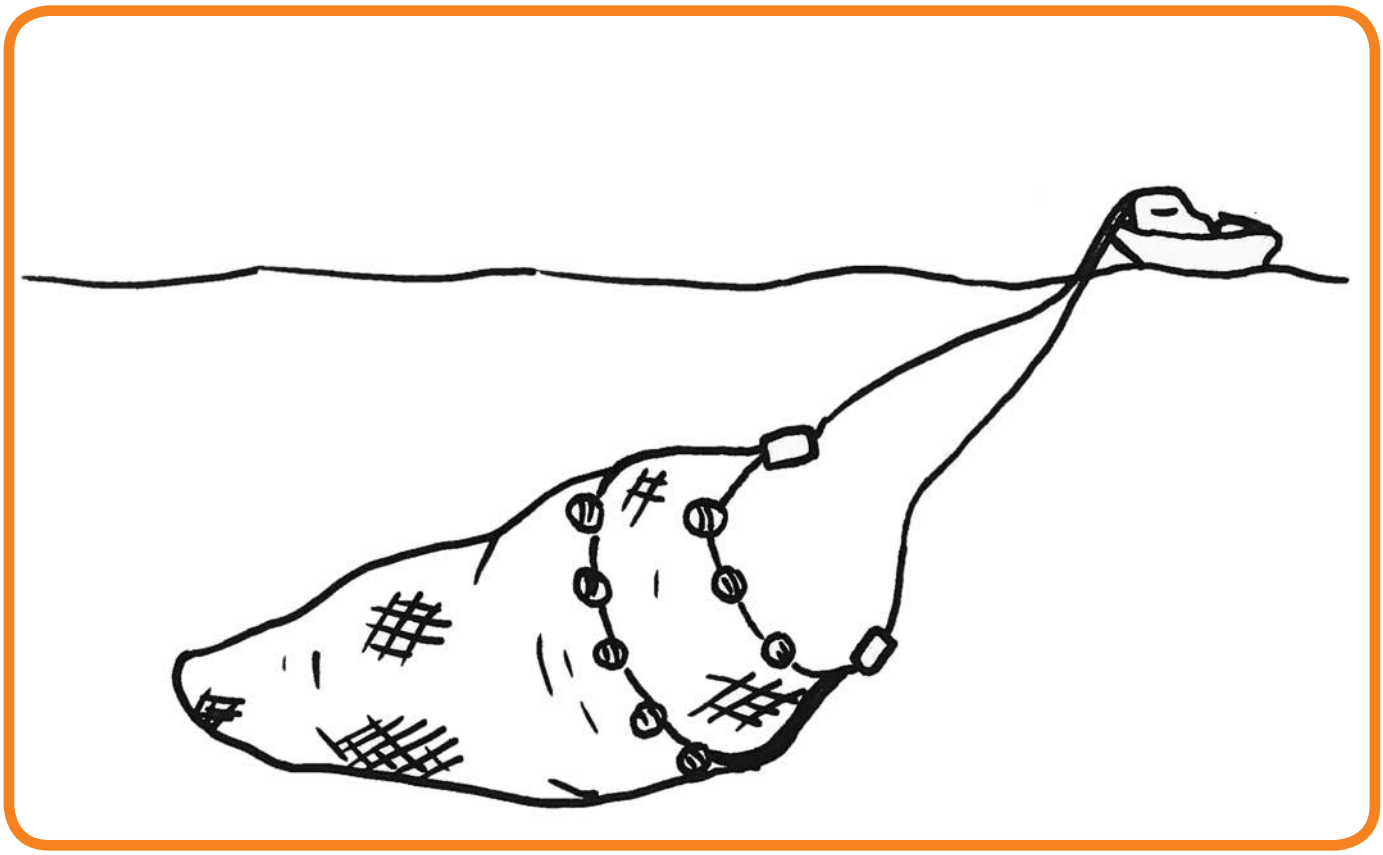
Bycatch
Gillnetting has been a major source of mortality for all sea turtle species. Turtles encountering a gillnet can quickly become entangled around their head or flippers as they try to escape. Gillnets can also entangle a wide variety of marine mammals, including large whales, porpoises, dolphins, and Steller sea lions. Animals can become entangled around their necks, mouths, and flippers.

Bycatch reduction
A streamer line, also called a bird scaring line, is a line with streamers. It is towed from the top of a boat. This helps scare away birds and prevents them from being caught in nets.

Video
https://youtu.be/AXyCCVXFmWk

Image credit: Morphart Creation, Shutterstock





Longline

Overview
A longline has one main fishing line that can range from 1-50 miles long. This main line has smaller lines of hooks with bait.

Target Catch
Longlines can be set near the surface of the water to catch fish such as tuna and swordfish. They can also be laid on the ocean floor to catch fish like cod and halibut.

Bycatch
Sea turtles can be attracted to the baited hooks. Loggerheads and leatherbacks are the species most commonly captured as bycatch. A hook can penetrate the turtle's flippers, head, mouth, or neck. If a turtle swallows an entire hook, it can become lodged in the turtle's digestive track. Pilot whales, false killer whales, sharks, and seabirds are known to steal bait and or target catch from longlines. Their mouths can be hooked or they can become entangled in the lines. Risso's dolphins, bottlenose dolphins, and several species of whales have been documented as bycatch.

Bycatch reduction
Most fishing hooks are J-shaped. Circle hooks have a much smaller opening. These hooks are much less likely to be swallowed by turtles and marine mammals.

Video
https://youtu.be/cjQQI56BT2o

Image credit: Food and Agriculture Organization of the United Nations

Midwater Trawl

Overview
Midwater trawls are large nets that are pulled through the water. The nets are so large that they catch an entire school of fish at one time.

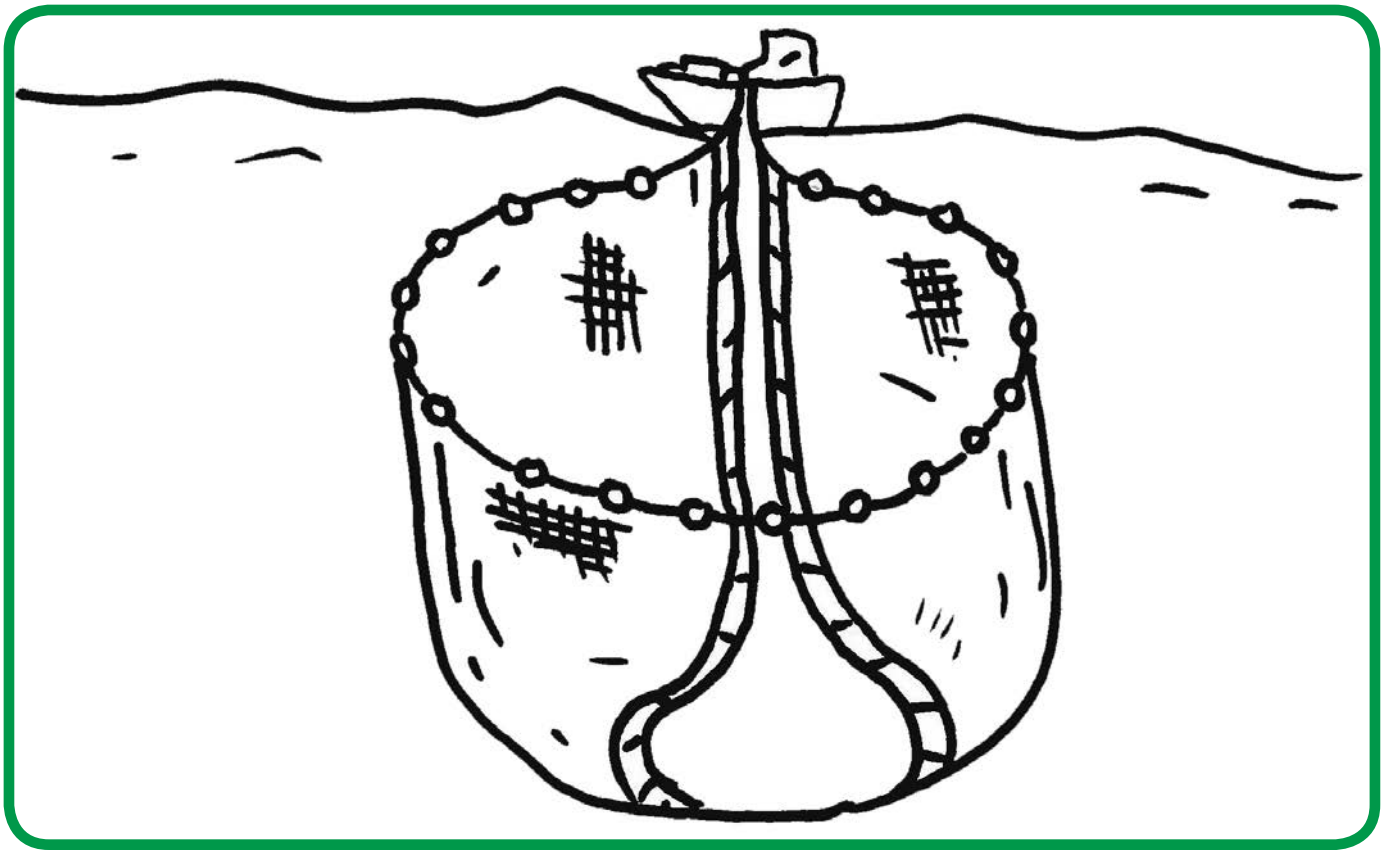
Target Catch
Midwater trawls are often used to catch squid, shrimp, and sardines.

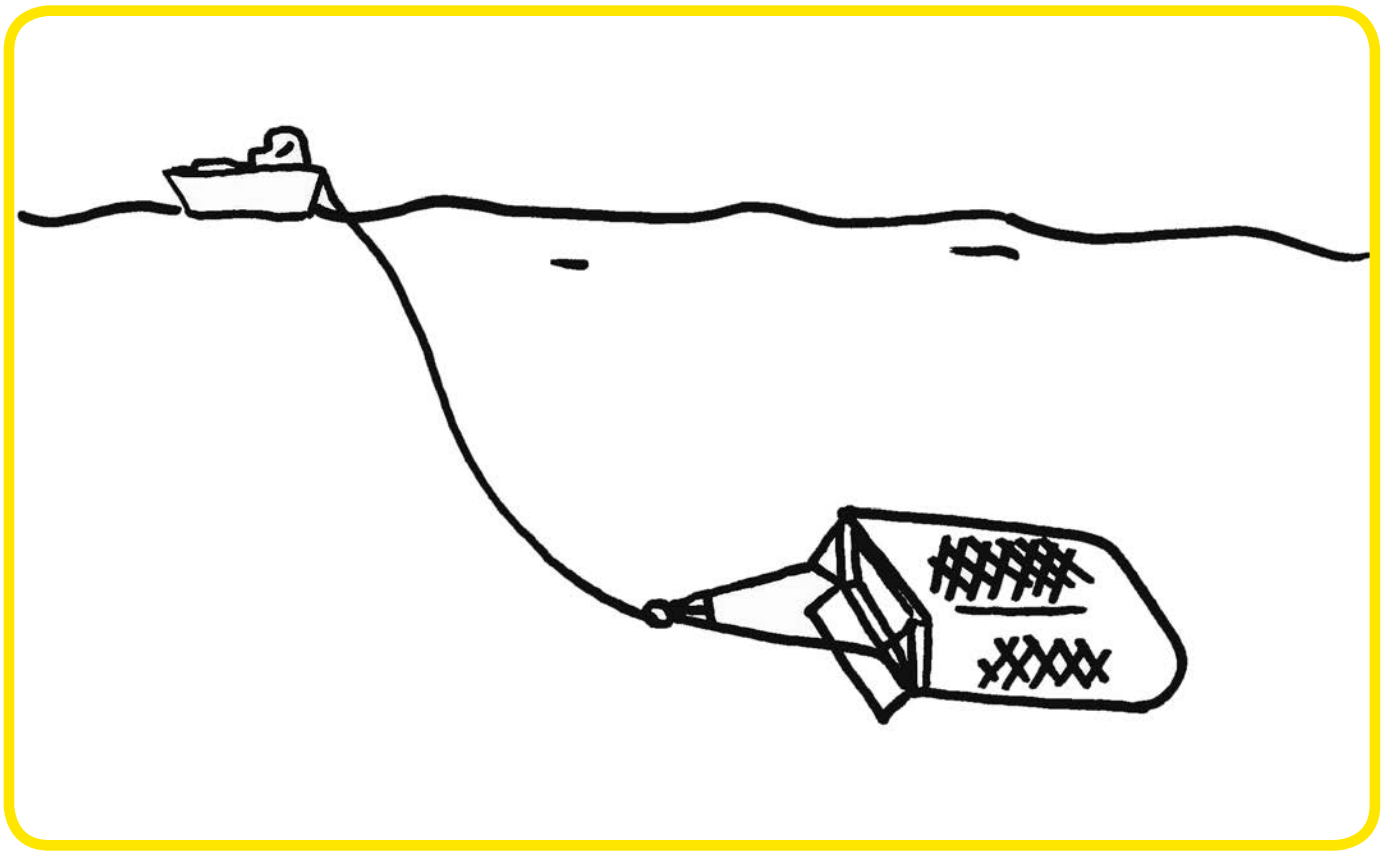
Bycatch
When the net is being released into the ocean or brought back to the ship, it filters a lot of water. This can unintentionally catch animals. As sea turtles swim to and from the ocean floor they are at risk of being captured. Many species of marine mammals forage (eat) and swim at midwater depths. This puts them at a high risk of being captured or entangled. They can also become confused due to boat noise. Pilot whales, white-sided dolphins, bottlenose dolphins, killer whales, and Steller sea lions are particularly susceptible to being caught in midwater trawls.

Bycatch reduction
A turtle excluder device is a grid of bars with an opening either at the top or the bottom of the trawl net. Small animals such as shrimp pass through the bars and are caught in the bag end of the trawl. When larger animals, such as sea turtles and sharks, are captured in the trawl, they strike the grid bars and are ejected through the opening.

Video
https://youtu.be/DzSFB4H9MC8

Image credit: Food and Agriculture Organization of the United Nations





Purse Seine

Overview
Purse seining creates a large wall of nets that encircle schools of fish. Fishermen pull the bottom of the netting closed—like a drawstring purse—to herd fish into the center. Fish aggregating devices are used to attract fish. These devices float in the water and are wrapped in bait. The bait attracts target catch, and bycatch, to the net.

Target Catch
This method is used to catch schooling fish, such as sardines and tuna. It is also used to catch species that gather to spawn, such as squid.

Bycatch
Purse seining is a non-selective fishing method. That means it captures everything that it surrounds. Sea turtles are frequently caught or entangled by purse seines. Marine mammals can also be encircled by the nets. They often cannot escape and can become entangled, injured, or stressed. Bottlenose dolphins, humpback whales, and several species of sharks are frequently caught in purse seines.

Bycatch reduction
Purse seines that do not use fish aggregating devices catch less bycatch. Instead of attracting fish to their nets, fishers go out to hunt for fish.

Video
https://youtu.be/kljRgbODbOw

Image credit: NOAA Fisheries

Dredge

Overview
In this fishing method, a dredge is dragged across the sea floor. ***Scraping dredges*** collect animals in the top layer of seafloor. ***Penetrating dredges*** use water jets to chase animals out from beneath the sediment and into the collection bag.

Target Catch
Dredges typically target oysters, scallops, clams, mussels, crabs, urchins, cucumbers, and conches.

Bycatch
Loggerhead, Kemp's ridley, and green sea turtles are commonly injured or captured in dredge fisheries. Pilot whales and common dolphins are particularly susceptible to being injured by dredging. In addition to being captured, small cetaceans, like dolphins or porpoises, can become entangled in the tow lines.

Bycatch reduction
Turtle deflector dredges block the entrance to the dredge and push sea turtles out of harm's way.

Video
https://youtu.be/pK767idHYmM

Image credit: Food and Agriculture Organization of the United Nations

Name Date Period

Fishing Gear Redesign

Directions

Your mission is to prevent marine animals from becoming bycatch. You will redesign one type of fishing gear so that it catches less bycatch. You might consider redesigning the nets or hooks; deterring potential bycatch; or creating tools that will help fishers avoid bycatch.

First, read your ***Fishing Method*** card. Then spend some time brainstorming your design before answering the questions below.

1. What is the name of your fishing method?

2. Which animals are you trying to catch?

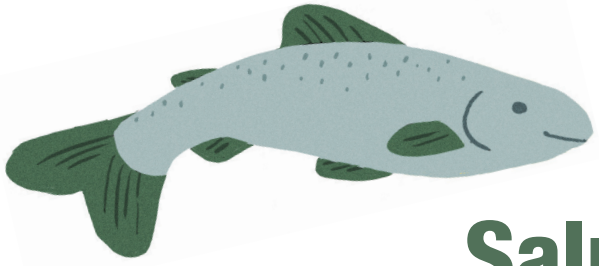
3. Which animals are you trying to avoid?

4. Describe how you would change this fishing gear.

5. How do your improvements prevent bycatch?

Fishing Gear Redesign, Page 2

6. Draw a picture of your redesigned fishing gear. Label any parts that might be unclear.



Lesson 8

Salmon Survival

During a free write, students brainstorm what salmon need to survive and the challenges they may face throughout their lifetime. A dice game is used to model the natural and human-made challenges facing salmon at difference stages of their life. Students use data from the game to calculate a salmon's chances of surviving into adulthood. A class discussion reveals the pros and cons of using a dice game as a model and how the game can be improved to better model salmon survival rates.

Objectives

Students will:

- Free write about what salmon need to survive and the challenges they encounter during migration.
- Play a game that simulates the challenges salmon face throughout their lifetime.
- Graph the percentage of salmon that spawned in each round of the game.
- Discuss the pros and cons of using games as a model.
- Calculate a salmon's probability of surviving into adulthood and spawning.

Students will understand:

- That salmon face many human-made and natural obstacles during their migration.
- Games can be useful for modeling concepts, but they may not be completely accurate.
- A very low percentage of salmon survive into adulthood.

Time Required

Approximately 1 hour.

Preparation

□ Cards: *Salmon Survival*
Print one set of cards per 15-20 students. Print single sided.

□ Dice
Gather 27 dice per set of 15-20 students.

□ Handout: *Salmon Survival Scorecard*
Print 1 copy per student.

□ Spreadsheet: *Salmon Survival Data*
Download and display this spreadsheet during Activity 1, Step 11 to aggregate the class' game data.

□ Display copy: *Salmon Survival Pyramid*
Project this diagram during Activity II, Step 1.

□ Cards: *Salmon Survival Explanation* (optional) Print 1 set of cards per student or group of 3-4.

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Keywords

Life cycle—The series of stages through which a living thing passes from the beginning of its life until its death.

Model—A system or thing used as an example.

Probability—The chance that something will happen.

Spawner—A mature salmon that is migrating back to its home stream to reproduce.

Supporting Vocabulary

Anadromous—Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.

Embryo—An unborn or unhatched offspring.

Migration—The relatively long-distance movement of individuals, usually on a seasonal basis.

Mortality rate—The ratio of the total number of deaths of individuals to the total population.

Replacement level—The amount of fertility needed to keep the population the same from generation to generation.

Survival—The act of staying alive, especially under adverse or unusual circumstances.

Background Information

A single female salmon can lay between 1,500 and 10,000 eggs.[27] The number of eggs laid varies greatly by species. Due to natural and human-made causes, only 0-10 of these eggs

CREDIT: MICHAEL VERHOEF, FLICKR

will survive to adulthood.[28] The survival rate can vary greatly depending on the species, location, and water conditions. For example, coho salmon are more susceptible to pollution than the other species of Pacific salmon, so in waters that are polluted, fewer coho survive to reach adulthood.[29]

The table below lists some of the major challenges facing salmon throughout their different life cycle stages.

Life cycle stage	Primarily natural challenges	Primarily human-made challenges
Egg	Disease Predators Unfertilized	Drought Warm water Turbidity (sediment in the water)
Alevin Fry Smolt	Disease Parasites Predators	Drought Habitat loss Invasive species Lack of prey Passage barriers (e.g., dams) Pollution Warm water
Ocean Adult	Disease Parasites Predators	Fishers Lack of prey Ocean acidification Warm water
Migrating Adult	Disease Parasites Predators	Drought Fishers Habitat loss Passage barriers (e.g., dams) Pollution Warm water

Lesson

Introduction

1. Have students create a t-chart. They should label the left-hand column "Needs" and the right-hand column "Challenges".
2. Ask students to close their eyes and imagine the salmon life cycle—imagine the salmon swimming in their home stream, growing bigger, and migrating out to sea. What might salmon need to complete their journey? What challenges might salmon encounter throughout their migration.
3. Give students 1 minute to write down all of the things salmon need to survive and the challenges they might encounter on their migration.
4. Have a few students share their answers. ***Salmon need cool, clean water to survive. Insects, fish, squid, etc. to eat. Rocks and fallen trees to hide. Gravel to make nests. During their migration, salmon face many challenges including predators, dams, drought, pollution, etc.***
5. Ask the class what happens to salmon whose needs are not being met. ***They might get sick, they might not be able to reproduce, they might die.***

Activity I

1. Divide the class into groups of 15-20.
2. Have each group arrange their desks or tables in a circle or square.
3. Give each group a set of ***Salmon Survival*** cards.
4. Ask students to arrange the cards in order on top of desks. Cards should be dispersed evenly around the circle and in consecutive order.
5. Give each group 27 dice.
6. Ask students to place one pair of dice next to each card with a number inside a circle. The subsistence fishing card will only need one die.
7. Give each student a copy of the handout ***Survival Scorecard***, and review the directions with the class.
8. Show students where they should go (to the side of the room) after they have completed their 3 rounds (lives).
9. Ask students to recall the directions:
   - Where do they start? ***At the egg card.***
   - How do they move on to the next card? ***Roll a number***

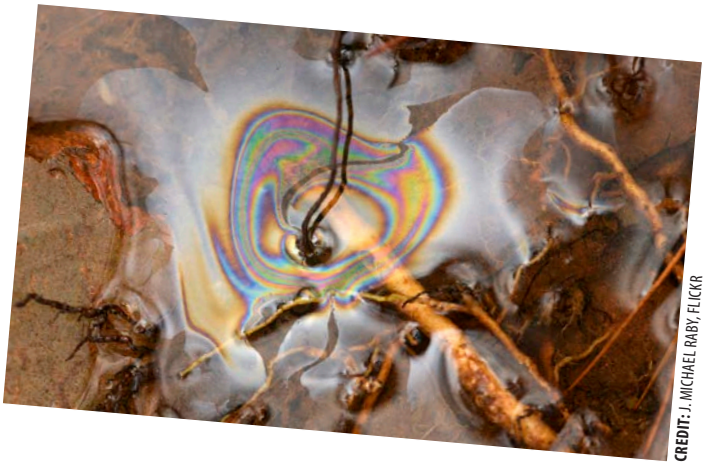
equal to or higher than the number in the circle.

- How do they die? ***Roll a number less than the number inside the circle or by spawning.***
- How many lives do they have? ***3***
- What happens after they die? ***Record the card number on their worksheet.***
- What happens after they die 3 times? ***Enter the data into the class spreadsheet and then answer the questions on the worksheet.***

10. Have students line up at the first card, Egg, and begin the game.
11. While students are working, project the spreadsheet *Salmon Survival Data*.
12. After students have completed their 3 rounds (lives), help them enter their data from Part I into the spreadsheet. Enter each student's data into a different column.
13. Once every student has completed their 3 lives and entered their data into the spreadsheet, project sheet 2 titled Class Data.
14. Have students complete Part IV of the handout.
15. Review the answers from Parts III and IV with the class. Be sure students justify their answers and graphs.
16. Lead a class discussion or think-pair-share exercise using the following prompts
    - What patterns did you notice in the game?
    - Does the percentage of spawners surprise you? Why, or why not?
    - Do you think the percentage of spawners is similar to what happens in real life? Why, or why not?

Activity II

1. Project the ***Salmon Survival Pyramid*** display copy.
2. In think-pair-share format, ask students to create a caption for the ***Salmon Survival Pyramid***.
3. Ask a few pairs to share their answers.
4. Share with the class that less than 1% of wild salmon survive to become spawning adults. For every 3,000 salmon eggs laid, only about 2 will survive to spawn.



CREDIT: J. MICHAEL RABY, FLICKR

5. Ask the class to compare and contrast these data with the data from their game.
6. Share with the class that games and models are used to help simulate or illustrate real data. In the field, scientists collect data about many different plants, animals, and environmental conditions. For example, they might count the number of salmon returning to their home stream; the temperature of the ocean in different locations and seasons; the amount of fish being caught by commercial fishers; etc.
7. Lead a class discussion, think-pair-share exercise, or free write using the following prompts:
    - What characteristics of this game made it a helpful model?
    - What characteristics of this game are unhelpful for teaching people about the survival rate of salmon?
    - How this game could be made more accurate? ***Complete more rounds and have a bigger sample size/more students participating***

Discussion Questions

1. Do you think the spawning numbers were always less than 1%? Why might this number have changed over time?
2. Why are low spawning numbers problematic?
3. How do low salmon numbers affect the ecosystem?
4. How do low salmon numbers affect people?
5. How can threatened or endangered salmon populations recover with such low spawning numbers?

CREDIT: MILES CARY, FLICKR

Action Project

Recent research has shown that urban runoff is so toxic that it can kill an adult salmon in less than 2.5 hours.[30] Urban runoff often contains a mixture of oil, gasoline, diesel, antifreeze, and heavy metals from brake pads. Urban runoff can be reduced when people walk, bike, and take public transportation. When cars need to be used, it is important that they are properly maintained to prevent the drips and leaks that ultimately wash into waterways. Students can work with your local transportation agencies and mechanics to create a ***Don't Drip and Drive*** campaign. During this campaign, mechanics can volunteer to diagnose car leaks and encourage people to fix these issues.

Extensions

Biology

How do scientists count spawning salmon and their eggs? Have students brainstorm different methods that biologist might use in the field.

Engineering

Fish passage engineers are **designing ways for salmon to overcome dams** and other passage barriers. Have students research the different methods being used and evaluate their effectiveness. Students can try to create models of these technologies and improve their design.

Math

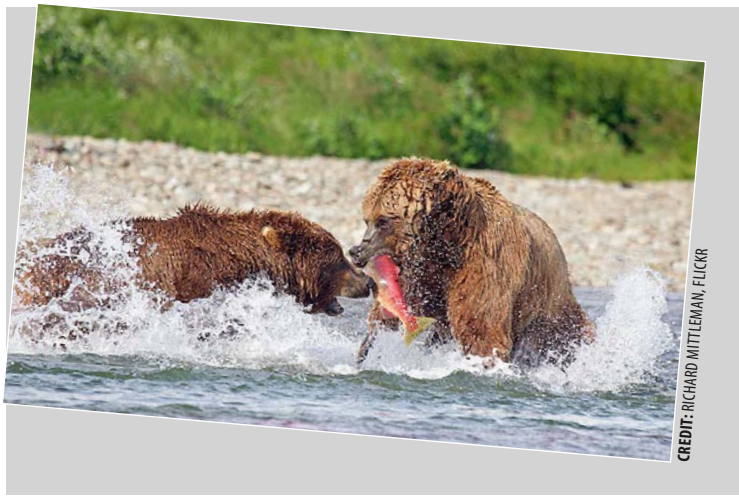
Explain that without enough salmon returning to spawn, salmon may face extinction. Have students think about how many salmon are needed to maintain a population and what criteria they would include in a population model.

Physical Education

Set up an obstacle course so that students can act out the salmon life cycle. Label one side of the gym as a river and the other side as the ocean. Use blue tape, ribbon, or string to outline the borders of the course. Consider using a web of string (fishing nets); ramps (waterfalls); heat lamps (warm water); cans, bottles, and other trash (litter); chairs covered in blankets (culverts); etc. to set up your course.

Writing

Assign each student to a factor from the game (e.g., commercial fishing, habitat restoration, predation, etc.). Have students research and write about how this factor affects salmon.



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Additional Resources

Books

Robert Snedden: *Environmental Engineering and the Science of Sustainability* (32 pages, 1110L)
Students will learn how environmental engineering began, and the many processes environmental engineers apply to find sustainable solutions to problems.

Sally Hewitt: *Your Local Environment* (32 pages, IG860L)
This book challenges students to look at the importance of caring for the world around them, and making it a better place for people, plants, and animals.

Brochures

NOAA Fisheries: Good Habitat, Bad Habitat
This handout illustrates the factors that contribute to good salmon habitat and bad salmon habitat.

NOAA Fisheries: I'm Counting on You
This brochure describes what salmon need to survive and what people can do to help.

Interactive

esri: FishViews
FishViews let you navigate rivers, coasts, and shores. Data can be viewed, recorded, and shared for specific locations along waterways.

Videos

PBS: Running the Gauntlet (53:19)
This video from PBS explores the challenges that modern salmon face and what people are trying to do to save them from extinction.

Animal Planet: Salmon Upstream (43:23)
Why are salmon disappearing from British Columbia? This documentary examines the many causes contributing to declines of salmon populations.

Name Date Period

Salmon Survival Scorecard

Background: During this game, you will experience the salmon life cycle. You will also encounter some of the challenges that salmon might face. The goal of the game is to become a spawner so that you can create the next generation of salmon.

Game Directions:

1. Line up at the first card, titled "You are an embryo inside an egg."
2. Move to the next card, "Turbidity."
3. Roll the dice.

If you roll a number:

- Equal to or greater than the number on the card in a circle, you can move to the next card.

- Less than the number on the card in a circle, your turn (life) is over. You must record your data in Part I and then start over from the first card, "You are an embryo inside an egg."

Bonus: Some cards have an additional number on the bottom. If you roll this number, you can skip ahead.

4. If you make it to the "Spawner" card, record your data in Part I and then start again from the first card, "Redd".
5. Keep playing the game until you have completed 3 turns (lives).
6. After you have completed your 3 turns (lives), move on to Part II of this worksheet.

Part I. Game Data
Directions: After each round (life), record the card where your salmon "died".

Round	Card number (1-14 or spawner)
1	
2	
3	

1-2 = Embryo/egg
3 = Alevin
4-5 = Fry
6-7 = Smolt
8-12 = Ocean adult
13-14 = Migrating adult
Spawner = Spawner

Part II. Record Your Data
Directions: Work with your teacher to record your data in the spreadsheet on the computer.

Part III. Individual data questions
Directions: Answer the questions below using your data from the game.

1. What was the highest life cycle stage you achieved?

   _____

2. What was the lowest life cycle stage you achieved?

   _____

3. Do you think your data is similar to what happens in real life? Why, or why not?

   _____

Salmon Survival Scorecard, page 2

4. How could this game be improved to better illustrate what happens in real life?

Part IV. Class data questions
Directions: After everyone in the class has entered their data into the spreadsheet, complete the questions below.

1. Which round was the most successful (highest number of spawners)?

2. What life cycle stage had the highest mortality? Is this similar to real life? Why, or why not?

3. Create a graph that shows the percentage of salmon that spawned in each round. Be sure to label each axis. If necessary, create a key.

Name

Salmon Survival Scorecard, Page 3

4. Why did you chose this type of graph?

5. Did the number of spawners vary greatly between different rounds?

6. In the wild, do you think the number of spawners changes a lot each year? Why, or why not?

YOU ARE AN EMBRYO INSIDE AN EGG.

Photo credit: Debbie Frost, NOAA Fisheries West Coast Region

1. TURBIDITY

4+

Logging, agriculture, mining, road building, urbanization, and construction can increase sediment in waterways, which decreases the clarity of water (turbidity). Salmon eggs rely on a steady flow of clean, cold water to deliver oxygen and remove waste. Eggs in turbid water are less likely to hatch.

Photo credit: MPCA Photos

2. WARMING WATER

5+

Climate change, dams, and industrial discharge can increase water temperature. Salmon eggs will not hatch if the water is too warm. Warm water also makes salmon more susceptible to predators, parasites, and disease.

Photo credit: Tim J Keegan, Flickr

YOU ARE NOW AN ALEVIN.

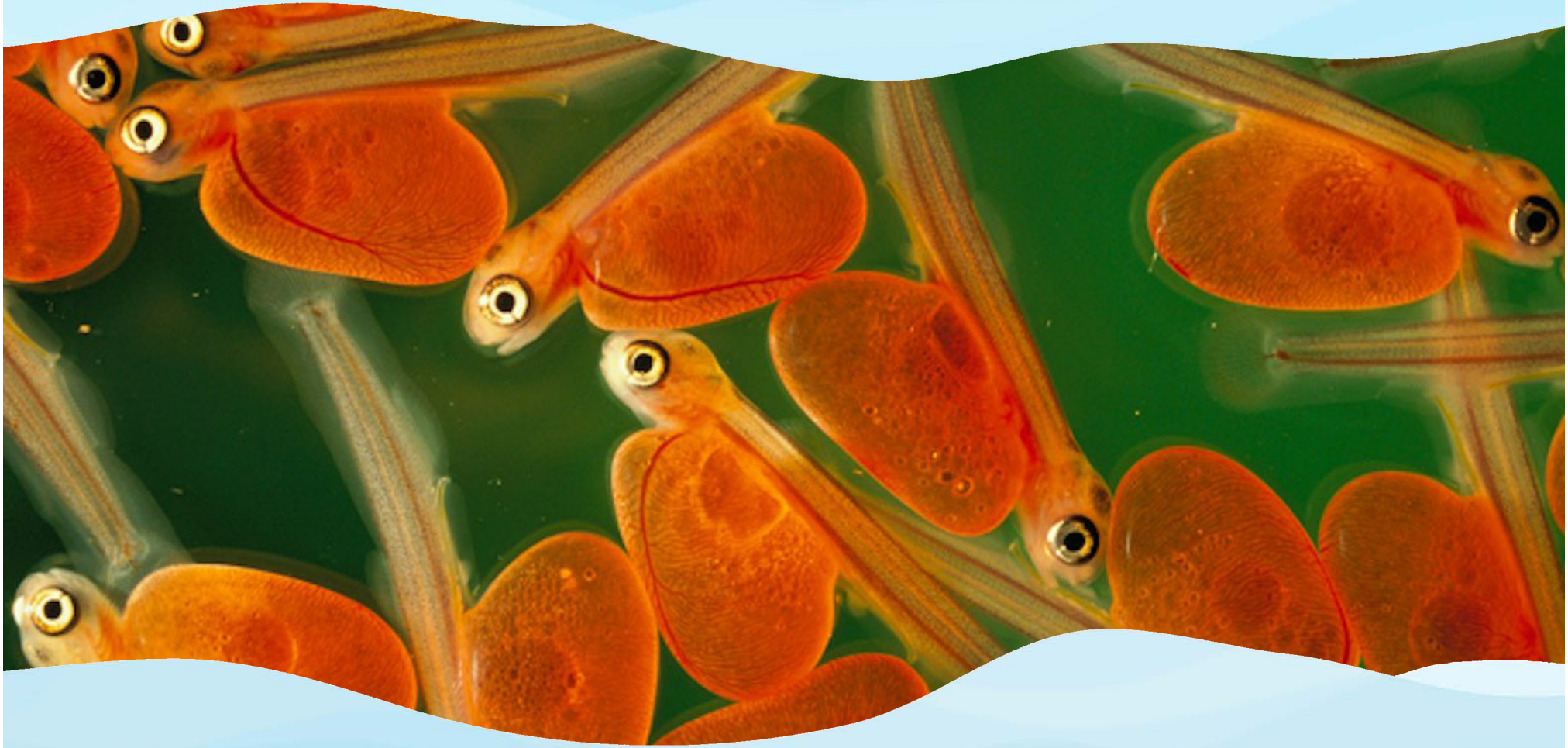


Photo credit: National Park Service

3. Habitat Loss

7+

ROLL A 6

Thanks to community restoration projects, you live in a healthy watershed. Swim ahead two spaces.

Photo credits: Top - credit waltarrrrr, Flickr; Bottom - Chesapeake Bay Program

YOU ARE NOW A FRY!

Photo credit: Paul Kaiser, US Fish and Wildlife Service

4. DISEASE

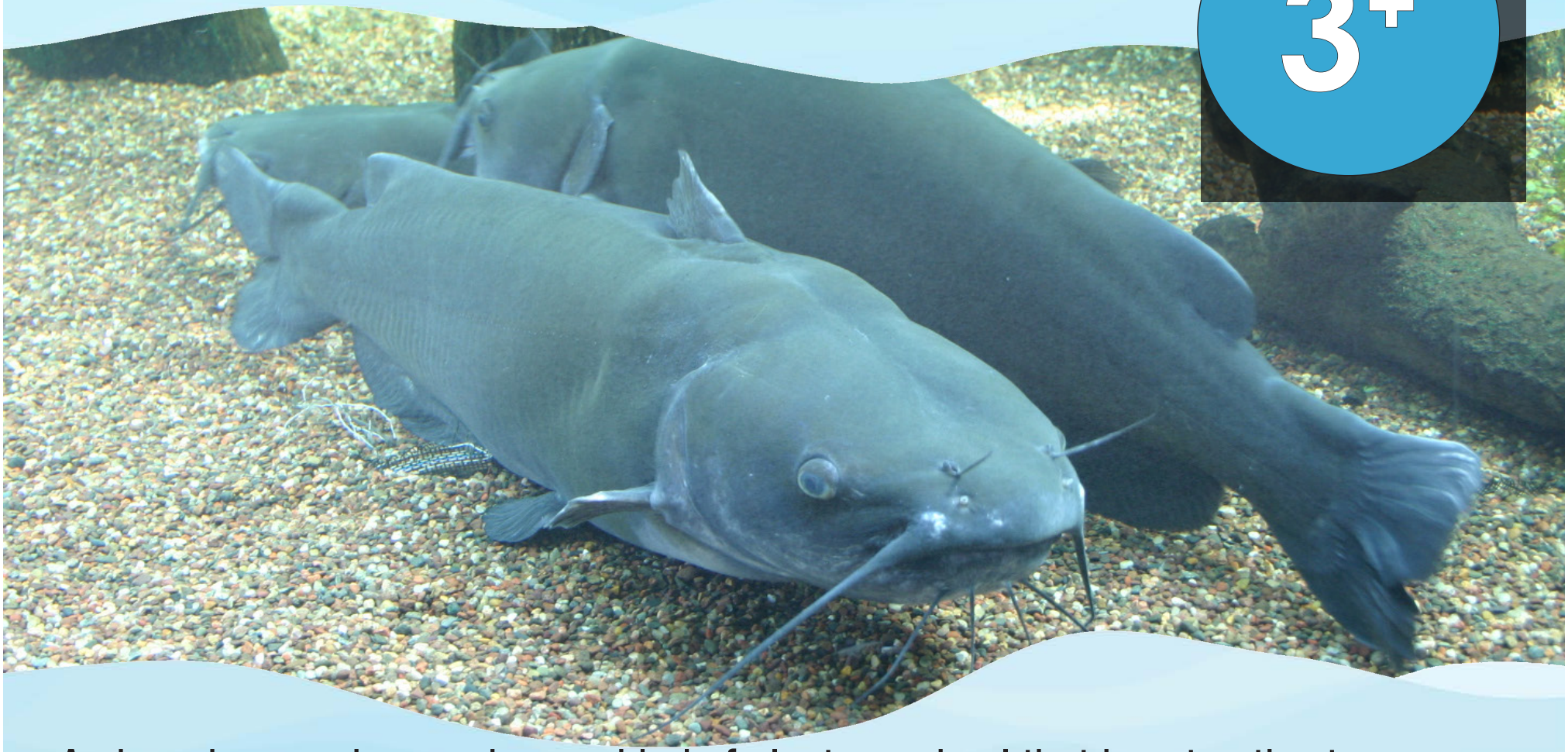
3+

Fish, just like other animals, are subject to a variety of diseases. These include environmental and nutritional diseases as well as infectious diseases caused by bacteria, viruses, or parasites. Warming water temperatures make salmon more susceptible to disease.

Photo credit: US Fish and Wildlife Service

5. INVASIVE FISH

3+



An invasive species can be any kind of plant or animal that is not native to an ecosystem and also causes harm to the ecosystem. Invasive fish, such as smallmouth bass, channel catfish, and brook trout eat young salmon and outcompete them for food.

Photo credit: Ryan Somma, Flickr

YOU ARE NOW A SMOLT!

Photo credit: NOAA Fisheries

6. PASSAGE BARRIERS

6+

ROLL A 7Thanks to a new fish ladder, you are able to migrate upstream and downstream more easily. Swim ahead two spaces.

Photo credits: Top - Tennessee Valley Authority; Bottom - Amit Patel, Flickr

7. PREDATION

5+

At every stage of their lives, salmon are susceptible to predators. While they are in estuaries and their bodies are adjusting to saltwater, salmon are particularly vulnerable to predators.

Photo credit: David Craig, Flickr

YOU ARE NOW AN ADULT IN THE OCEAN!

Photo credit: US Fish and Wildlife Service, Pacific Region

8. PREY AVAILABILITY

5+

When the oceans are cold, salmon primarily feed on Pacific sand lance and smelts, which triggers their growth. When waters are warmer, there is less food available, and they primarily eat juvenile anchovies and rockfish, which are less-desirable.

Photo credit: Mandy Lindeberg, Aaska Fisheries Science Center

9. OCEAN ACIDIFICATION

4+

Ocean acidification is primarily caused by increases in carbon dioxide through the burning of fossil fuels. When carbon dioxide dissolves in water, it forms an acid. When the oceans become too acidic, salmon lose their sense of smell and are less likely to find prey or to avoid their predators.

Photo credit: MPCA Photos, Flickr

10. Commercial Fishing

6+

Commercial fishing is catching fish and other seafood for a profit. Commercial fishing can be done in a simple manner with small boats and little technical equipment. It can also be done on a large scale with powerful deep-sea boats and sophisticated industrial equipment.

Photo credit: Seabank Org, Flickr

11. SUBSISTENCE FISHING

2+

Subsistence fishing is a type of fishing in which most of the fish is eaten by the fisher and their family. The fish that is caught is not sold for profit. Subsistence fishers often use traditional fishing methods such as rod and tackle, fishing arrows and harpoons, cast nets, and small fishing boats.

Photo credit: US Forest Service Region 5

12. RECREATIONAL FISHING

5+

ROLL A 7

Thanks to sustainable seafood apps, more people are fishing and eating sustainable seafood. Swim ahead two spaces.

FISHWATCH
U.S. SEAFOOD FACTS

Photo credits: Top - Juhan Sonin, Flickr; Bottom - FishWatch

YOU ARE NOW A MIGRATING ADULT!

Photo credit: Northwest Fisheries Science Center

13. URBAN RUNOFF

6+

Thanks to rain gardens, pollution has been filtered from stormwater runoff before it reached your home stream. Swim ahead two spaces.

Photo credits: Top - CameliaTWU, Flickr; Bottom - PA Resources Council

14. DROUGHT

8+

Drought can harm salmon at many points in their life cycle. A lack of water in streams and rivers can prevent salmon from reaching their home stream.

Photo credit: Shever, Flickr

YOU'VE MADE IT HOME TO SPAWN!

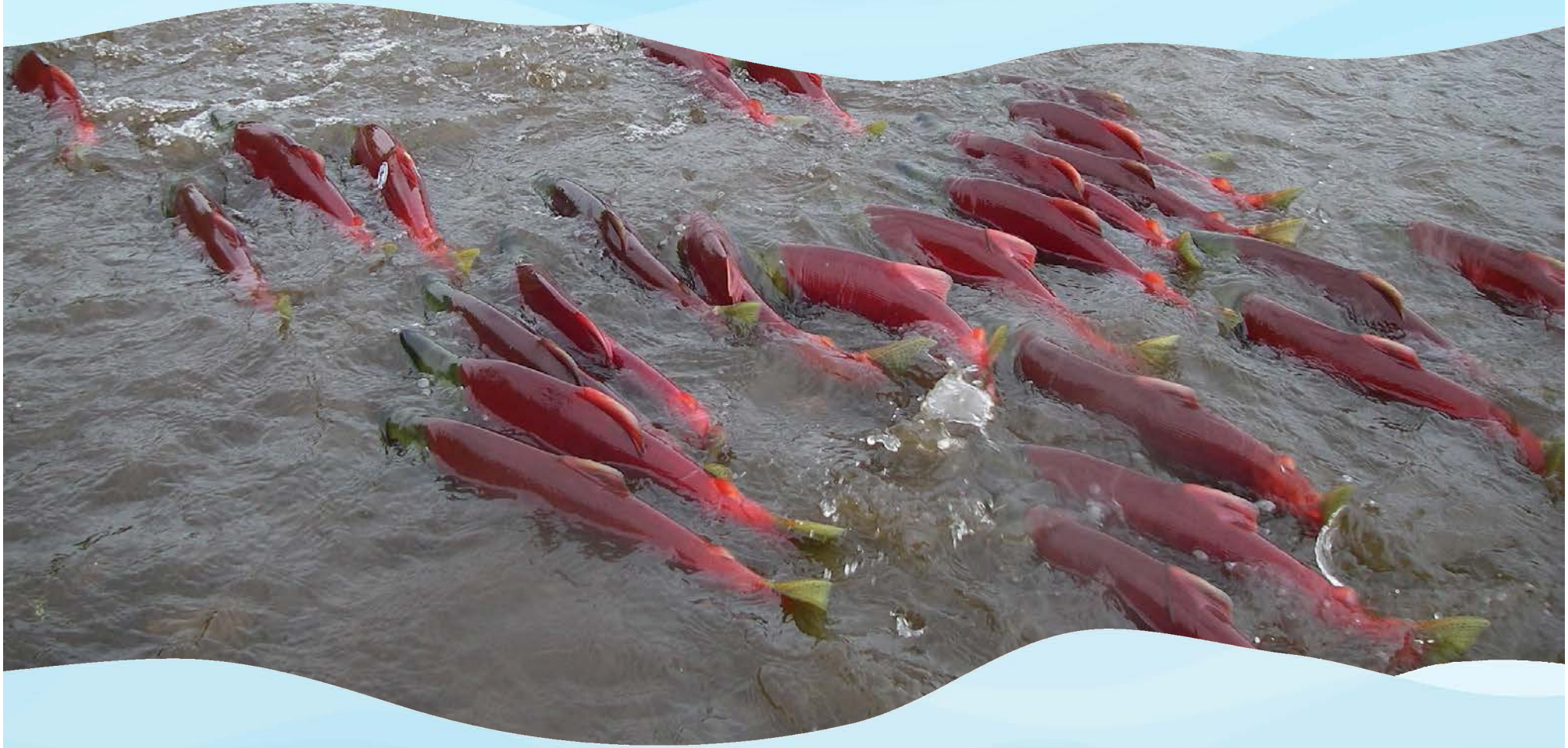
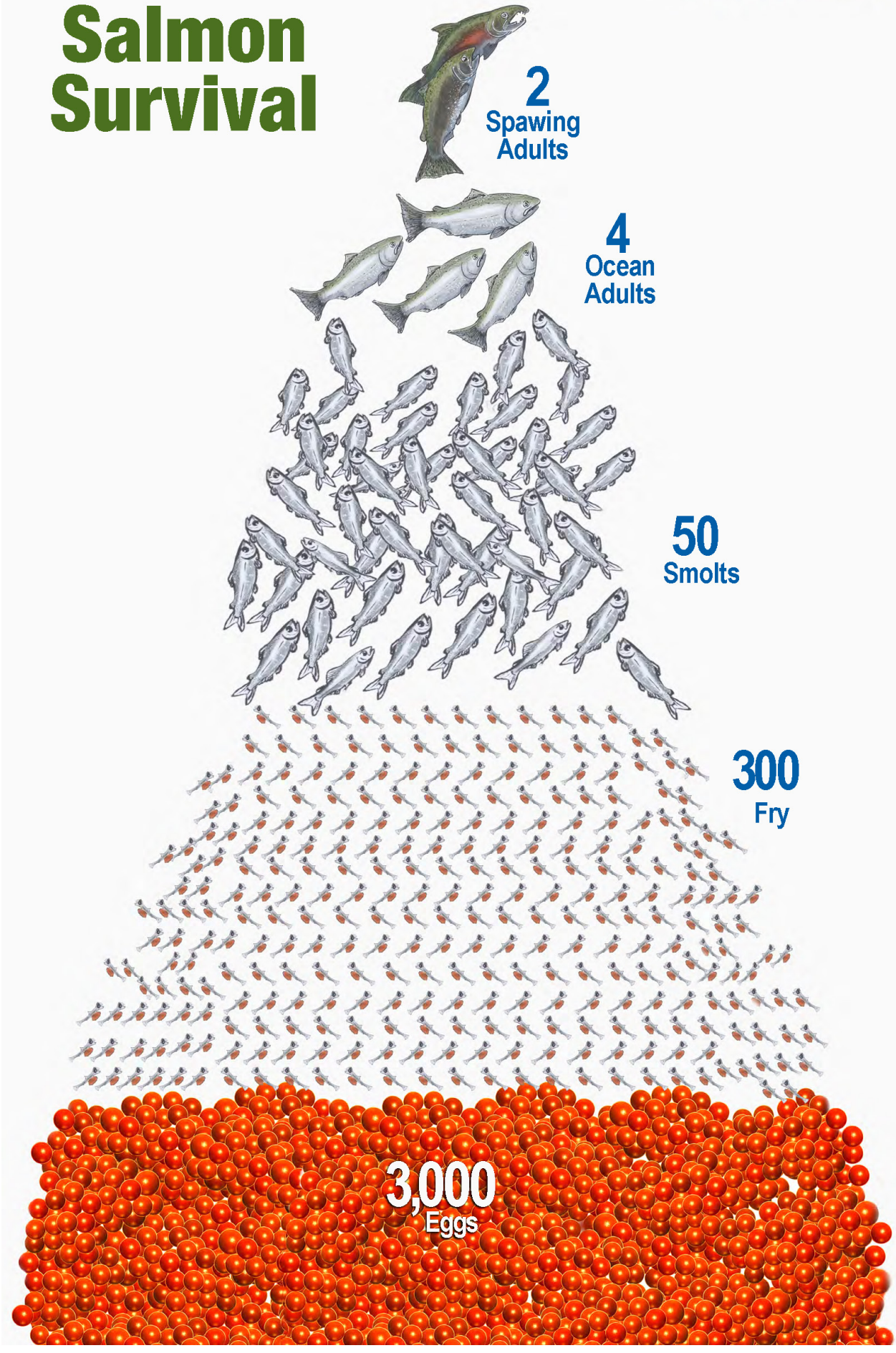


Photo credit: National Science Foundation

NOAA FISHERIES

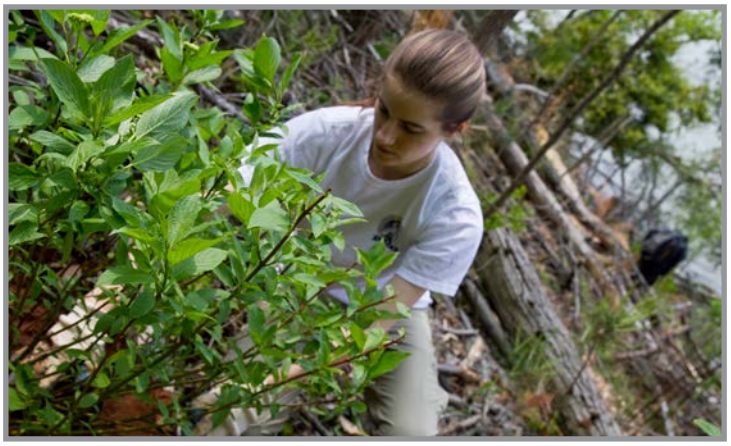
Salmon Survival



Credit: MPCA Photos, Flickr

Credit: Tim J Keegan, Flickr

Credit: waltarrrrr, Flickr

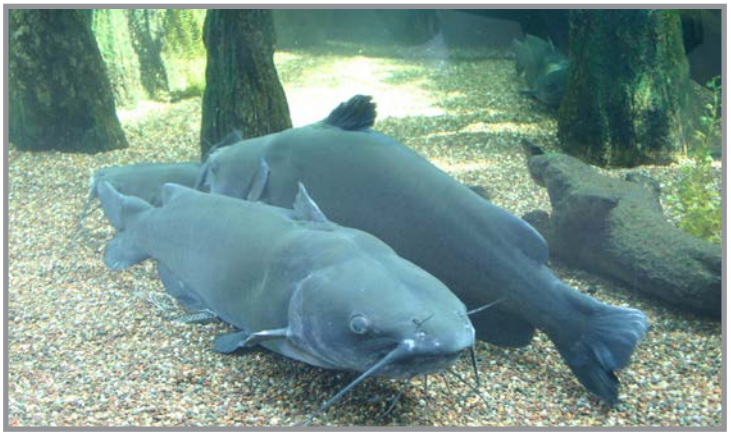


Credit: Chesapeake Bay Program

Credit: David Craig, Flickr

Credit: US Fish and Wildlife Service

Credit: USFWS Fish and Aquatic Conservation, Flickr



Credit: Ryan Somma, Flickr

Warming Water
Climate change, dams, and industrial discharge can increase water temperature. Salmon eggs will not hatch if the water is too warm. Warm water also makes salmon more susceptible to predators, parasites, and disease.

Turbidity
Logging, agriculture, mining, road building, urbanization, and construction can increase sediment in waterways (turbidity). Salmon eggs rely on a steady flow of clean, cold water to deliver oxygen and remove waste. Eggs in turbid water are less likely to hatch.

Habitat restoration
Salmon cannot survive in warm water. Plants shade the water and help keep water cool. Wood and roots from shoreline plants help shelter young fish from predators. Plants also filter runoff and hold soil in place to minimize erosion.

Habitat loss
Salmon habitat has been affected by logging, mining, grazing, irrigation, road construction, and urban development. In most western states, about 80-90% of the historic riparian habitat has been eliminated. As of 2017, Washington and Oregon have lost 33% of their wetlands, while California has lost 91%.

Disease
Fish, just like other animals, are subject to a variety of diseases. These include environmental and nutritional diseases as well as infectious diseases caused by bacteria, viruses, or parasites. Warming water temperatures make salmon more susceptible to disease.

Predation
At every stage of their lives, salmon are susceptible to predators. While they are in estuaries and their bodies are adjusting to saltwater, salmon are particularly vulnerable to predators. Common predators include sea birds, bears, seals, sea lions, toothed whales, larger fish, otters, and sharks.

Invasive species
An invasive species can be any kind of plant or animal that is not native to an ecosystem and also causes harm to the ecosystem. Invasive fish, such as smallmouth bass, channel catfish, and brook trout eat young salmon and outcompete them for food.

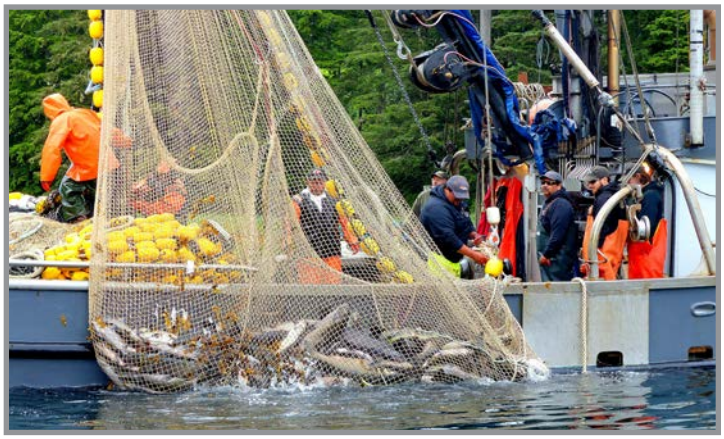
Invasive species removal
By removing invasive species, salmon have a much better chance of surviving. Invasive fish can eat salmon or outcompete them for food. Invasive plants can prevent salmon from migrating and reduce the amount of oxygen available in the water.

Credit: Tennessee Valley Authority

Credit: Amit Patel, Flickr

Credit: Mandy Lindeberg, Alaska Fisheries Science Center

Credit: MPCA Photos, Flickr



Credit: Seabank Org, Flickr

Credit: US Fish and Wildlife Service, Flickr

Credit: Juhan Sonin, Flickr

FISHWATCH
U.S. SEAFOOD FACTS

Fish Ladder
Fish ladders allow salmon to pass dams and other passage barriers. These ladders are water-filled and allow fish to swim up a series of steps.

Passage Barriers
Dams, culverts, tidegates and other barriers can impede fish from migrating both downstream and upstream.

Ocean Acidification
Ocean acidification is primarily caused by increases in carbon dioxide through the burning of fossil fuels. When the oceans become too acidic, salmon lose their sense of smell. When they lose their sense of smell, salmon are less likely to find prey or to avoid their predators.

Prey Availability
When the oceans are cold, salmon primarily feed on Pacific sand lance and smelts, which triggers their growth spurt. When waters are warmer, there is less food available, and they primarily eat juvenile anchovies and rockfish, which are less-desirable.

Subsistence Fishing
Subsistence fishing is a type of fishing in which most of the fish is eaten by the fisher and their family. The fish that is caught is not sold for profit. Subsistence fishers often use traditional fishing methods such as rod and tackle, fishing arrows and harpoons, cast nets, and small fishing boats.

Commercial Fishing
Commercial fishing is catching fish and other seafood for a profit. Commercial fishing can be done in a simple manner with small boats and little technical equipment. It can also be done on a large scale with powerful deep-sea boats and sophisticated industrial equipment.

Sustainable Seafood
Sustainable seafood programs, such as FishWatch and Seafood Watch, provide facts about which seafoods are the most sustainable. This helps consumers make informed decisions when buying fish at a market or ordering it at a restaurant.

Recreational Fishing
Recreational fishing is also known as sport fishing or angling. Fishers catch fish for fun, for competition, or to eat. Rods, reels, hooks, baits, and small boats are typically used to catch the fish. The fish are often released back into the water or cooked by the fishers. Recreational fishing does not include selling or trading fish.

Credit: Shever, Flickr

Credit: US Fish and Wildlife Service, Flickr

Credit: CameliaTWU, Flickr

Credit: EmNicholas, Flickr

NOAA FISHERIES

Rain Garden
Rain gardens are a natural solution to pollution. The combination of soil, roots, and vegetation help filter stormwater runoff from parking lots, rooftops, and roads. After going through the rain garden, the filtered water goes back into the soil.

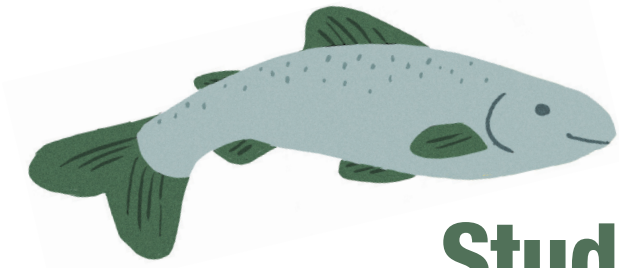
Drought
Drought can harm salmon at many points during their life cycle. When rivers and streams dry up, salmon eggs will die. If there is not enough water in streams and rivers, salmon cannot migrate to the ocean or back to their home streams.

Water Conservation
When we conserve water, more water is left in our waterways. Water conservation is especially important during drought, when salmon might not have enough water to complete their migrations.

Runoff
Rain cannot soak into hard surfaces such as roadways, parking lots, and rooftops. So rain streams across these surfaces and picks up oil, grease, heavy metals, pesticides, and other toxic chemicals. These pollutants flow directly into waterways. Stormwater runoff from urban roadways is so toxic that it can kill adult fish in as little as 2.5 hours.

NOAA Fisheries
Under the Marine Mammal Protection Act and the Endangered Species Act, NOAA Fisheries works to recover protected marine species while allowing economic and recreational opportunities.

Contact wcr.education@noaa.gov for more information.



Lesson 9

Student Stewards[31]

The lesson opens with a writing exercise in which students respond to prompts about the role salmon play in our society, economy, and environment. During a class discussion, students describe what the word stewardship means to them and list some reasons why stewardship is important. In small groups, students analyze case studies about youth environmental heroes and how their work ultimately affects salmon.

Objectives

Students will:

- Write about the role salmon play in our society, economy, and environment.
- Define the word stewardship and its importance to salmon and watershed health.
- Analyze case studies about youth who are working to protect watersheds and endangered species.
- Present information about their assigned case study.
- Summarize information presented about other case studies.

Students will understand:

- People of all ages are responsible for creating a sustainable future.
- Youth can be powerful change agents.
- By being stewards of salmon, we are also protecting watersheds and everything that lives in them.

Time Required

Approximately 1 hour.

Preparation

□ Handout: *Case Study*
Print 4-5 copies of each case study.

□ Handout: *Student Stewards*
Print 1 copy per student.

Keywords

Environmental stewardship—Responsible use and protection of the natural environment through conservation and sustainable practices.

Conservation—The protection of animals, plants, and natural resources.

CREDIT: CHESAPEAKE BAY PROGRAM, FLICKR

Background Information

Environmental stewardship empowers people of all ages to assume responsibility for creating a sustainable future. Teaching environmental stewardship involves fostering the development of several core values and beliefs. For students to become environmental stewards, they must understand that all people are part of the environment and that their actions can have affects both locally and globally. Stewards also understand that people have a responsibility to respect and care for Earth and all of its inhabitants.

Schools play an important role in preparing and empowering students to become stewards. Before students can take on this role, they must understand that youth can make a difference. In order to help students understand how they can make a difference, this lesson features case studies of students who are making change in their communities and beyond. The extensions following this lesson provide resources for students to learn more about stewardship and to become engaged on a deeper level.

Around the world, youth are working together to build stronger communities, create healthier environments, and raise awareness of endangered species. The case studies presented in this lesson highlight kids who are actively promoting water conservation, climate change solutions, salmon habitat restoration, and marine debris prevention. Each of these projects can ultimately contribute to watershed restoration and the recovery of salmon and inspire your students to take action in their own communities.

CREDIT: BUREAU OF LAND MANAGEMENT OREGON AND WASHINGTON

Lesson

Introduction

1. Write the following prompts on the board and give students a few minutes to complete each sentence on a piece of paper:

   - One of the most interesting things that I have learned about salmon is…
   - Salmon are a keystone species…
   - Salmon are important to culture…
   - Without salmon fishers…
   - Salmon are connected to people…

2. In think-pair-share format, have students share their answers.
3. Write the word ***stewardship*** on the board and ask students what the word means to them.
4. Explain that environmental stewardship refers to responsible use and protection of the environment.
5. In popcorn format or through a free write, have the students list reasons why people should be stewards of watersheds and salmon.
6. Ask students to share examples of how they, their family, their friends, or other community members have acted as environmental stewards.
7. Share the following excerpt with the class:

   Since salmon live in streams, rivers, estuaries, and the open ocean, the health of salmon populations are a good indicator of how well we are taking care of our ecosystems. By being stewards of salmon, we are also protecting watersheds and everything that lives in them—including people.

Activity

1. Share with the class that today they will be learning about young people around the world who are environmental stewards.
2. Divide the class into 6 evenly-sized groups.
3. Assign each group a different case study.
4. Give each student a copy of the assigned case study.
5. Instruct students how you would like them to read the case study (e.g., silently, together as a group, round robin, etc.).
6. Once groups are finished reading, give each student a copy of the handout ***Student Stewards***. Have students complete Part I.

   Option: Ask each group member to take on a different role such as reader, recorder, presenter, timekeeper, etc.

7. Tell the class that each group will have two minutes to present their case study. While groups are presenting, the audience will complete Part II of the handout ***Student Stewards***.
8. Give each group about two minutes to present their answers from Part I.
9. Bring the class back together and lead a class discussion using the following prompts:

   - Do any of these project inspire you to take action?
   - How could our class or school create programs like these?
   - How would you like to get involved in environmental stewardship?

Discussion Questions

1. What are some reasons people might want to become environmental stewards?
2. Do people have a responsibility to be environmental stewards?
3. What are important skills or characteristics of people who work to be environmental stewards?
4. How could getting involved in environmental stewardship projects improve your quality of life?
5. Do you need to complete big projects—like the ones in the case studies—to be a steward?

Action Project

Start a Stream Team or Salmon Savers program at your school. Stream Teams often monitor water quality, remove invasive species, pick up litter, and plant native species. In addition to these types of activities, Salmon Savers also educate the public about the health of local salmon runs and what people can do to help. The **National Wildlife Federation**, **Department of Conservation of New Zealand**, and **New South Wales Environment Protection Authority** provide step-by-step guides for designing and implementing school-wide programs. For additional support, contact **wcr.education@noaa.gov**.

CREDIT: MOUNT RAINIER NATIONAL PARK, FLICKR

Additional Resources

Books

Mary Coley: *Environmentalism: How You Can Make a Difference* (32 pages, 690L)
This book describes what environmentalism is and what students can do to make a difference.

Megan Kopp: *Living in a Sustainable Way: Green Communities* (32 pages, 1020L)
Students will discover how people around the world are choosing to live more sustainably.

Rae Simmons *Sustainable Lifestyles in a Changing Economy* (64 pages, 110L)
This book covers the effects of living unsustainably and small steps that kids can take, such as using less energy and shopping at second hand stores, to make a difference.

Guides

Shelburne Farms: The Guide to Education for Sustainability
Learn strategies for integrating sustainability into your school and curriculum.

Ontario EcoSchools: Environmental Stewardship Guide
This guide provides schools with tools for developing environmental stewardship campaigns for the whole school.

EPA: Volunteer for Change
Find examples of volunteer projects from around the country.

Video

Sylvia Earle: My wish: Protect our oceans (18:04)
Sylvia Earle shares astonishing images and stats about the ocean and encourages everyone to protect our planet.

The Grey Water Project - Fremont, California

"I started this project to be a part of the solution to the California drought."

- Shreya Ramachandran, Founder of The Grey Water Project

Around the world, drought affects millions of people. Because of droughts, some people might not have enough water to drink or to shower. Farmers may not have enough water for their crops or farm animals. Climate change is likely to make droughts become more regular and severe.

COURTESY OF T THE GREY WATER PROJECT

Drought not only affects people, but it also affects aquatic plants and animals. If there is not enough water in rivers and streams, salmon cannot migrate to or from the ocean. Salmon also need enough water to lay their eggs. If there is not enough water in streams or rivers, the water can become too warm for salmon to survive.

Shreya Ramachandran, a middle schooler in California, has seen these effects of drought first hand.

"I talked to people whose wells have run dry, leaving them waterless, and farmers who have lost their years' crops," said Shreya. "I was touched, and I wanted to find a way to help conserve water."

Soon after witnessing the effects of drought in California, Shreya travelled to India. In India, she noticed that the droughts were so severe that people had to abandon their farms or villages. She also noticed that many Indians had adapted to living through droughts.

"I learned about the many ways locals save water, including rainwater collection systems which are mandatory in every household," explained Shreya. "However, I was particularly interested in reuse of greywater (which is lightly-used water), especially from the laundry."

In India and other countries with frequent droughts, people often reuse water. Water from showers, bathtubs, kitchen sinks, and laundry is fairly clean. It can be saved to water gardens or flush toilets. This helps save water and money.

After returning to the US, Shreya's interest in reusing grey water continued to grow. Shreya was particularly interested in using grey water from laundry. After some research, she

COURTESY OF T THE GREY WATER PROJECT

The Grey Water Project, Page 2

COURTESY OF T THE GREY WATER PROJECT

found that some laundry detergents can be toxic to plants and aquatic life. If people are watering their gardens with grey water, they have to make sure it is safe for the environment.

After talking with her grandmother, Shreya found out about soap nuts. Soap nuts are a natural laundry detergent that comes from a berry. Shreya wanted to find out if this type of laundry detergent would harm plants and aquatic life too.

After a series of tests, Shreya found that soap nuts do not harm plants or wildlife. She was surprised to learn that grey water with soap nuts even helped the plants grow! This was a great finding since soap nuts cost less than most natural laundry detergents.

She presented her findings at local water districts. She also won several awards at regional, state, and national science fairs. Shreya's work has inspired so many people that she won the **President's Environmental Youth Award**. Way to go, Shreya!

After this discovery, Shreya formed The Grey Water Project. This program encourages Californians to conserve and reuse water. Through social media, Shreya shares information about conserving water and using grey water. She also gives presentations at local schools, water boards, libraries, and community events.

The Grey Water Project also hosts a water conservation challenge for kids. The challenge encourages kids to take shorter showers, turn off faucets when brushing their teeth, use grey water to water plants, and more.

To learn more about Shreya's project, visit:
www.thegreywaterproject.org.

COURTESY OF T THE GREY WATER PROJECT

Take Action!

Want to get your school or family involved in water conservation? Visit Water Use it Wisely for water saving tips, games, and contests.

www.wateruseitwisely.com/kids

WATER USE IT WISELY®

Pigtails Art - Sioux Falls, South Dakota

"Endangered animals are important to the planet and to people. My hope is that my project will inspire people all over the world and show children they have the power to change the world and save animals too."

- Bria Neff, Founder of Pigtails Art

Bria Neff has always had a passion for art. She first started drawing animals at age four. By second grade, she was entering and winning art competitions.

COURTESY OF AMITY NEFF

The Animal Action Education's 2015 Art and Essay Contest changed Bria's life. Her painting of an African lion was one winner of the contest. Bria was so inspired by winning this contest that she wanted to do more to protect endangered species. After the contest, she began asking her mom questions about why animals were endangered and what that meant.

"She wanted to know what endangered meant, how many animals were endangered and above all else—why? Why were they dying, why were they hunted, and what could she do to save them?" remembers Amity Neff, Bria's mom.

Bria's original goal was to raise $10,000 by her 11th birthday. The first painting she sold was a depiction of two lions, titled "Brotherly Love." This painting sold for $125. In her first year alone, she raised more than $5,000!

Bria's artistic process is thorough. Before painting an animal, Bria first finds pictures of the species and studies them. She even researches each animal at the library or by watching documentaries. To compliment her art, she writes a report about each species!

Bria likes to paint animals with detailed eyes and vivid expressions.

As Bria explained, "I wanted to give them a face so people would know how important they are."

Through her research, Bria has learned a lot about endangered species. She has learned that it is important to protect both animals and their habitats. She has also found that every species has an important role to play in its ecosystem. Habitat loss, deforestation, and climate change

COURTESY OF AMITY NEFF

COURTESY OF AMITY NEFF

are some of the major problems leading to extinction. By the time she was ten years old, Bria had painted over 200 species and donated $10,560! She gives the money to her favorite charities, including International Fund for Animal Welfare, The Wolf Conservation Center, and The Jane Goodall Institute.

To further raise awareness about endangered species, Bria has hosted art shows, published coloring books, and created social media campaigns.

In celebration of Earth Day 2016, Bria started a campaign called Chalk the Walk Earth Day. On social media, she asked people to make sidewalk art representing love for Earth. She then asked people to take pictures of their sidewalk art and post the pictures on social media. Bria plans to continue this campaign every Earth Day.

One of her coloring books is titled "Endangered Faces of The Great Plains Zoo." The book features coloring pages of the zoo's 24 endangered species, and messages about protecting animals.

The coloring book is sold at the local zoo. The profits are donated to the zoo's conservation programs. Bria hopes that her coloring books inspire other kids to make a difference.

"I hope they can learn that they can help and save the animals, and they can change the world," she said.

Since Bria has inspired so many people with her art and generosity, she was awarded the **2017 International Youth Eco-Hero Award**. Way to go, Bria!

To learn more about Bria's work, visit: **www.pigtailsart.com**.

COURTESY OF AMITY NEFF

Take Action!

Want to raise money for your favorite endangered species? Panda Nation provides fundraising tools for endangered species, such as salmon.

https://support.worldwildlife.org/site/SPageServer/?pagename=panda_nation_fundraising

PANDA NATION
Be the hero nature needs

The Solutionaries Project - Burlington, Vermont and Mzuzu, Malawi

"Ever feel like the world is all bad news? So did we. So we set out to find the people in our communities who are doing good things."

- Miles Lamberson, The Solutionaries Project

Sometimes the news can make us feel overwhelmed. Hearing about big events like climate change can even make us feel powerless. When people hear bad news, they often shut down instead of taking action.

COURTESY OF THE SOLUTIONARIES PROJECT

Students from Vermont Commons School were feeling overwhelmed after hearing about climate change disasters in their classes. Instead of ignoring climate change, the students made a plan.

"It's about seeing what is wrong with the world, and taking the steps to make it better—no matter how small those steps are." - Maggie Homer, The Solutionaries Project

The students set out to use the news to empower people, rather than paralyzing them with fear. Students from Vermont Commons School worked with students from Mzuzu Academy in Malawi, a small country in southeastern Africa, to create a podcast series. A podcast is like radio show on the internet.

Together, they launched The Solutionaries Project. During their podcasts the students interview local people who are taking action. Most of the podcasts focus on climate change. Others focus on community issues like poverty, happiness, and agriculture.

What does climate change have to do with salmon? Climate change can increase the temperature of water. If water is too warm, salmon eggs will not hatch. Another effect of climate change is ocean acidification. Ocean acidification makes it harder for salmon to detect predators and prey. Climate change can also cause more severe droughts. Without enough water, salmon can not migrate.

In one climate change-focused podcast, students interviewed Duane Peterson. Duane is a cofounder of a solar panel installation company called SunCommon. This company works to make solar panels cheap and easy to install. By making solar panels cheaper, more people can buy them. Instead of burning fossil fuels, solar panels use energy from the sun to create electricity. This reduces carbon dioxide emissions, a major cause of climate change.

COURTESY OF THE SOLUTIONARIES PROJECT

The Solutionaries Project, Page 2

COURTESY OF THE SOLUTIONARIES PROJECT

While The Solutionaries are working on their podcasts, they are gaining valuable skills. Students learn about different career opportunities. They work on their writing and editing skills. Maybe most importantly, they get to know members of their community.

To learn more about The Solutionaries Project, visit: http://solutionariespodcastproject.blogspot.com/.

COURTESY OF THE SOLUTIONARIES PROJECT

In another episode, students interviewed locals about deforestation in Malawi's Chikangawa Forest. So many trees have been cut from the forest that the region has more droughts and floods than normal. Students interviewed workers from Raiply, a factory near the forest. This factory is working to plant trees and protect the biodiversity of the forest. They also interviewed local villagers whose livelihood is being affected by deforestation.

"It is our duty to preserve the environment and its resources for future generations, rather than using them all up." - Spencer Reed, The Solutionaries Project

The Solutionaries also write essays about their vision for a positive future. In these essays, students think about how their own choices affect the environment. They give advice for staying optimistic when there is too much negativity on the news. Students discuss what a positive future looks like and how we can achieve this future.

"I want my children to live in a better world, but one that values the environment as an equal to technological advancement." - Peter Larsen, The Solutionaries Project

Take Action!

Want to share stories that are important to our planet or your community? Submit a story to Voices of Youth.

www.voicesofyouth.org

VOICES OF YOUTH

Students Saving Salmon Club - Edmonds, Washington

"I think everyone in the project is a hero for just being part of something that's making an effort to make the Edmonds streams better for the salmon. Everyone who's taking any sort of action is a hero."

- Ava Wilson, member of Students Saving Salmon Club

Willow Creek, Shellabarger Creek, and Shell Creek are small creeks in Western Washington State. These creeks empty into Puget Sound, which leads to the Pacific Ocean. The creeks are home to insects, amphibians, and fish.

COURTESY OF JOE SCORDINO

Members of the Students Saving Salmon Club (SSSC), want to learn more about the health of these creeks and how the water quality is impacting salmon. Students conduct hands-on research at these creeks to test the oxygen levels, water temperature, bacteria levels, pH, and nitrates. After they collect, analyze, and graph their data, students meet with the city council and other community groups. They tell community members about the condition of local creeks, and offer different solutions to improve habitat for salmon.

Salmon currently spawn in only one of the three creeks—Shell Creek. SSSC members volunteer with the Edmonds Stream Team to find out about water quality in all three creeks to determine if that might affect salmon. Club members compare the data from local creeks to data from healthy salmon creeks.

The other two creeks, Willow and Shellabarger, drain into the Edmonds Marsh, which currently drains to Puget Sound through a 1,600-foot pipe. This long stretch of pipe likely prevents salmon from returning. The City of Edmonds is undertaking a feasibility study to replace the pipe with a tidal channel to allow salmon to enter the Marsh and streams.

The group has been able to make a big affect because of their enthusiastic members and mentors.

As Taylor Blevins said, "Everyone is hardworking and has a determined attitude. Everyone who is volunteering wants to be there and truly make a difference for the salmon and to help out streams."

The group's enthusiasm and efforts are paying off. Students have broadened their efforts and have begun working with homeowners. Students go door-to-door and talk with homeowners about landscaping and how it affects salmon. Even though this process can be challenging, club members find it rewarding,

COURTESY OF JOE SCORDINO

Students Saving Salmon Club, Page 2

COURTESY OF JOE SCORDINO

reaching out to homeowners, students learn important communication and outreach skills. The SSSC has become a great way for students to learn new skills, explore future career paths, and work alongside experts.

To learn more about the Students Saving Salmon Club, viisit: https://twitter.com/ewhssavesalmon.

COURTESY OF JOE SCORDINO

"It took longer than we expected to go from door-to-door and not everybody was willing to talk to us," said Taylor Blevins. "Nevertheless, we were able to reach all the houses we wanted to and came back at a later date to talk to the people we had missed."

After students survey the homeowners, they work with them to plant salmon-friendly plants along the creek. These plants help keep the water cool, prevent erosion, and provide cover for salmon to hide from predators. Jared Yu, club secretary, found that working with homeowners really stretched his skills.

"It was hard to have to talk to strangers at first but it helped build my confidence and communications skills," Jared said. "It was encouraging that a lot of the residents were already taking measures to be safe, and we can help by spreading knowledge of what homeowners can do to prevent contamination and improve stream habitat."

It's not only the salmon who are benefiting from SSSC. By working with scientists, students learn how to properly sample and record data. Through data analysis and graphing, students improve their math skills. When students present data to the city council, they learn about local politics. By

Take Action!

Want to bring a salmon club to your school? Contact your local Adopt-a-Stream program, Adopt-a-River program, or Students for Salmon club.

ADOPT A STREAM FOUNDATION

TreePeople Youth Leadership Program - Los Angeles, California

"As the summer season swings into action and temperatures start to rise, it's the perfect time to remember that as Angelenos, we all have the responsibility to act as stewards for our water and urban trees."

- Edith de Guzman, member of TreePeople

Los Angeles has been experiencing more frequent droughts. These droughts have greatly affected the city's trees. Drought can cause burned leaves, slow growth, and a loss of roots. Trees that have experienced long-term droughts are more vulnerable to pests and diseases.

COURTESY OF TREE PEOPLE

TreePeople, a nonprofit organization in Los Angeles recognizes that the city's trees need help.

"After five years of historic drought and extreme heat, many of LA's trees are thirsty and vulnerable," said Caitlin Dunham from TreePeople. "And without healthy trees shading campuses and communities, students suffer."

Why do trees matter so much? Trees provide many environmental benefits, including cleaning our air. Trees remove carbon dioxide from the air and store large amounts of carbon in their wood. Carbon dioxide is a major cause of climate change.

What does climate change have to do with salmon? Climate change can increase the temperature of water. If water is too warm, salmon eggs will not hatch. Another effect of climate change is ocean acidification. Ocean acidification makes it harder for salmon to detect predators and prey. Climate change can also cause more severe droughts. Without enough water, salmon can not migrate.

In order to get kids involved, TreePeople created the Youth Leadership Program. This program teaches young people how to care for trees in their communities. The program was started in 2014, and in three years volunteers have cared for more than 600 trees!

TreePeople's programs are unique because volunteers continue to care for trees five years after they were planted. This helps ensure the trees survive long into the future.

Throughout the summer, students will make sure that the trees are taken care of properly. In addition to watering the

COURTESY OF TREE PEOPLE

COURTESY OF TREE PEOPLE

trees, students mulch and re-stake trees when needed. They also learn how to remove suckers from trees. Suckers are plants that grow near the trunk of the tree or small branches that grow from major branches. They are called suckers because they "suck" nutrients from the trees. Students also look for ants. Lots of ants traveling on the trunk or on branches can indicate there is something wrong with the tree.

Trees are not only important for the environment, but they are also important for people. Living near trees can reduce neighborhood crime. Trees can increase the value of your home. They also keep temperatures cooler in summer, which reduces cooling costs. Research has shown that people who have access to trees and nature have higher academic achievement and less stress.

While some neighborhoods in Los Angeles have plenty of trees, others have almost none. TreePeople works to ensure that low-income neighborhoods have trees too.

"In urban areas, extreme heat is a social justice issue," said Jessica Jewell of TreePeople. "Low-income communities and people of color are at highest risk, as they tend to live in neighborhoods with less trees, more heat-retaining surfaces, poorly-insulated housing and limited access to air conditioning."

By working with people of all ages from neighborhoods around the city, TreePeople hopes to create a healthy urban environment for all everyone.

To learn more, visit:
www.treepeople.org.

COURTESY OF TREE PEOPLE

Take Action!

Want to plant trees in your schoolyard or community? Contact the Charitree Foundation to get free trees for your school!

www.charitree-foundation.org/request-trees-for-kids/free-trees-for-schools/

The Charitree Foundation

Youth Media for Trash Free Waters - New York, New York

There are 5,250,000,000,000 (trillion) pieces of plastic debris in the ocean.[32] And this number is growing every day! What can kids do about such a huge problem? Members of Youth Media for Trash Free Waters are setting an example for students around the world. In this program, kids produce creative videos that tackle issues like waste and litter.

COURTESY OF CAFETERIA CULTURE

But what does litter have to do with salmon? When litter reaches the ocean, it is broken into smaller and smaller pieces. Salmon, and other animals, can mistake this trash for food. When animals eat too much trash, they can get sick or die. About 25% of fish sold at markets have trash in their guts.[33]

COURTESY OF CAFETERIA CULTURE

Students in the Youth Media for Trash Free Waters program first learn about litter and how it affects animals in the ocean. They then work with professionals to learn how to tell interesting stories. Some of their stories include animations, dances, songs, or interviews with scientists. After students conduct interviews, collect data, create story ideas, and decide on a video style, they work with professionals to develop short videos.

In addition to making videos, students collect and analyze data. While students and local community members clean up beaches, they count the amount and types of trash they find. This information is shared with neighbors, community groups, and local governments. They also share this data with elected officials so that they can better understand litter issues.

The kids want to make sure that their neighbors understand that litter on their streets winds up in the ocean. To demonstrate this, students compare the litter they find on their local streets with the litter they find on beaches. They then share this information with their neighbors.

To help spread the word about these litter and marine debris issues, the videos include a take action message and a social media campaign. Some students have even given talks at press conferences. Others have met with elected officials to share their knowledge.

Some students have even started campaigns to reduce waste. They work with local restaurants and grocery stores

COURTESY OF CAFETERIA CULTURE

COURTESY OF CAFETERIA CULTURE

to reduce single-use plastics. Single-use plastics are things like straws, candy wrappers, and plastic bags that are thrown away after being used just one time. Single use plastics are a big source of litter and marine debris.

Other students have chosen to get involved with microbeads. Microbeads are tiny pieces of plastic that are in products like face wash or toothpaste. Microbeads get washed down the sink, and eventually into the ocean. Students in one video show people how to make their own skincare products without microbeads.

Not only are students helping minimize waste and stop litter, but they are gaining valuable skills. Throughout this program, students learn creative storytelling through visual and performing arts. They also learn how to produce professional-looking videos. Through data collection and outreach to the public, students learn about citizen science and civic engagement.

This program was funded by a grant from the US Environmental Protection Agency (EPA) Region 2. Local partners—such as NYC Department of Environmental Protection, Brooklyn College, local community centers, and libraries—were key to the success of this program! If you have an idea for a program in your community, you can work with your teachers or parents to apply for a grant from NOAA's Marine Debris Program or your Regional EPA.

To learn more, visit:
www.cafeteriaculture.org/trash-free-waters.html.

COURTESY OF CAFETERIA CULTURE

Take Action!

Want to help scientists track marine debris? You can report litter and marine debris using the Litterati or Marine Debris Tracker apps.

www.litterati.org
www.marinedebris.engr.uga.edu

Name Date Period

Student Stewards

Part I. Case Study Analysis

Directions: Read the questions below and discuss the answers with your group. Answer the questions using complete sentences. Your group will present their answers during a classroom presentation.

1. Summarize this project in 1-2 sentences.

2. What is the goal of this project?

3. How is this project an example of environmental stewardship?

4. List at least two ways this project could help salmon.

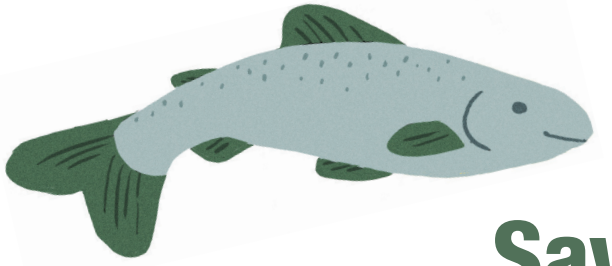
5. Do you think you could start a project like this? Why or why not?

Student Stewards, Page 2

Part II. Group Presentations

Directions: Complete the table below while other groups present their case studies.

Case Study	What is the goal of this program/ project?	How could this program/project help salmon?	How could you get involved?
The Grey Water Project			
Pigtails Art			
The Solutionaries Project			
Students Saving Salmon Club			
Youth Leadership Program			
Youth Media for Trash Free Waters			



Lesson 10

Saving Salmon

Students answer a questionnaire that describes their everyday actions that affect the environment. Afterward, the class discusses whether or not small actions affect the environment. The class then brainstorms a list of action projects that promote salmon stewardship. Small groups work together to create an action plan to achieve their action project.

Objectives

Students will:

- Recall their daily routine and describe how day-to-day actions can affect the environment.
- Devise and implement a salmon stewardship action plan.
- Reflect upon their service learning experience.
- Showcase their service learning project for community members.

Students will understand:

- Everyday actions affect salmon and watersheds.
- While salmon are facing many challenges, there are things students can do at home and school to help.
- Students can collaborate with each other and community members to address pressing issues.
- Stewardship projects benefit both people and the environment.

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Time Required

The time will vary depending on the complexity of the students' projects.

- Initial planning - 2-3 hours
- Group meetings - 2-3 hours every week
- Implementation - 5-15 hours over the course of the project
- Reflection - 1-2 hours
- Demonstration - 1-2 hours

Preparation

□ Signs
Post three different signs labeled "Always," "Sometimes," and "Never" on different walls of the classroom.

□ Handout: *Action Plan*
Print 1 copy per student or group of 3-4.

□ Art supplies
Students may need markers, butcher paper, poster board, and other art supplies throughout this project.

□ Internet access (optional)
Some students may wish to access the internet for research, to create social media campaigns, or to design flyers.

□ Letters to parents/guardians (optional)
If you would like parental involvement in these projects, consider sending a letter home to students' parents or guardians. The Buck Institute for Education offers a customizable letter for service learning projects.

Keywords

Action plan—A detailed plan outlining actions and resources needed to reach a goal.

Environmental stewardship—Responsible use and protection of the natural environment through conservation and sustainable practices.

Supporting Vocabulary

Campaign—A series of activities designed to produce a particular result.

Service learning—Providing service to others while simultaneously learning specific skills and information.

Background Information

Service learning can be defined in many ways. In general, it involves students working together on a project that benefits their community. It is easy for students to get caught up in their daily lives, which often revolve around friends, sports, social media, or academics. Service learning helps students see their role in the

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larger community and truly understand why it is important to be an engaged citizen.

Although students are working with an end goal in mind, service learning is about the entire process. Not only do students become invested in a hands-on project, but they also learn the steps and skills it takes to work toward a common goal. By being part of decision-making processes, taking on leadership roles, connecting with community members, and engaging in deep reflections, students learn meaningful skills that are not easily achieved in a lesson plan alone.

Service learning is also an important way to engage students in salmon recovery. Throughout this unit, students have learned about the cultural, environmental, and economic importance of salmon and the many threats facing these iconic fish. By concluding this unit with a service learning project, students will feel empowered to make a difference, will share their newly learned knowledge with family and friends, and will think about how their daily actions can affect salmon and their watersheds.

Lesson

Introduction

1. Ask students to close their eyes and think about their daily routine. Have them think about the things they do every day from the time they wake up until the time they go to sleep.
2. Tell the class that they will participate in a short questionnaire.
3. Point out the "Always," "Sometimes," and "Never" signs posted around the room. Explain that after you read a statement, students will move to the sign that represents their answer.
4. Read the following statements one at a time. Wait for all students to move under a sign before reading the next statement.
   - I turn off the water when brushing my teeth.
   - I use reusable water bottles instead of disposable water bottles.
   - I pick up litter on the street.
   - I recycle and compost whenever possible.
   - I turn off the lights when I leave the room.
   - I bring reusable bags to the grocery store.
   - I shutdown my computer at night.
   - I walk, bike, and take public transportation whenever possible.
   - I unplug my phone charger when my phone is done charging.
5. Ask students to return to their seats.
6. Ask students to give a thumbs up if they agree with the following statements or a thumbs down if they disagree. Pause after each statement and ask a few students to justify their responses.
   - The actions we take every day can affect the environment.
   - The actions we take every day can affect watersheds.
   - The actions we take every day can affect salmon.
7. Share with the following excerpt with the class:

   Even small actions can make a big difference. By turning off lights and electronics, we can reduce our climate change impact. By turning off the tap, we leave more water for aquatic plants and animals. By picking up litter, we prevent marine debris. There are many things we can do every day to help reduce our affect on the environment.
   By getting involved in education campaigns—like anti-litter campaigns—or hosting outreach events—like tree plantings—we can make an even bigger difference. There are many ways that we can get involved at school or in our communities to make a bigger impact.

Activity

1. Share with the class that they will be working on a project or campaign to help salmon or watersheds.

2. Give students a few minutes to free write about the things they could do to help salmon. If students need more support ask them to recall the case studies that they read in Lesson 9. You may also wish to share some of the following suggestions:

   - Educate the community about single use plastics (e.g., plastic bags, straws, water bottles, etc.)
   - Create a waste-free lunch campaign at your school.
   - Encourage their family to use less water.
   - Start a bike-to-school program for kids in their neighborhood.
   - Take shorter showers and reuse grey water.
   - Contact local restaurants or the school cafeteria and encourage them to only use sustainable seafood.
   - Design a campaign that encourages people to wash their cars at commercial car washes instead of at home.
   - Host a fundraiser for a local nonprofit that is working on salmon habitat restoration.

3. Have students write their suggestions on the board. Ask students not to duplicate suggestions that are already listed. If the list is not very diverse, consider writing some of the suggestions from Step 2.

4. Students will work in groups of 3-4 to complete their project. Divide the class into groups of 3-4 to determine the number of ideas that need to be selected.

5. Tell the class they will need to narrow the list down to _____ ideas. These projects should be achievable given the resources available.

6. Give students a minute to silently pick their favorite projects.

7. Share the following excerpt with the class:
   I will now read aloud the names of each project. I need 3-4 volunteers for each project. You may only select one project. If you would like to volunteer for the project, raise your hand.

8. Write the names of 3-4 student volunteers next to each project.

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9. After you have read through the list of projects, ask students to get into their groups.

10. Explain that today each group will work together to develop a group agreement, assign tasks to each group member, and create an action plan. Over the next few weeks, small groups will work together to implement their project.

11. Give each student or group a copy of the ***Action Plan***.

    Tech Extension: Students can use Google Keep, a free tool, to organize and coordinate their projects.

12. Walk students through the handouts. Be sure to assign a deadline and any other parameters that might be helpful for your class (e.g., potential partners, available art supplies, spaces for presentations, computer labs, etc.).

13. Give students time to complete parts I-IV their handout. Circulate around the room to answer questions. If the answers would be helpful for the rest of the class, share this information aloud.

14. Bring the class back class back together to discuss any potential issues or challenges.

15. Tell the class that groups will be meeting regularly to continue working on their projects.

16. See the suggested Group Meeting, Reflection, and Demonstration exercises below. Work with the class to create a group meeting schedule and to plan a day of reflection and a community demonstration.

Group Meetings

At least once a week, host group meetings so students can continue planning and implementing their projects.

1. Ask students to get out their Action Plan.

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2. Have students return to their groups.
3. Each group should review their Action Plan and work on the next steps.
4. Circulate around the room to answer any questions.
5. Have each group report back on their overall progress and any challenges they might be facing.

Reflection

After the groups have completed their projects, lead a class discussion using one or more of the following prompts. Alternatively, students may respond to the prompts with an essay or free write.

- How well did you work together in your groups? What could have been improved?
- What were the easiest and most challenging parts of this project?
- What did you learn from this project?
- How could your project have been more successful?
- What are the side benefits of helping salmon?
- What have you learned about yourself throughout this project?
- How could you continue to be involved in salmon stewardship efforts after this project?
- How does this project also help people?

Demonstration

After groups have completed their projects and reflections, a demonstration is a great way for them to celebrate their successes and share their experiences with others. Consider hosting one of the following demonstrations at your school or local community center.

- Create posters that could be hung at school or in the community library.
- Host a workshop to teach other kids how to get involved.
- Write an article in a local newspaper or blog.
- Share each of the projects at a school assembly.

Discussion Questions

1. How well did you work together in your groups? What could have gone better?
2. What motivates you to take action?
3. What steps can you take to start addressing an issue you care about?
4. Why might not everyone take action after learning about an important issue?
5. By working to protect salmon, how do we also help people?

Extensions

Art Extension

Have students create a mural or other art installation that depicts their vision of the future for salmon.

Writing Extension

Have students write a letter to a newspaper or blog explaining their project, how it benefits salmon, and what others can do to get involved.

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Additional Resources

Books

Molly Cone: Come Back, Salmon (48 pages, 930L)
This story chronicles how an elementary school adopted a polluted stream and ultimately brought salmon back to their community.

Cathryn Berger Kaye: Going Blue: A Teen Guide to Saving Our Oceans, Lakes, Rivers & Wetlands (160 pages, 1170L)
This book gives teens the tools and inspiration to transform their ideas into action as they plan and do a meaningful service project.

Guides

Cathryn Berger Kaye: The Complete Guide to Service Learning (288 pages)
This educator's guide from contains service activities, community service project ideas, quotes, reflections, and resources that can help engage youth in reaching out and giving back.

Barbara Lewis: The Kid's Guide to Service Projects (160 pages)
This kid's guide contains over 500 service learning project ideas—from simple to large scale—in an engaging, kid-friendly format.

Environmental Protection Agency: Learning by Doing: Students Take Greening to the Community
Find projects ideas, contacts who can help you start a program in your area, and grants that can support your projects.

Learn and Serve America: K-12 Service-Learning Project Planning Toolkit
This comprehensive guide provides educators with background information on service learning, standards for creating meaningful projects, and templates for communicating about projects with administrators and parents.

Vickie Lake: Service Learning in the PreK-3 Classroom (224 pages)
This educator's guide provides practical project design strategies for instructors at all levels of service learning experience.

Youth Service America: 55 Environmental Service-Learning Projects
With 55 environmental service-learning projects, this guide covers a myriad of topics ranging from recycling to transportation and schoolyard habitats to beach cleanups.

Professional Development

NOAA Planet Stewards

The NOAA Planet Stewards Education Project supports educators in the development and implementation of projects involving hands-on activities that conserve, restore, and protect human communities and natural resources.

Name Date Period

Action Plan

Deadline: _____

Group Project: _____

Part I. Create a Group Member Agreement
Directions: Before your group begins creating an action plan, it is important to create a Group Member Agreement. This agreement will help students identify expectations of one another. Work together to create a shared list of expectations for the group.

Each member of the group should try to:

1. _____
2. _____
3. _____

Each member of the group should try **not** to:

1. _____
2. _____
3. _____

If a group member is not following our Group Member Agreement:

1. _____
2. _____
3. _____

Part II. Define Roles
Directions: Teams are more likely to stay on task when each member has a role. Work together to assign each person in your group a role.

Facilitator: _____
The facilitator moderates discussions, keeps the group on task, and assigns work as needed. The facilitator might say things like, "Let's hear from someone else next." or "That's an interesting idea, but let's get back to the task at hand."

Recorder: _____
The recorder takes notes, summarizes team discussions, and keeps all necessary records. The recorder might say things like, "Did I summarize this correctly?" or "Could you please repeat what you just said?"

Runner: _____
The runner gets supplies or requests help from the teacher when the group needs support. The runner might say things like, "I will go get the markers. How many do we need?" or "It looks like we might be stuck. Should I go get the teacher for help?"

Timekeeper: _____
The timekeeper keeps the group on schedule and makes sure the group is aware of upcoming deadlines. The timekeeper might say things like, "We only have five minutes left, let's move on to the next topic." or "Remember, our final project is due in two weeks."

Action Plan, Page 2

Part III. Brainstorm
Directions: Spend some time thinking and talking about the questions below. Then work with your group to come to a consensus.

1. What are the goals of this project?

2. What steps do we need to take to complete this project?

3. What information do we need to know before we begin?

4. What supplies will we need?

5. Will we need to do any advertising (e.g., posters, social media, flyers, etc.)?

6. How will we know if our project has been successful (e.g., number of people who attended an event, number of people who committed to taking shorter showers, amount of money raised, etc)?

Name

Action Plan, Page 3

Part IV. Plan

Directions: Complete the following table with as much detail as possible. If necessary, use the internet for additional research.

Action Steps What will be done?	**Time Required** How long will it take to complete this step?	**Responsibilities** Who will do each part?	**Deadlines** When is each step due?	**Resources** What resources are needed?
Step 1				
Step 2				
Step 3				
Step 4				
Step 5				

Action Plan, Page 4

Action Steps What will be done?	**Time Required** How long will it take to complete this step?	**Responsibilities** Who will do each part?	**Deadlines** When is each step due?	**Resources** What resources are needed?
Step 6				
Step 7				
Step 8				
Step 9				
Step 10				

Name

Action Plan, Page 5

Part V. Reflect
Directions: Answer the questions below using complete sentences.

7. Did your group achieve its goals? Explain.

8. What went well?

9. What could have gone better?

10. Describe how you worked as a group.

11. Was your project successful? Why or why not?

12. How does this project also help people?

Pre/Post Assessment

Name Date Period

Pre/Post Assessment

Recalling

Directions: Match the words on the left with their definitions on the right.

1.	Ecosystem	_____	A. The changes that a living thing goes through from the beginning of its life until death.
2.	Life cycle	_____	B. The long-distance movement of animals.
3.	Migration	_____	C. An area of land where water drains down to a single point.
4.	Stewardship	_____	D. Plants, animals, and other living organisms and the nonliving parts of their environment.
5.	Watershed	_____	E. Responsible use and protection of the natural environment.

Reasoning

Directions: Circle the **most** correct answer.

6. What makes the salmon life cycle unique?
   a. Salmon start their lives as eggs.
   b. Salmon are born in saltwater and migrate to freshwater.
   c. Salmon are cold blooded.
   d. Salmon are born in freshwater and migrate to saltwater.

7. How can pollution affect a salmon's ability to migrate?
   a. Pollution can make salmon blind.
   b. Pollution can attract predators to the water.
   c. Pollution can reduce a salmon's ability to smell.
   d. Pollution can make salmon swim more slowly.

8. Which is **not** a common example of how pollution on land can affect salmon?
   a. Gasoline drips from cars on the street and is carried into a nearby stream.
   b. A large pile of leaves from a backyard is blown into creek.
   c. Manure from farms runs off into a local river.
   d. Fertilizers from gardens and yards are swept down a storm drain.

9. Throughout their lives salmon live in many different ecosystems. What do these ecosystems have in common?
   a. All of the ecosystems are aquatic.
   b. All of the ecosystems are fresh water.
   c. All of the ecosystems are salt water.
   d. All of the ecosystems are warm water.

10. Why are salmon considered a keystone species?
    a. Salmon only eat meat.
    b. Many plants and animals depend on salmon.
    c. Salmon are at the top of their food chain.
    d. Many populations of salmon face extinction.

11. Which is **not** an example of culture?
    a. Food
    b. Music
    c. Water
    d. Dance

12. Which example could be considered sustainable fishing?
    a. Only catching fish with healthy populations.
    b. Fishing for species that are at the top of their food chain.
    c. Catching as many fish as possible before they go extinct.
    d. Fishing with your family or friends.

13. Why do many salmon die before they become adults?
    a. Salmon get too tired and cannot swim all the way to the ocean.
    b. Bald eagles are a major predator of young and old salmon.
    c. People have created many challenges for salmon.
    d. Sea lions eat too many salmon eggs.

14. Why might a person be considered a steward?
    a. They enjoy eating seafood.
    b. They like watching animals in the wild.
    c. They help teach their friends how to fish.
    d. They try to protect the environment.

15. How can you help protect salmon?
    a. Walk and ride your bike whenever possible.
    b. Use lots of fertilizers on your garden to help aquatic plants grow.
    c. Stop washing your hands to save water.
    d. Only eat salmon listed as endangered.

Explaining

Directions: Answer the following questions using complete sentences.

16. Imagine that a car drips oil onto a road.
    a. How could this oil make its way into the ocean?

Name

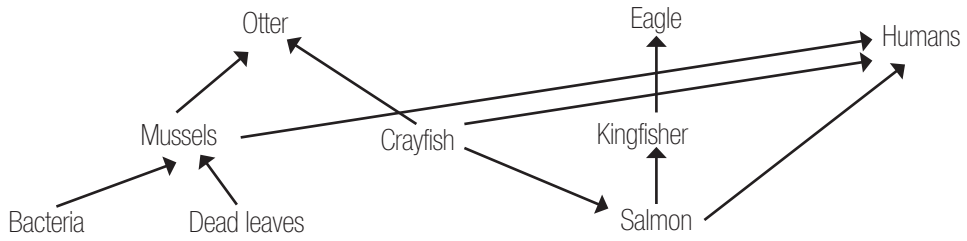
Pre/Post Assessment, Page 3

b. How could people prevent this oil from reaching the ocean?

17. Over time, people have changed or damaged salmon habitat.
    a. What are two ways that people have negatively affected salmon habitat?

    b. How have these affects harmed salmon?

Use the diagram below to answer question 18.



18. If salmon went extinct, how could animals and plants be affected? List at least two specific examples.

19. How do salmon play an important part of cultures around the world?

20. There are many ways that people can get involved to help save salmon.
    a. Describe one specific action that individuals can take to save salmon or their habitats.

b. How does this action help salmon?

c. Why should people try to save salmon?

Reflecting

Directions: Circle the number that shows how much you agree or disagree with each statement.

1	2	3	4	5
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

21. I know a lot about salmon.
    1 2 3 4 5

22. I am an environmental steward.
    1 2 3 4 5

23. People should help protect salmon.
    1 2 3 4 5

24. My personal actions can negatively affect salmon.
    1 2 3 4 5

25. My personal actions can negatively affect watersheds.
    1 2 3 4 5

26. My personal actions can positively affect salmon.
    1 2 3 4 5

27. My personal actions can positively affect watersheds.
    1 2 3 4 5

28. I find ways to save water in my everyday life.
    1 2 3 4 5

29. I encourage others to be environmental stewards.
    1 2 3 4 5

30. We do not need to conserve freshwater because we have plenty.
    1 2 3 4 5

Teacher Master: Pre/Post Assessment

Recalling (5 points total, 1 point per question)

1. Ecosystem: D (Lesson 4)
2. Life cycle: A (Lesson 1)
3. Migration: B (Lessons 1 and 2)
4. Stewardship: E (Lessons 9 and 10)
5. Watershed: C (Lesson 3)

Reasoning (10 points total, 1 point per question)

6. D (Lesson 1)
7. C (Lesson 2)
8. B (Lesson 3)
9. A (Lesson 4)
10. B (Lesson 5)
11. C (Lesson 6)
12. A (Lesson 7)
13. C (Lesson 8)
14. D (Lesson 9)
15. A (Lessons 9 and 10)

Explaining (10 points total, 2 points per question)
Answers will vary. Suggested answers included below.

16.

a. When it rains, the oil will be swept into a storm drain or a local waterway. This storm drain and waterway eventually flow into the ocean.

b. Driving less, maintaining vehicles, using electric cars, adding filters to roadways or storm drains, etc.

17.

a. Building passage barriers such as dams, culverts, dikes, etc.
Pollution from cars, pesticides, herbicides, paints, manure, pet waste, etc.
Habitat loss from building piers, homes, and business on the waterfront.
Warming water due to climate change and industrial discharge.
Overfishing

b. Passage barriers prevent salmon from migrating.
Pollution can impair a salmon's sense of smell, impacting their navigation.
Without enough suitable habitat, salmon do not have a place to lay their eggs, rest, or hunt.
Water that is too warm can kill salmon and salmon eggs.
Overfishing prevents fish from reproduce enough to maintain their population.

18. Answers will vary.

19. Salmon are a centerpiece of cultural celebrations around the world. From salmon soup in Finland to fish cakes in Japan, and salmon

stuffed pie in Russia to cured salmon in Sweden—salmon is deeply tied to food culture. The annual migration of salmon is also tied to cultural celebrations, festivals, and dances.

20.

a. Conserving water
   - Walking, biking, and using public transportation instead of driving
   - Using nontoxic products
   - Eating sustainable seafood
   - Using reusable, recyclable, and compostable items instead of disposable ones

b. Conserving water leaves more water for the waterways on which salmon depend.
   - Driving less minimizes CO_2 emissions and helps keep water temperatures cooler
   - Eating sustainable seafood takes pressures off of threatened and endangered populations.
   - Disposable items, such as straws and plastic bottles, are a major contributor to marine debris.

c. By protecting salmon, we help preserve ecosystems, cultures, jobs, and sources of protein. When we protect salmon, we also protect our waterways and everything living in them.

Reflecting (0 points)
No correct answers. Use this section as a springboard for discussion and to assess students' attitudes and behaviors.

Glossary

A

Abiotic factor—A nonliving environmental medium (e.g., water, soils, nutrients) or nonliving environmental characteristic (e.g., light, temperature, pH, humidity).

Action plan—A detailed plan outlining actions and resources needed to reach a goal.

Alevin—A newly hatched salmon that is entirely dependent upon its yolk sac for nutrition.

Anadromous—Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.

B

Biodiversity—The variety of life in a particular habitat or ecosystem.

Biotic factor—A living part of an ecosystem (e.g., animals, plants, and microorganisms).

Bycatch—The species that fishers accidentally catch. Sometimes this catch is discarded because fishers do not want it, cannot sell it, or are not allowed to keep it.

C

Campaign—A series of activities designed to produce a particular result.

Catadromous—Fishes that spend most of their life in freshwater and then migrate into saltwater to spawn.

Commercial fishing—Catching fish for commercial profit. The fish is often sold to fish markets, restaurants, or fish processors.

Conservation—The protection of animals, plants, and natural resources.

Consumer—Organisms that must eat other organisms to obtain energy; consumers are also called heterotrophs.

Cuisine—a style or manner of cooking food or presenting food; often related to a particular country or culture.

Culture—The behaviors, beliefs, arts, and products (things) of a community or group of people.

Custom—An action or way of behaving that is usual and traditional among the people in a particular group or place.

D

Decomposer—An organism that breaks down organic material over time.

Discard—To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel.

E

Economy—The system of production, distribution, and consumption of goods and services.

Ecosystem—A community of organisms (plant, animal, and other living organisms) and the abiotic parts of their environment.

Ecosystem engineer—Organisms that create, modify, destroy, or maintain a habitat in which they live or frequent. Examples include prairie dogs and beavers.

Egg—An animal reproductive body consisting of an ovum or embryo together with nutritive and protective envelopes.

Embryo—An unborn or unhatched offspring.

Environment—The physical surroundings in which we live, including living (biotic) and nonliving (abiotic) factors.

Environmental stewardship—Responsible use and protection of the natural environment through conservation and sustainable practices.

F

Fish farming—Raising fish commercially in tanks or enclosures, usually for food.

Fish hatchery— A place for artificial breeding, hatching, and rearing fish through the early stages of their lives.

Food chain—A linear sequence of organisms through which nutrients and energy pass as one organism eats another.

Food web—Including many interconnected food chains, a food web is a more realistic representation of consumption relationships in ecosystems.

Foundation species—Organisms that play a major role in creating or maintaining habitat. Coral is one example.

Fry—Salmon become fry when they have absorbed their yolk sac and emerge from their gravel nest (redd).

G

Ghost fishing—The accidental capture of aquatic organisms by fishing gear that has been lost or discarded into the sea and which continues to entangle or trap aquatic animals.

H

Homing—An animal's ability to return to a place or territory after traveling a distance away from it.

I

Imprint—Rapid learning that occurs during a brief receptive period and establishes a long-lasting behavioral response to a specific individual or object or location.

K

Keystone host—Producers that provide food and/or shelter for keystone species.

Keystone mutualists—Two or more species that engage in mutually beneficial interactions. These species are often pollinators.

Keystone species—A species on which other species in an ecosystem largely depend, such that if it were removed, the ecosystem would change drastically.

L

Life cycle—The series of stages through which a living thing passes from the beginning of its life until its death.

M

Migration—The relatively long-distance movement of individuals, usually on a seasonal basis.

Milt—The semen of a male fish.

Model—A system or thing used as an example.

Mortality rate—The ratio of the total number of deaths of individuals to the total population.

N

Nares—Fish nostrils which are used for smelling, not breathing.

Natal stream—A salmon's home stream; where a salmon hatched.

Nonpoint source pollution—Harmful substances released from many different sources that cannot be individually identified.

Nutrient vector—Organisms that transfers nutrients from one habitat to another.

O

Olfaction—The sense of smell.

P

Photosynthesis—The process of using sunlight to synthesize foods from carbon dioxide and water.

Pollutant—Any substance introduced to the environment that adversely affects the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Point source pollution—Harmful substances released from an identifiable source.

Pollution—The release of substances into the environment that adversely affect the health of an organism, the health of an ecosystem, or the usefulness of a resource.

Probability—The chance that something will happen.

Producer—Organisms that can make their own energy from inorganic materials and an energy source such as sunlight; producers are also called autotrophs.

R

Recreational fishing—Harvesting fish for personal use, sport, or challenge (e.g. as opposed to profit or research). Recreational fishing does not include sale, barter, or trade of all or part of the catch.

Redd—A gravel nest made by a spawning female salmon.

Replacement level—The amount of fertility needed to keep the population the same from generation to generation.

Retained incidental catch—The species that fishers accidentally catch and keep.

Ridgeline—An area of higher ground separating two adjacent streams or watersheds.

Run—Seasonal migration undertaken by fish, usually as part of their life history.

S

Service learning—Providing service to others while simultaneously learning specific skills and information.

Smolt—A young salmon that assumes the silvery color of the adult and is ready to migrate to the sea.

Society—A community, nation, or other group of people who have common interests, institutions, or culture.

Spawner—A mature salmon that is migrating back to its home stream to reproduce.

Stormwater runoff—Rainfall, melted snow, or irrigation water that flows across the ground's surface and is eventually returned to streams. Runoff can pick up pollutants from air or land and carry them to receiving waters.

Storyboard—A sequence of drawings or photographs, typically with some directions and text, representing the shots planned for a book, movie, or TV show.

Subsistence fishing—Fishing to feed one's family or community.

Survival—The act of staying alive, especially under adverse or unusual circumstances.

Sustainable—The principle of meeting current needs without limiting the ability of future generations to meet their needs.

T

Target catch—The species that fishers are trying to catch.

Topography—The shape of the land.

Tradition—The handing down of statements, beliefs, legends, customs, information, etc., from generation to generation.

W

Watershed—An area of land where surface water drains down to a single point.

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