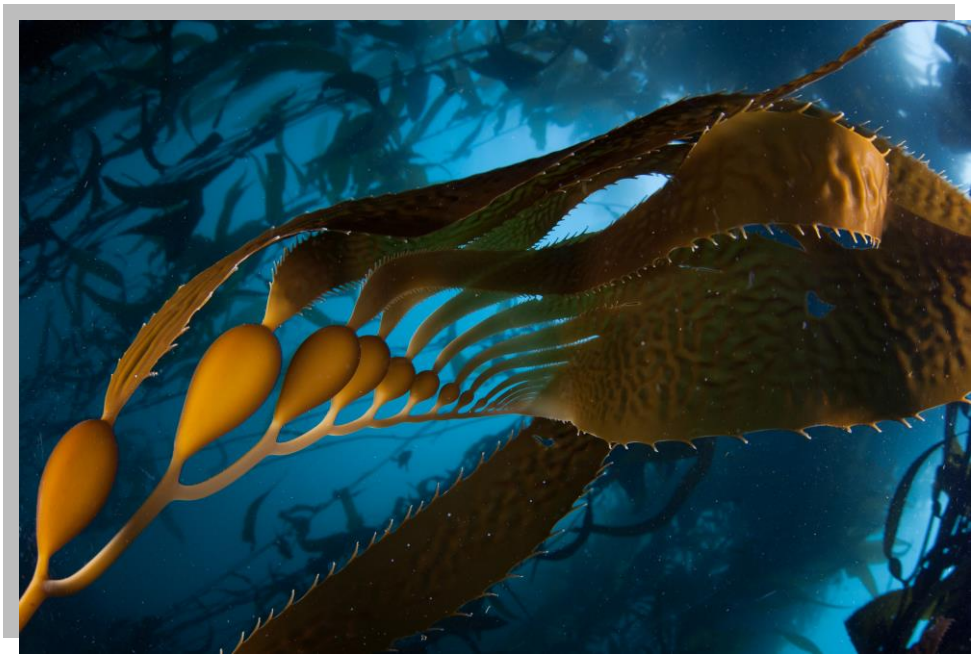
DIVING INTO OREGON'S KELP FORESTS



A TEACHER'S GUIDE

OREGON COAST AQUARIUM

"THE NUMBER OF LIVING CREATURES OF ALL ORDERS WHOSE EXISTENCE INTIMATELY DEPENDS ON KELP IS *WONDERFUL...*"

-Charles Darwin,
evolutionary biologist
and world explorer

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ABOUT THIS GUIDE

This *Teacher's Guide to Diving Into Oregon's Kelp Forests* was developed to support teachers of Grades 6-8. The enclosed materials could also be adaptable for older or younger students.

This guide contains supporting information and resources to answer 3 Driving Questions, plus an Introductory Activity, Wrap-Up and Reflection Activities, and supporting materials for a field trip to Oregon Coast Aquarium. You will find background information, step-by-step instructions for activities, tips for successful teaching, and more. We also provide resources to help you build your content knowledge and find additional activities and materials. This Guide is designed to be interactive, with embedded links you can easily access for more information throughout. A digital version of this document is available at aquarium.org/education/teacher-resources/.

We hope you find this Guide helpful and that you enjoy engaging your students in the science and wonder of kelp forests! Please don't hesitate to contact our Teacher Programs Manager (listed below) with questions or comments, or for additional support and resources.

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WHY TEACH ABOUT OREGON'S KELP FORESTS?

Local connections

Though invisible to most people without a boat or SCUBA gear, kelp forests are a dominant ecosystem along much of Oregon's coastline. These "underwater forests" provide food and shelter to thousands, if not millions of species. They are oases of life and productivity in the ecological desert that is the open ocean. Aside from the important role it plays in marine ecosystems, kelp is also harvested and used by people as a direct food source and as a thickening product in foods, bath products, and cosmetics. Kelp beds are also important to both commercial and recreational fisherman due to the number and diversity of fish which live in these habitats. These commercially-fished species contribute millions of dollars per year to our economy.

Next Generation Science Standards

The Next Generation Science Standards (NGSS) emphasize hands-on, student-driven investigation, and a systems approach to learning that spans the bridge between nature, science, and people.

There are a number of NGSS Performance Expectations which are supported by this curriculum. See the first page of each activity for a list of NGSS Performance Expectations aligned to that activity. Depending on how you adapt these activities, you may be meeting additional standards - check out the NGSS website to browse by topic and grade level.

The Three Dimensions of the NGSS include Science and Engineering Practices, which real professionals in those fields must use in their work; Disciplinary Core Ideas, which are content knowledge benchmarks related to the various sciences; and Cross-Cutting Concepts, which are big ideas about how the world works. This unit addresses the following areas:

NGSS THREE DIMENSIONS ALIGNED TO THIS UNIT		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Asking questions/defining problems Analyzing and interpreting data Constructing explanations and designing solutions Obtaining, evaluating, and communicating information	From molecules to organisms: structures and processes Ecosystems: interactions, energy, and dynamics Biological evolution: unity and diversity Earth and human activity	Patterns Cause and effect Systems & system models Energy and Matter Structure and Function Stability and Change

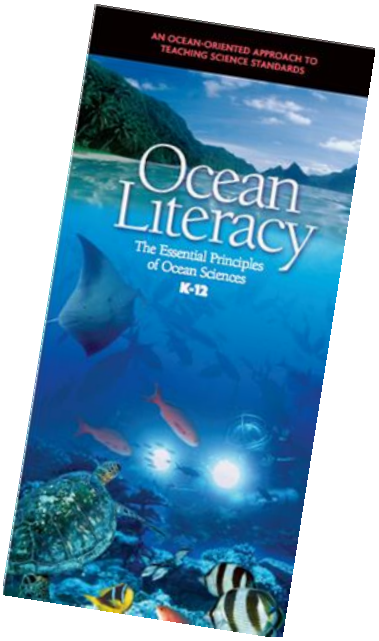
Common Core for Math, Literacy, and Social Science

Common Core State Standards (CCSS) for multiple subjects can easily be incorporated into a kelp forest unit, even if your emphasis is on science. Adding exercises that involve reading, writing, math, history, and civics will give students a more meaningful understanding of the content. This type of interdisciplinary teaching has also been proven to help information "stick" much more effectively. Throughout this Guide, we have included activities and exercises that help meet the CCSS for Grades 6-8. Just as with the NGSS, we encourage you to consult the Oregon Common Core Standards to check exactly which standards you may be addressing with your particular kelp forests unit.

Ocean Literacy

Ocean Literacy is *an understanding of the ocean's influence on you, and your influence on the oceans*. This includes knowledge of fundamental ocean concepts, the ability to communicate about the oceans in a meaningful way, and the power to make informed and responsible decisions regarding the ocean and its resources. In the early 2000's, stakeholder groups from across the country worked together to produce a Framework for Ocean Literacy for Grades K-12, identifying the most important concepts one should understand to be an ocean literate citizen. There are Seven Essential Principles of Ocean Literacy:

1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean makes Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.



Each Ocean Literacy Essential Principle has several Fundamental Concepts, which outline more specific learning goals. The Framework also includes a Scope and Sequence for Grades K-12, which shows how to most effectively address concepts at each grade band. Each activity in this curriculum is aligned with one or more Essential Principles and Fundamental Concepts of Ocean Literacy; see the "aligned standards" section of each activity for details.

Environmental Literacy

Oregon's environmental resources serve as a foundation of our state's economy and have created a dynamic heritage, one that we want to ensure and sustain for generations. Preparing Oregon's children to protect this valuable legacy and to understand their relationship to it is challenged by the fact that many of our youth are utterly disconnected from the natural environment. To create a sustainability-minded citizenry, we must instill an environmental ethic from a young age. In Oregon, environmental literacy is defined by the Oregon Environmental Literacy Plan (OELP). This plan was generated by a diverse task force created by the No Oregon Child Left Inside Act (HB 2544) in 2010.

Environmental literacy is defined as *an individual's understanding, skills and motivation to make responsible decisions that considers his or her relationships to natural systems, communities, and future generations.*

OELP goals addressed by this curriculum include:

- Understand the dynamics of systems and change
- Recognize the need for diversity in all systems
- Demonstrate love and respect for nature
- Participate as active, informed members of their local and global communities
- Strive to envision the features of a sustainable future
- Become applied, lifelong learners

STUDENT LEARNING GOALS AND DRIVING QUESTIONS

By the end of this unit, students will be able to:

- Recognize what makes Oregon kelp forests special
- Understand the interconnections within a kelp forest food web
- Explain why sea otters are important for healthy kelp forests
- Identify issues facing kelp forests and how people can help mitigate these issues

These goals will be achieved through hands-on investigation of three Driving Questions:

1. *How do living and non-living factors interact in a kelp forest?*
2. *How have Oregon's kelp forests changed over time?*
3. *How can we take care of kelp forests?*

This Teacher's Guide was designed to support the ideals of Project-Based Learning. Project-Based Learning, also known as PBL, is a teaching method in which students are engaged throughout a curriculum by a meaningful question to explore, a real-world problem to solve, or a challenge to design or create something. Students practice inquiry by developing their own questions and determining how to answer them. At the conclusion of a PBL unit, they demonstrate their learning through the creation of high-quality products and presentations of their work to others.

While this curriculum is not a complete PBL unit, it could easily be extended into a longer project in which students investigate the Driving Questions as part of the bigger picture. To generate a true PBL unit, you can use the above Driving Questions to provide background and context within a larger, authentic question, such as *what would the impacts be of re-introducing sea otters in Oregon?* Or, *what can we as middle school students do to protect local kelp forests?* The key to a good authentic question is that it has local application, is open-ended, and can yield an impactful product or presentation at the end. This Resources Page is a great place to start, or contact the Oregon Coast Aquarium Teacher Programs Manager Sara Roberts at sara.shawroberts@aquarium.org for PBL guidance and support.

SUGGESTED TIMING AND TEACHING SEQUENCE

Time requirements

This guide contains supporting background information and materials for 3 Driving Questions (D.Q.'s), an Introductory Activity, Wrap-Up and Reflection Activities, and a field trip to Oregon coast Aquarium. Each of these is designed to accommodate 1-2 typical class periods of 50 minutes each. Assuming you follow the curriculum as written, you can expect this entire unit to take two school weeks, or between 8-9 class periods. If your time is limited, you may also choose to use only one or two of the enclosed activities. If you choose to use this curriculum as an accompaniment to a Project-Based Learning unit, it will require a longer time commitment – anywhere between two weeks and two months, with these investigations interspersed with your PBL work time.

Teaching sequence

In general, this guide was designed to be followed as written; that is, the investigations are provided chronologically. Of course, due to time and resource availability and field trip scheduling, you may also choose to "jump around" as appropriate. The activities were designed to be implemented in the classroom before your field trip to Oregon Coast Aquarium (and the beach, if desired). Regardless of when your field trip occurs, we encourage you to generally follow the 3 Driving Question investigations in the order they are provided. This sequence was specifically designed to build student inquiry, from specific knowledge, to broader understanding, and finally to genuine care and concern for kelp forest ecosystems.

Suggested timeline

DAY 1: Introductory Activity: *Kelp is All Around*

DAYS 2-3: D.Q. 1: How do living and non-living factors interact in a kelp forest? (Activity: *Underwater Webs*)

DAYS 4-5: D.Q. 2: How have Oregon's kelp forests changed over time? (Activity: *An Otterly Complex Problem*)

DAY 6: D.Q. 3: How can people care for Oregon's kelp forests? (Activity: *Predators, Prey, and Plastic*)

DAY 7: Field trip to Oregon Coast Aquarium

DAY 8: Wrap-up and Reflection Activities

INTRODUCTORY ACTIVITY: KELP IS ALL AROUND

Time: 30-50 minutes | **Materials:** everyday household items, some containing kelp and some not (see list below for specific examples); projector and internet access for videos; OPTIONAL: collected seaweed or agar agar powder, Bunsen burners or stove, heatproof containers, ice cube molds, fine sieve or cheesecloth (see "Expand" activity)

For most people, kelp forests seem to be remote ecosystems far removed from our daily routine– but in fact, kelp and other algae play a huge role in our everyday lives. Kelp has long been used as a food source, especially in Asian cultures, but modern food scientists have found a way to take this one step further. In this introductory activity, students will learn just how much they encounter kelp every day.

Engage – Part 1 (8 mins): To introduce this unit and help students visualize what a kelp forest looks like, use the video from "Nat Geo Kids/Nature Boom Time" entitled *Kelp Forests* that can be found at www.youtube.com/watch?v=GDbHoF6loa8 (run time: 6 mins). Briefly have students recall a few things they learned about kelp forests from the video.

Engage – Part 2 (2 mins): Ask students: *have you ever eaten kelp?* Likely, only a few students will believe they have, but then you can tell them that in fact likely *all* of them have eaten kelp! Introduce and write on the board the following words: *agar*, *algin, alginate,* and *carrageenan.* These are all chemicals that are distilled from kelp to use in foods and other products as a thickener. Show students the collection of food wrappers and containers, some with ingredients lists that include the above kelp products. Items to collect that may contain agar, algin, alginate, or carrageenan include:

- Ice cream
- Toothpaste
- Shampoo
- Hand or body lotion
- Pudding
- Dairy products (i.e. yogurt, coffee creamer)
- Vitamins or other pharmaceuticals

You'll also want some other items that do NOT contain kelp products. These could be almost anything. Be sure that all wrappers and containers you bring in are empty and clean.

Aligned Standards

Next Generation Science:

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Common Core for Literacy in Science and Technical Subjects:

6-8.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

Ocean Literacy:

Principle 5: e. The ocean provides a vast living space with diverse ecosystems from the surface to the seafloor.

Principle 6: b. The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies.

Explore (10 mins): Ask students to briefly look over the collection of containers and wrappers you've brought in, without yet touching or examining them. Ask students to hypothesize how many of these products they expect to contain seaweed extracts. Then, allow them to investigate. Have students look for the four seaweed extracts in the ingredients lists, letting them freely explore and discuss what surprises them. If items do *not* contain a seaweed extract, what ingredient might they have instead that serves the same purpose?

Explain (5 mins): Use the video from "Today I Found Out" entitled *Why is seaweed used in making ice cream?* available at www.youtube.com/watch?v=ohFwINdaO8w to show students how and why seaweed products are used in food products. This video also discusses the history of the use of agar and carrageenan for food and other purposes.

Expand (25 mins): If time and resources allow, have students make their own (NON-EDIBLE) "seaweed jelly"! You will need seaweed you have collected off the beach; make sure it's not too old or slimy. You can also use dried "Irish Moss" (a type of red seaweed) or agar agar powder, both of which can be found in health stores or online. You'll also need Bunsen burners or a small stove, heatproof containers, ice cube molds, and fine sieve or cheesecloth.

1. Place 2 cups of water for every ½ cup of seaweed (or 1 teaspoon of powder) in a heatproof container over high heat.
2. Bring to a boil and simmer for 15-20 minutes.
3. Pour the water and seaweed into another container through a sieve or cheesecloth to catch all the seaweed and sediment.
4. Pour the hot liquid into ice cube trays.
5. Let sit until set. The amount of time this takes will depend on the temperature of the room you're working in. You can also chill the trays overnight and have students check out the finished results the next day.

TIP: You may also choose to prepare some "seaweed jelly" yourself at home prior to this lesson and simply bring it in to show your students.

When boiled, some seaweeds form a gel that resembles jelly.

Evaluate: Can students name the four seaweed extracts and some examples of how they are used in everyday products?

D.Q. 1: HOW DO LIVING AND NON-LIVING FACTORS INTERACT IN A KELP FOREST?

BACKGROUND INFORMATION

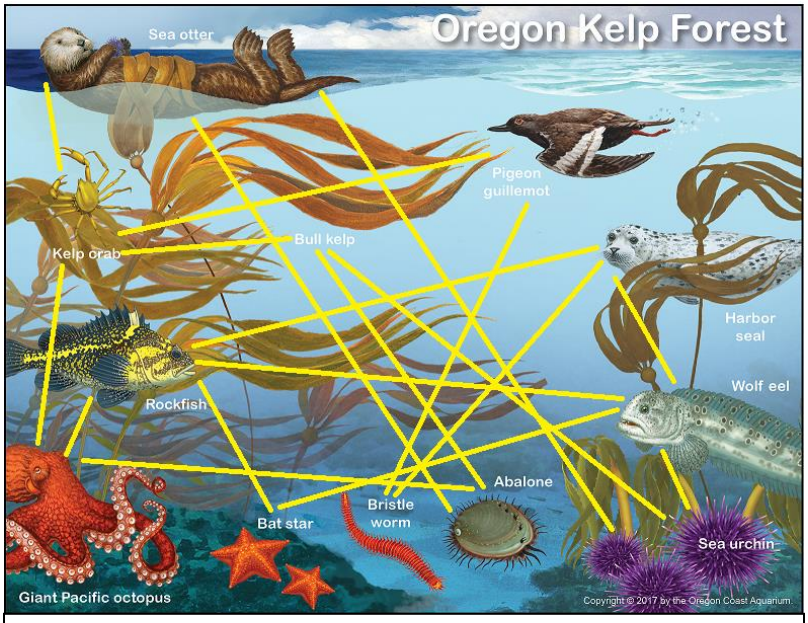
The kelp forest ecosystem is made up of thousands of amazing living as well as non-living components. Each component plays a special role in the *food web*. Despite its name, a food web isn't just about who eats who; it includes all of the flows of energy between everything in the ecosystem, both the organisms and their environment. This includes the sun, providing energy for photosynthesizing organisms; the consumption of one creature by another; and the waste that results from this consumption.

You can categorize the components of the food web based on their role within the ecosystem:

- *Producers* are plants or algae that get their energy from the sun through a process called photosynthesis.
- *Consumers* are animals that eat producers, other consumers, or both.
- *Decomposers* are animals, bacteria, or fungi, that break down, or decompose waste matter (detritus, decaying bodies, or poop), returning/recycling nutrients back into the system.

Sometimes a specific component falls into more than one category (i.e. a Kelp Crab functions as both a Consumer and a Decomposer).

Energy flows between producers, consumers, and decomposers throughout the kelp forest food web create interdependent relationships among the key components. If just one species has a change in its population (either an increase or decrease) or disappears, it can affect hundreds of other organisms. Eventually, if enough changes occur, it can result in a reorganization of the entire food web and ecosystem.



Connections between species living in a kelp forest are complex. All of these species depend on each other and on a healthy ecosystem.

D.Q. 1: HOW DO LIVING AND NON-LIVING FACTORS INTERACT IN A KELP FOREST?

STUDENT ACTIVITY: UNDERWATER WEBS

Time: two 50 minute periods | **Materials:** roll of yarn or string; index cards; crayons/markers/colored pencils; single hole punch; research materials such as books and internet access (see suggestions)

Energy is what fuels all life and processes on earth. In a food web, energy flows between the biotic (living) and abiotic (non-living) components of the ecosystem, including the sun, nutrients, waste, predators and prey. By simulating a food web, students will explore these interdependent relationships in a kelp forest, and compare and contrast these with other ecosystems.

Aligned Standards

Next Generation Science:

5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Ocean Literacy:

Principle 5: d. Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

Principle 5: e. The ocean provides a vast living space with diverse ecosystems from the surface to the seafloor.

PART 1 (first class period)

Engage (5-10 mins): Ask students to brainstorm all of the components they think are necessary in a healthy kelp forest ecosystem. You may need to review or introduce the terms *producer, consumer,* and *decomposer.* Write down student responses on the board. These may include the above terms or other ideas such as predators, prey, or specific species.

Explore – Part 1 (30 mins): Have each student choose a kelp forest organism to research. These should be a variety of species representing different types and ecological roles of plants and animals. You can use the list of species provided below, or challenge students to select their own based on their research. Ask students to find and record the following information about their species on one side of an index card:

- What does it eat?
- What eats it?
- Where within the kelp forest does it live?
- How does this organism influence its environment?
- What other species does this organism depend on?

Oregon kelp forest species students may research include: bull kelp, giant brown kelp, harbor seal, California sea lion, leopard shark, gray whale, kelp bass, hermit crab, copper rockfish, kelp crab, bristle worm, bat star, sea urchin, abalone, wolf eel, giant Pacific octopus, sea otter, Pigeon Guillemot, sunflower star, Pacific sea nettle, kelp rockfish, giant green anemones, cormorants, sardines, featherboa kelp, bat ray, and Western gull.

You'll need to provide research materials, or internet or library access to allow students to find the above information about their species (*see list of resources on next page*).

Explore – Part 2 (10-15 mins): After students have finished collecting all of the above information, have them create a nametag for their organism on the other side of their research index card. This should include a sketch and the organism's name. Finish the nametags by punching a hole into both upper corners, and tying a piece of string long enough to go over the student's head to both holes.

PART 2 (second class period)

Explore – Part 3 (40 mins): Have students sit or stand in a circle. Starting with one "species", ask that student to hold the ball of yarn or string and then name another organism in the circle with which their species interacts (i.e., that it eats, is eaten by, or depends on). Holding the end of the string, that student should then roll or toss the ball to the other species it named. That student will then take hold of the string, and pass the ball onto another "species" with which it interacts. Continue this process until every species is linked by the string within the "ecosystem".

Next, ask students to choose one organism which seems less important than the others. The student representing that species should drop their piece of string. Then have the student who started with the ball of yarn tug on their part of the string. Any student that feels a tug should tug their string in return, and so on, until you reach the dead end that is the species which dropped out of the ecosystem. Ask students how this demonstrates what happens when a link in the ecosystem is lost. (Other species are negatively affected.) Have the students whose species depended on that organism drop out of the game as well, and repeat the tugging process as above. This time, students will find that many more of the species in the ecosystem were affected by the loss of just a few links.

Explain/Evaluate (10 mins): Use the following questions to reinforce the above discussion and evaluate student understanding:

- What happens when we remove a link in the kelp forest ecosystem? (Organisms that depend on it are affected. The web itself changes shape.)
- Were the changes more dramatic when the system was composed of many species or when it had fewer species? (fewer)
- What can we say about the relationship between how many parts the system has (its complexity or diversity) and how stable it is? (In general, complexity makes it more stable.)
- What would happen if humans were introduced to the web? (Allow students to postulate ideas about ways that humans impact the kelp forest ecosystem.)

Suggested Resources for student research

Books

Smith, Howard. *Small Worlds: Communities of Living Things.* Scribner, 1987. ISBN: 068418723X

Rhodes, Mary Jo and Hall, David. *Life in a Kelp Forest.* Childrens Press, 2005. ISBN: 0516243969

Hall, Howard. *The Secrets of Kelp Forests: Life's Ebb and Flow in the Sea's Richest Habitat*. London Town Press, 2007. ISBN: 0976613492

Connor, Judith and Baxter, Charles. *Kelp Forests (Monterey Bay Aquarium Natural History Series).* Monterey Bay Aquarium, 1990. ISBN: 1878244019

Cole, Melissa. *Wild Marine Habitats: Kelp Forests.* Blackbirch Press, 2004. ISBN: 1567119093

Wu, Norbert. *Beneath the Waves: Exploring the Hidden World of the Kelp Forest*. Chronicle Books, 1992. ISBN: 0877018359

Websites

https://olympiccoast.noaa.gov/living/

https://sanctuaries.noaa.gov/visit/ecosystems/kelpdesc.html

http://oceana.org/marine-life/marine-science-and-ecosystems/kelp-forest

https://www.nps.gov/subjects/oceans/kelp-forests.htm

http://www.cabrillomarineaquarium.org/exhibits/socal-marine-habitats/kelp-forests.asp

https://dtmag.com/thelibrary/kelp-forests-in-the-sea/

Extend: Ask students to investigate another ecosystem and its species, and compare and contrast it with what they learned about kelp forests. They can choose any ecosystem to compare; some ideas include a deciduous forest, an evergreen forest, a prairie, the intertidal zone (tide pools), etc. Students should research their chosen ecosystem to answer the following questions:

- What are the most important species in your ecosystem?
- How do these species interact with each other?
- How do the living things interact with the non-living components of the ecosystem?

After students have gathered this information, ask them to list ways that their ecosystem is similar to the kelp forest and ways that it is different. Have students communicate their work on a poster that can be displayed in the classroom. Have the class do a "gallery walk" to observe all their classmates' posters.

D.Q. 2: HOW HAVE OREGON'S KELP FORESTS CHANGED OVER TIME?

BACKGROUND INFORMATION

Kelp forests support diverse and productive ecological communities throughout the world, providing numerous ecosystem services to humans. In fact, kelp forests are among the most productive ecosystems in the world, rivaling agricultural fields and tropical rainforests. These direct and indirect benefits to humans include oxygen production, nutrient cycling, habitat for fisheries, shoreline protection, food and food products such as carrageenan and alginate, and more. Kelp forests' ecosystem services are worth billions of dollars annually, and are dependent upon a healthy ocean and careful resource management.

Research shows that kelp forests are increasingly threatened by a variety of human impacts, including climate change, pollution, overfishing, and commercial kelp harvesting. Warmer waters carry less of the nutrients which are vital for kelp to grow and thrive, and also generate more frequent and severe storms which can rip kelp forests to shreds. (See this article for more on how climate change is impacting kelp forests.) Poor water quality caused by coastal runoff, including sewage, industrial disposal, and sediments, can smother new kelp shoots and reduce reproductive success. Commercial kelp harvesting is another threat to long-term kelp forest stability: hundreds of thousands of tons are removed each year for a number of products, including fertilizers, food additives, and pharmaceutical and beauty products. And overfishing can remove vital links in the kelp forest ecosystem, leading to imbalances in predator-prey relationships that can echo throughout the entire food web.

A formerly vibrant kelp forest can quickly become an urchin barren in the absence of key predators.

Kelp forest ecosystems have historically been known for their resilience under these sorts of changes, but recent evidence suggests that the capacity of kelp forests to recover from disturbances may be decreasing. Not only are kelps becoming unable to function at their optimum levels – in many cases they are dying off, causing a shrinking of kelp forests around the world. In addition to the negative impacts for humans, the loss of such a fundamental foundation species means a decrease in all other species that depend upon it. And as these species disappear from the food webs, it paves the way for other species – such as sea urchins – to take over. A large "herd" of sea urchins can graze away kelp forests at the rate of 30 feet per month, transforming formerly healthy kelp forests into what are known as "urchin barrens".

One solution to this issue is the reintroduction of sea urchin predators into kelp forests – specifically, sea otters. Sea otters have been extirpated (locally extinct) in Oregon for more than a century, hunted for their furs. But in recent years, there have been increasing numbers of sea otter sightings off the Oregon coast. While sea otters were successfully reintroduced to northern California and Washington in the 1970's, the reintroduction failed in Oregon. The question is: are our local waters now healthy enough to accommodate a wild population of sea otters? Scientists are still trying to answer that question, and determine whether or not a reintroduction program is feasible.

One thing is certain: if people do not take action to reduce our impacts on kelp forests and sustainably manage those that remain, we could lose these vital ecosystems – and all of the important ecosystem services they provide.

DID YOU KNOW? Oregon Coast Aquarium divers and Oregon Department of Fish and Wildlife scientists work together to monitor the health of kelp forests in local marine reserves. Note how much of the kelp in this photo is disintegrating or has been grazed away. Learn more here!

D.Q. 2: HOW HAVE OREGON'S KELP FORESTS CHANGED OVER TIME?

STUDENT ACTIVITY: AN OTTERLY COMPLEX PROBLEM

Time: two 50 minute periods | **Materials**: Copies of Kelp Forest Sites Investigation (pages 19-21) for each student; Library/computer lab access

Sea otters are one of the most iconic animals for ecosystem balance and health. In this unit, students will first learn how and why sea otters are so important for kelp forests. Then, they will propose methods for communicating these ideas to the public.

Aligned Standards

Next Generation Science:

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Ocean Literacy:

Principle 6.e: Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean.

PART 1

Engage (10 mins): Ask students to describe their idea of what a healthy ecosystem (any ecosystem) should look like. This may include descriptions of both living and non-living components: the air, the animals and plants, etc. Encourage students to share descriptions of specific natural places they may have visited. What was it about those places that made students believe that they were healthy?

Next, tell students that although some places might appear healthy to the untrained eye, in some cases scientists such as *ecologists* (people who study the health of ecosystems) determine that something in the ecosystem is off-balance. This is now the case in many of the world's kelp forests, including those off the coast of Oregon.

Introductory video (20 mins): Show students the video *Some animals are more equal than others: Keystone species and trophic cascades* located at https://www.youtube.com/watch?v=hRGg5it5FMI. This video helps reinforce what they learned about producers, consumers, and decomposers in the previous "Underwater Webs" activity, and introduces the concept of keystone species. Ask students to take notes while watching the video about what most interests them and what they think is the most important information.

Explore (20 min): Distribute copies of the following two pages illustrating two different kelp forests. Tell students to imagine they are divers surveying two different kelp forest sites. Make careful observations about the below two sites, noting what species you see, how abundant they are, etc. Then have students fill out the accompanying Student Worksheet.

SITE 1

My observations (types of animals, amount of kelp, etc):

SITE 2

My observations (types of animals, amount of kelp, etc):

STUDENT WORKSHEET: KELP FOREST SITES INVESTIGATIONS

Which site has higher *abundance* of species?

Which site has higher *diversity* of species?

Which do you think is a better indication of a healthy ecosystem: high abundance or high diversity? Why?

Which site do you think is healthier? Why?

If you were a natural resource manager, what steps would you take to improve or maintain the health of the less-healthy site?

TEACHER ANSWER KEY: KELP FOREST SITES INVESTIGATIONS

Which site has higher *abundance* of species?

Site 2

Which site has higher *diversity* of species?

Site 1

Which do you think is a better indication of a healthy ecosystem: high abundance or high diversity? Why?

High biodiversity is the most important indication of a healthy ecosystem because it shows that the numbers of predators and prey are in a good balance. When the numbers of producers and consumers are at healthy levels, the entire food web will be able to maintain good population levels and the ecosystem will be able to thrive.

Which site do you think is healthier? Why?

Site 1 appears to be healthier because it has high diversity, and no single species is overly abundant. It also has a keystone species present (the sea otter) and many more kelp plants than Site 2.

If you were a natural resource manager, what steps would you take to improve or maintain the health of the less-healthy site?

Good answers include introducing sea otters to the area; planting more kelp plants; and/or controlling the sea urchin population at Site 2. Students may also write about taking steps to improve water quality, such as educating the public, preventing pollution of our coasts, etc.

PART 2

Explain (5 mins): Tell students that although Oregon (and the entire West coast) historically had a large population of sea otters, these animals were decimated by the fur trade in the 1800s. Hunters killed sea otters by the thousands for their thick, warm coats. By the early 1900s, the species had been driven to the edge of extinction and there were no longer any sea otters off the coast of Oregon. The only place that sea otters survived was in remote regions of Alaska. In the 1970s, scientists undertook a massive effort to transport some of the Alaskan sea otters to Washington, Oregon, and Northern California, hoping to create new populations of otters all along the west coast and thus help restore coastal ecosystems. And it worked – everywhere but in Oregon, where mysteriously, all of the reintroduced otters either died or disappeared. Scientists aren't exactly sure why this happened, but we do know that sea otters attempting to return to our shores must contend with pollution, boat traffic, and entanglement with fishing gear. To address these threats and ensure that sea otters have access to the kelp forests they need, we will need the cooperation and support of scientists, fishermen, and the general public to craft a Sea Otter Recovery Plan.

Expand (40 mins, OR assign as homework): Challenge students to create a persuasive poster, newspaper editorial, pamphlet, cartoon, or other form of media encouraging the general public to support sea otter recovery in Oregon. They can be as creative as possible with how they design these materials, but all of their products should include:

- Basic information about sea otters including habitat, lifestyle, and interesting facts
- The role that sea otters play in keeping kelp forests healthy
- Why kelp forests are important (i.e., why should people care about this issue?)
- Ways that people can help make sure Oregon waters are healthy for ALL species

To prepare their persuasive writings, students should use the following websites:

Oregon Wild Otter Watch

OSU grad students writes about her sea otter research

Facts about sea otters

The Northern Sea Otter and the Oregon Coast

Evaluate (10 mins): Have students display their final products on their desks, then have the entire class stand up and walk around the classroom to view each others' work. Have students vote to select their favorite design, based on which they think would be most persuasive.

Extend: Have students share their designs with an authentic audience! This could include the local newspaper; city council; Oregon Coast Aquarium; ODFW scientists; etc. Contact Oregon Coast Aquarium's Teacher Programs Manager for help connecting with a community partner

D.Q. 3: HOW CAN WE TAKE CARE OF KELP FORESTS?

BACKGROUND INFORMATION

Kelp forests are under direct threat from human activities. Kelps require specific water and temperature conditions to thrive. As the world ocean continues to warm due to global climate change, a decline in the range and abundance of kelp forests is expected. Because kelps require clean, clear water to thrive, coastal runoff and pollution are also urgent threats.

One of the greatest threats to all ocean ecosystems and species is plastic pollution. This is pieces of plastic, ranging from microscopic to the size of cars, that have made their way from land to sea. Most of this pollution was carried from inland areas to the coast by rivers, then carried by currents far out to sea. Because most plastics never fully break down, these bits of pollution may remain in the marine ecosystem forever.

Plastics in the ocean cause numerous negative impacts on animals and ecosystems. Since a lot of plastic is small and brightly colored – just like prey fish – many predators mistake plastic for food. From sea turtles mistaking plastic bag for jellies, to whales consuming thousands of plastic bits instead of plankton, the occurrence of plastic ingestion by marine animals is well-documented. Because these plastics can't be digested, they fill animals' bellies, making them feel full and causing them to stop eating. Many of these animals die from starvation with bellies full of trash.

Sea turtles often mistake plastic bags for the jellies they love to eat.

Pollution can also entangle or trap animals. Discarded fishing gear, such as nets and monofilament line, can accidentally capture everything from fish to sharks to sea lions. These animals either starve, drown, or become permanently injured. Trash can also become a carrier for toxins and disease that most marine organisms would not otherwise encounter.

The good news is that plastic pollution in the ocean is a clear problem with a direct source: humans. People can take action in their communities and in their own lives to reduce the amount of plastic being consumed at the source. There is also a lot of research being done to determine how we might collect plastic from the ocean or break it down more quickly, although a great deal more research and funding is needed before such large-scale strategies can become a reality.

For answers to frequently asked questions about plastics in the ocean and additional resources, visit the 5 Gyres Institute. An infographic describing ways we can reduce plastics in our own lives can be found at Plastic Oceans Foundation.

D.Q. 3: HOW CAN WE TAKE CARE OF KELP FORESTS?

STUDENT ACTIVITY: PREDATORS, PREY, AND PLASTIC

Time: 45-50 minutes | **Materials**: Plastic cups; about 50 colored beads (purple, orange, yellow); timer

In this activity, students will learn through a series of exercises how predator-prey relationships affect species populations in the kelp forest, and how human pollutants can negatively impact the food web. Then, they will brainstorm solutions to reduce human impacts on ocean ecosystems.

Prep: Just before class, spread out the beads on the floor in an open space. (To make the game more challenging, you can also place beads in random locations around the room.) When students come in, give each student one plastic cup.

Engage: Tell students they are going to become sea otters, hunting for food. The plastic cups will be their "stomachs" in which they will collect their food, while the beads on the floor represent their prey. Ask, w*hat do sea otters eat?* Help students recall a sea otter's diet, which includes urchins, mussels, clams, and crabs.

Explore: Part 1. All students begin the game as sea otters. They can only "eat" (collect) purple beads, which represent urchins. When they find a purple bead they should place it in their "stomach" (cup). Allow them to "hunt" for 30 seconds or until most of the purple beads are gone. Then ask students if they think they found enough urchins to survive – each student should have at least a few purple beads in their cup and feel like they got a good "meal".

Start the timer over and have students do another round of hunting. This time, students will have a much harder time finding purple beads. The sea otters that cannot find any purple beads "starve" and are out of the game (ask them to step aside out of the playing area). Continue until all the purple beads are gone. Ask students, *what happened to the urchin population? What happened to the sea otter population as the urchins disappeared?* Students should note that the urchins were all eventually eaten, causing the sea otters to begin dying off.

Aligned Standards

Next Generation Science:

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Oregon Social Science:

4.12 Explain how people in Oregon have modified their environment and how the environment has influenced people's lives.

5.11 Describe how technological developments, societal decisions, and personal practices influence sustainability.

Ocean Literacy:

Principle 6: d. Humans affect the ocean in a variety of ways. Human development and activity leads to pollution (point source non-point source, and noise pollution), changes to ocean chemistry, and physical modifications (changes to beaches, shores, and rivers).

Next, have the students who were the "starved" sea otters return all their purple beads to the game area. Then have only the remaining sea otters hunt again for 30 seconds. Ask, *Was it easier to find food this time?*

Explain: This exercise represents what happens in a *balanced, healthy ecosystem.* The populations of predators and their prey go up and down in response to each other. When predators increase, prey decreases. Predators then decline, the prey species return, and the cycle continues. Over the long term, both predators and prey are able to maintain a relatively stable population and the ecosystem as a whole remains healthy.

Explore: Part 2. Collect all the purple beads so that students' cups are empty again. Tell students they are now all going to become urchins searching for food. Ask students what urchins eat (*kelp*). Tell students that orange and yellow beads represent different types of kelp. This time, don't use the timer, but instead have students collect as many orange and yellow beads as they can until they're gone. Ask, *are you well-fed urchins?* Each student should have plenty of beads in their cups and feel that they were able to get plenty of food.

Now introduce the twist: tell students that while the yellow beads *seemed* like kelp to the urchins, they actually represent plastic pollution! Plastics are often consumed by urchins and other animals on the ocean which cannot tell the difference between trash and food. Have students count how many orange and how many yellow beads they got. *How much of their "food" was actually plastic?* Ask what they think would happen to the sea otter population if all of the urchins who ate yellow beads died. The sea otters would be unable to find food and would die off, too. Ask students to think further: *what would happen to the other animals who are connected to sea otters and urchins in the kelp forest food web?*

Explain: This second exercise represents what can happen when an ecosystem is affected by pollution and becomes *unbalanced.* Plastic trash breaks down into smaller and smaller pieces but never fully dissapears, and the entire food web can become impacted.

Expand: Ask students to think about and share what types of pollution they might find at the beach, lake, around town, or wherever they have spent time outdoors. *How did that trash get there?* Help students understand that people either dropped the items there, or it was moved there by wind, waves, rivers, or rain. Together as a class, brainstorm solutions to reduce ocean pollution and record ideas on the board. Ideas may range from simple solutions such as collecting trash or not littering, to methods to remove or prevent pollution. Encourage creativity!

Extension opportunity: Have students design, build, and present their inventions for ocean pollution prevention or removal.

Evaluate: Can students explain what happens to a food web when plastics enter the ecosystem? Do they feel empowered and motivated to take action to reduce pollution?

FIELD TRIP TO OREGON COAST AQUARIUM

A field trip to the Aquarium helps to build student knowledge and understanding in a safe, accessible environment. It's a great way to both reinforce classroom learning and to prepare for forthcoming activities. While we have placed the field trip here after the conclusion of your three Driving Question investigations, you may also opt to visit the Aquarium before you begin classroom activities as an introductory and knowledge-building experience, or midway through your unit to review knowledge gained and connect it to real animals and ecosystems that students can see and touch. You may choose to have students observe exhibits or provide more structure with the *Kelp Creatures Scavenger Hunt* on the next page. We also have a number of lab programs aligned to various grade levels and topics, including our new program "Go With The Flow", which helps students develop their understanding of how energy flows between producers, consumers, and decomposers throughout the kelp forest food web.

There are several galleries and exhibits which display the habitats and organisms your students learn about during this unit. In our "Coastal Waters" gallery, you will find both an Oregon Kelp Forest exhibit and a California Kelp Forest exhibit. Challenge students to identify similarities and differences between the two habitats; they may be surprised by the varying array of biodiversity! In the "Passages of the Deep", be sure to pause in the "Orford Reef" tunnel, which simulates the swaying forests of bull kelp found off Oregon's Cape Blanco. And of course, be sure not to miss our playful sea otters: check our website for scheduled feedings and keeper talks.

Click this button to start planning your field trip to Oregon Coast Aquarium!

Some teachers choose to combine their field trip to the Aquarium with a field trip to the beach on the same day. This can be a great strategy, because it means only one day of out-of-school time, and because Oregon Coast Aquarium is near a number of excellent beaches. For more information on any of Oregon's coastal State Parks, visit the Oregon State Parks website, or call the Interpretive Rangers at (541) 563-8500 – they may be able to meet your class at the beach to do educational activities. If you choose to do both on the same day, we recommend you consult the tide charts so you can be at the beach during low tide – the best time for tidepool viewing and beach access.

"Kelp surfing" is an easy and fun exploration when the rocks are too dangerous for exploration. Students simply dig through the washed-up kelp and seaweed (known as the *wrack line*), searching for animals. If the tide has recently been high enough to wet the wrack line, students will be able to find anything from crabs to small shrimp to snails. You can also challenge them to find bits of plastic or other trash, collecting it for proper disposal.

KELP CREATURES SCAVENGER HUNT

Find these Kelp Forest residents throughout our exhibits and check them off as you go. For each, think about the following questions and discuss them with your group.

☐ **Bull Kelp**

Why are the blades (kelp leaves) floating?

☐ **Pigeon Guillemot**

How does this bird move through the water?

☐ **Kelp Crab**

Where did you find this crab and what is it doing?

☐ **Rockfish**

Where in the exhibit did you find a rockfish?

☐ **Wolf Eel**

What do the wolf eel's teeth look like?

☐ **Harbor Seal**

What senses does the seal use to find food?

☐ **Sea Urchin**

How does the urchin defend itself?

☐ **Octopus**

How does the octopus hide?

☐ **Abalone**

How does the abalone move?

☐ **Bat Star**

Where is the bat star's mouth?

☐ **Sea Otter**

How do otters eat hard foods like urchins?

☐ **Bristle Worm**

Bristle worms burrow in sand or mud. Find an exhibit where you think a bristle worm could live.

WRAP-UP AND REFLECTION ACTIVITIES

By the end of their *Diving into Oregon's Kelp Forests* unit, students should be able to:

- Recognize what makes Oregon kelp forests special
- Understand the interconnections within a kelp forest food web
- Explain why sea otters are important for healthy kelp forests
- Identify issues facing kelp forests and how people can help mitigate these issues

The following activities will help you to assess the knowledge and understanding students gained, and to further foster that sense of connection to the kelp forest – perhaps the most important outcome of all, because it encourages ongoing interest and care for ocean ecosystems.

"Teach A First Grader" Activity

One of the best ways to gain understanding in a topic is to teach others about it. Tell your students to imagine that a first grader has asked them, *What is a kelp forest?* Challenge your students to write themselves a "script" for how they would respond to that question in a way a small child could understand. Encourage students to write in simple, but engaging, language.

As a bonus activity, invite a class of First Graders to visit and have your students give them a mini-lesson about kelp forests!

Concept Mapping

This activity works well for visual learners. First, explain that a *concept map* is a diagram that shows relationships between concepts relating to one main theme. It may be helpful to show students the examples found on this page.

Ask students to draw a circle containing the words "Kelp Forest" in the center of a blank sheet of paper. Then ask them to create a concept map showing everything they've learned about kelp forests and the connections between each of those ideas.

Assessment

Use these activities to assess how well students understand our three Driving Questions:

1. *How do living and non-living factors interact in a kelp forest?*
2. *How have Oregon's kelp forests changed over time?*
3. *How can we take care of kelp forests?*

BIBLIOGRAPHY OF LINKS & ADDITIONAL RESOURCES

Page 5 NGSS Website - https://www.nextgenscience.org/

Page 6 Oregon Common Core Standards - http://www.ode.state.or.us/search/page/?id=3566

Ocean Literacy Framework - http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/

Page 7 Oregon Environmental Literacy Plan - http://www.ode.state.or.us/gradelevel/hs/oregon-environmental-literacy-plan.pdf

Page 8 Project-Based learning - http://www.bie.org/

PBL Resources - http://www.bie.org/resources

Page 16 Ecosystem services - http://www.habitat.noaa.gov/abouthabitat/ecosystemservices101.html

Human impacts - https://sanctuaries.noaa.gov/visit/ecosystems/kelpimpacts.html

Climate change and kelp forests - http://www.planetexperts.com/climate-change-cutting-planets-kelp-forests/

Foundation species - https://en.wikipedia.org/wiki/Foundation_species

Page 17 Sea otters sightings in Oregon - http://www.oregonwild.org/wildlife/otter-watch

Scientists investigate sea otter reintroduction - http://blogs.oregonstate.edu/gemmlab/2017/09/04/new-study-looks-investigate-potential-reintroduction-sea-otters-oregon/

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Facts about sea otters - https://defenders.org/sea-otter/basic-facts

The Northern Sea Otter and the Oregon Coast - https://castormagazine.wordpress.com/2016/07/08/the-northern-sea-otter-and-the-oregon-coast/

Page 24	Most plastics never break down - https://marinedebris.noaa.gov/sites/default/files/Gen_Plastic-hi_9-20-11_0.pdf
	Collecting ocean plastics - https://www.theoceancleanup.com/technology/
	Break down plastics more quickly - https://www.cbsnews.com/news/could-an-enzyme-eradicate-plastic-pollution-in-the-worlds-oceans/
	5 Gyres Institute – https://www.5gyres.org/faq/
	Plastic Ocean Foundation - https://plasticoceans.org/infographic-reduce-plastic-pollution/
Page 27	Aquarium lab programs - http://aquarium.org/education/on-site-school-programs/
	Oregon State Parks - http://oregonstateparks.org/
	Plan your Oregon Coast Aquarium field trip - http://aquarium.org/visit/field-trips/
Page 29	Concept map examples - http://www.readingrockets.org/strategies/concept_maps

Additional Resources

Kelp Forests on the Oceanscape Network: http://oceanscape.aquarium.org/explore/subecosystems/kelp-forests

Glaciar Bay National Park - kelp forests: https://www.nps.gov/glba/learn/nature/kelp-forest.htm

Kelp forests page at the National Parks Service: https://www.nps.gov/subjects/oceans/kelp-forests.htm

PBS LearningMedia – Kelp forests video and materials: https://opb.pbslearningmedia.org/resource/kqed07.sci.life.eco.kelp/kelp-forest/#.WtfSSC7waUk

Kelp Forests – A Young Explorer's Guide from Monterey Bay Aquarium: https://www.montereybayaquarium.org/education/classroom-resources/games-and-activities/kelp-forests

Oregon Conservation Strategy for Nearshore Ecosystems: http://www.oregonconservationstrategy.org/ecoregion/nearshore/

NOAA Education Portal: http://www.noaa.gov/education/