EXPLORING OREGON'S ROCKY SHORES

A TEACHER'S GUIDE

OREGON COAST AQUARIUM

"THE SEA, ONCE IT CASTS ITS SPELL, HOLDS ONE IN ITS NET OF WONDER FOREVER."

-Renowned ocean scientist and explorer, Jacques Yves Cousteau

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ABOUT THIS GUIDE

This *Teacher's Guide to Exploring Oregon's Rocky Shores* was developed in conjunction with a workshop by the same name, held on August 5, 2017 at Oregon Coast Aquarium. This curriculum packet is designed for workshop attendees as well as other interested educators to support a Rocky Shores unit for Grades 3-5. The enclosed materials could also be adaptable for older or younger students.

This guide contains supporting information and resources to answer 4 Driving Questions, plus an Introductory Activity, Wrap-Up and Reflection Activities, and 2 field trips. 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 the rocky shores! Please don't hesitate to contact our School Liaison (listed below) with questions or comments, or for additional support and resources.

Sara Roberts

School Liaison

Oregon Coast Aquarium

Sara.ShawRoberts@aquarium.org

541-867-3474 ext. 5317

WHY TEACH ABOUT OREGON'S ROCKY SHORES?

Local connections

Rocky shores and intertidal habitats make up the majority of Oregon's shoreline – about 62%, according to the Oregon Parks and Recreation Department. This defining feature of our coast not only provides habitat for numerous unique species of seaweeds, fish, mammals, invertebrates, and birds, but is an important resource for humans as well. Rocky shores and their tidepools serve as nurseries for juvenile animals, some of which grow up to become important staples for the commercial fishing industry, such as Rockfish and Red Rock Crabs. In Oregon, the fishing industry is a significant part of our state economy, contributing around $150 million to the economy annually. Our state also has a number of Marine Reserves, protected areas where human use is limited and wildlife thrives, providing high biodiversity zones that then spread and help restore populations in surrounding waters. Oregon's wild shores are also an important part of our history and culture. Native peoples have been harvesting shellfish, salmon, and plants along the coast for at least 12,000 years. Before Oregon's highways were built, brave travelers used the beaches as roads for cars and horses to travel between coastal towns. Today, all people can freely access the coast thanks to the Oregon Beach Bill. Our beaches give us a place of sanctuary and peace, a space where we can connect with friends and loved ones, and inspire a sense of wonder. We encourage you to tap into these deeply personal, intrinsic connections to the coast with your students to make the science more meaningful.

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 Performance Expectations within the NGSS which can be supported or met by this curriculum. See the first page of each activity for a list of specific NGSS Performance Expectations aligned to that activity. Of course, depending on how you adapt these activities, you may be able to meet additional NGSS standards. Check out the NGSS website to browse the standards by topic, grade level, and more.

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. By following this curriculum, you can meet a number of standards across the Three Dimensions, including:

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing explanations and designing solutions	Variation of traits	Cause and effect
Engaging in argument from evidence	Adaptation	Systems and system models
Developing and using models	Structure and function	Energy and matter
Obtaining, evaluating, and communicating information	Interdependent relationships in ecosystems	Patterns
	Human impacts on Earth systems	

Common Core for Math, Literacy, and Social Science

Common Core State Standards (CCSS) for multiple subjects can easily be incorporated into a rocky shores 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 our shorelines. 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 3-5. 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 rocky shores 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:

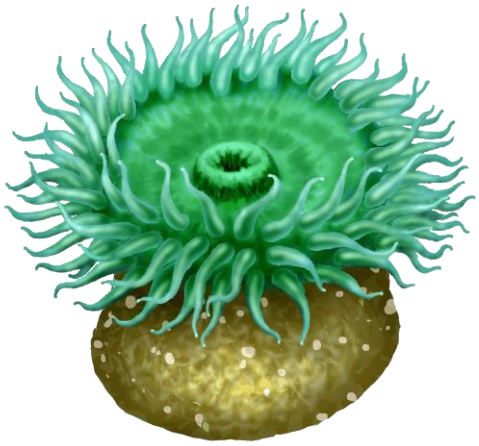
1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean makes Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are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

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



STUDENT LEARNING GOALS AND DRIVING QUESTIONS

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

- Explain how tides work and how they affect rocky shore animals
- Identify common rocky shore organisms
- Describe common intertidal adaptations and how they function
- Feel a greater sense of connection to the rocky shore
- Demonstrate awareness and respect for nature by following proper tidepooling etiquette
- Understand how humans impact rocky shore organisms, and what they can do to mitigate those impacts

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

1. *What are rocky shores?*
2. *How do tides work?*
3. *What lives at the rocky shore?*
4. *How can we care for rocky shores?*

This Teacher's Guide (and the workshop it accompanies) 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 *How do tide pool animals cope with changes to their environment?* or *What can we as students do to protect rocky shore life?* 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 School Liaison 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 4 Driving Questions (D.Q.'s), an Introductory Activity, Wrap-Up and Reflection Activities, and 2 field trips. Each of these is designed to accommodate the typical class period, taking between 30-50 minutes. Assuming one day for a field trip to Oregon Coast Aquarium, and one day for a field trip to the tidepools (though these can also be done on the same day), you can expect this entire curriculum to take two school weeks, or between 6-8 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 between field trips to the beach and to Oregon Coast Aquarium. Regardless of when your field trips occur, we encourage you to generally follow the 4 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 rocky shore ecosystems.

Suggested timeline

DAY 1: Introductory Activity

DAY 2: D.Q. 1: What are rocky shores? (Activity: *Moving with the Tides*)

DAY 3: D.Q. 2: How do tides work? (Activity: *The Sun, the Moon, and the Tides*)

DAY 4: Field trip to Oregon Coast Aquarium

Day 5: D.Q. 3: What lives at the rocky shore? (Activity: *Invent a Rocky Shore Creature*)

DAY 6: D.Q. 4: How can we care for rocky shores? (Activity: *Tidepool Obstacle Course*)

DAY 7: Field trip to the rocky shore

DAY 8: Wrap-up and Reflection Activities (may be done during rocky shore field trip)

INTRODUCTORY ACTIVITY

Time: 30-45 minutes | **Materials:** white board or paper; writing/drawing implements

What exactly are rocky shores? Chances are, if you've lived in Oregon for some time, both you and your students have visited at least one of our state's many rocky beaches. But it can be hard to explain what exactly makes rocky shores what they are – besides rocks!

Engage (5 mins): To introduce this unit and help students to recall their own experiences, ask students to show by a raise of hands who has been to a rocky shore. Ask them to describe their experience – *what did they see, hear, smell, and feel?* Write down these responses on the board. If you have a class of students who have largely never been to the beach, it will help to begin by showing this video and asking them to describe what they notice.

Explore (20 mins): Next, tell students that they are going to create a picture of what they think the rocky shore is – what it looks like, what lives there, anything they wish to include. This should be an open-ended challenge with very little guidance given, to encourage students to generate the drawing on their own. This serves as an excellent pre-unit assessment of their current knowledge. Give each student a piece of paper and writing implements with which to draw and allow them to do so uninterrupted.

Explain (5 mins): After sufficient time has been given for them to draw, ask them to describe what they created, pointing out the various features and explaining why they put them there. Do not correct or add to what they have drawn; again, the point of the exercise is to activate students' prior knowledge and to assess what they already know and understand (or don't) about rocky shores.

Evaluate: Can students clearly explain the features of their drawings?

NOTE: Make sure you collect and save the drawings. (They can also be displayed around the room!) This activity will be used again at the end of the unit to compare their baseline knowledge to what they learned.

Expand (15 mins): If time allows, read a related book. *Life in a Tidepool* by Allan Fowler, *In One Tidepool* by Anthony Fredericks, *Between the Tides* by Fran Hodgkins, and *Science Chapters: All About Tide Pools* by Monica Halpern are good options for elementary students.

Aligned Standards

Next Generation Science:

5-ESS2-1. Develop a model using an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Common Core for English Language Arts:

College and Career Readiness for Reading – 7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

Ocean Literacy:

Principle 5: f. Ocean ecosystems are defined by environmental factors and the community of organisms living there.

Principle 6: c. The ocean is a source of inspiration, recreation, rejuvenation, and discovery.

D.Q. 1: WHAT ARE ROCKY SHORES?

BACKGROUND INFORMATION

Life in the intertidal

"Rocky shore" is a broad term that encompasses a number of habitats, from the underwater subtidal zone to the nearly dry splash zone. Simply put, it is an area of the ocean shoreline where rocks, rather than sand, are the dominant substrate. It is a place where the tides are the driving force, changing the conditions from hour to hour and influencing all organisms which live there. Because of this, rocky shores are also known as the *intertidal zone.*

In Oregon, there are two low tides and two high tides every day. The changes which occur during and between these tides are drastic. Imagine a bucket of water left outside in the sun all day. What would happen to it? You could easily observe that the temperature increased, and you may be able to see that the water level lowered due to evaporation. With a little more investigation and some special tools, you would also find that oxygen levels decreased.

The spaces between the rocks in the intertidal zone, also known as *tide pools*, act just like this bucket. When the tide is in, cold, oxygen-rich seawater sweeps into the tidepools, restoring the temperature and bringing nutrients to the animals living there. But when the tide recedes, the temperature of the water begins to rise in the sunlight. Oxygen is used up by the animals and microorganisms living in the tide pools. Water evaporates, lowering the water levels and also raising salinity (the amount of salt in the water) – because the salt is left behind when the water evaporates. Rainfall can help lower the temperature, but also lowers salinity. The returning cycle of the high tide brings a return to more normal ocean conditions, but also risks: pounding waves can beat animals around and rip them from the rocks, and can also bring predators into the tidepools, such as octopus.

The organisms living in the tidepools must be adapted to withstand all of these extreme conditions: wet and dry, cold and warm, salty and fresh, and everything in between. Because of this, tidepool animals are some of the most resilient creatures on our planet.

Sea stars and anemones cluster towards the diminishing water in a tidepool.

LEARN MORE!

Visit NOAA Ocean Explorer's Virtual Tidepool

Intertidal Zones

The various zones at a rocky shore are determined by their location and their exposure to the air and water. From highest to lowest geographically, these are:

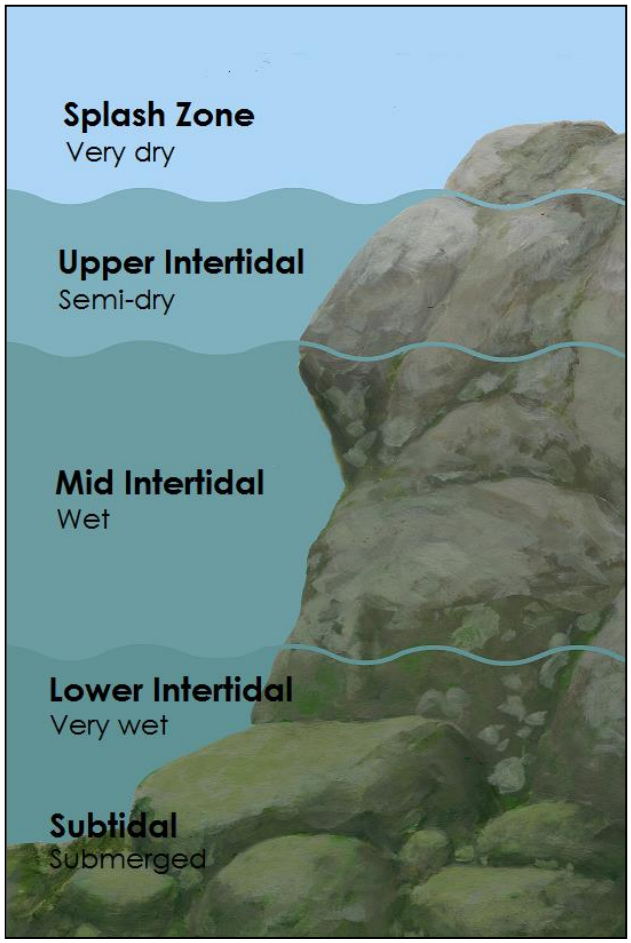
Splash Zone: The splash zone is above the surf line most of the time. It is reached by waves only during storms and the highest tides, but is splashed and sprayed occasionally by the waves below it.

Upper Intertidal Zone: The high tide zone is almost always exposed to the air, except during the highest high tides.

Mid Intertidal Zone: Extending from just below average sea level to the upper limit of the average low tides, this is the largest zone, and is covered and uncovered by water twice each day as the tides roll in and out.

Lower Intertidal Zone: This area is covered by water most of the time. It is exposed to air only during the lowest low tides.

Subtidal: The subtidal zone is covered with water almost all of the time. It may be exposed to air only during extreme low tides, known as *negative tides*.



The rocky shore also includes the beach itself, which can be made up of sand, shells, pebbles, or some combination of all those substrates. A number of animals from nearby habitats may visit this area of the rocky shore, even if they are not considered "marine" species. These may include turkey vultures, coyotes, raccoons, and more. Offshore, large marine mammals will often visit the edges of tidepools to hunt or rest, such as gray whales, dolphins, and sea lions.

LEARN MORE!
Visit Oregon Coast Aquarium's Oceanscape Network and Oregon Tide Pools

D.Q. 1: WHAT ARE ROCKY SHORES?

STUDENT ACTIVITY: MOVING WITH THE TIDES

Time: 15 minutes for prep, 45-50 minutes for activity | **Materials:** Sidewalk chalk (if doing activity outdoors) or masking tape (if doing indoors); "Critter Cards" (pg 16-17) printed and cut out

Conditions at the tidepools are always changing, and sometimes, the locations of the animals living there change with it! Some species are stuck to the rocks and don't move around, but others are mobile, and they follow the tides as the water moves up and down the rocks. In this activity, students will learn how rocky shore animals move into different tidal zones throughout the day during high tide, mid tide, and low tide.

Preparation (before students arrive) (15 mins): Set up the activity area, preferably outside on a paved area, or in a cleared space in a large classroom. You will need to create the five intertidal zones on the ground using sidewalk chalk or masking tape to designate each area, in the following order: *Subtidal, Lower Intertidal, Mid Intertidal, Upper Intertidal, Splash Zone.* Each area should be large enough for several students to stand in it a time. Label each zone with the chalk (or written labels). Next, print and cut out the "critter cards" provided on pages 16-17. Depending on your class size, you will have 2-5 students playing the role of each creature, so make sure you make enough copies for your class.

Engage (15 mins): Using the information provided on the previous pages, introduce students to the changing conditions found at the rocky shore throughout the day. Describe how temperature, salinity, and oxygen levels are different at high tide versus low tide. Ask students, *what would you do if you were standing outside and it started to rain? What if it got really hot? Would you stay where you are?* Of course not! Students would move somewhere to find shelter, and rocky shore organisms do the same thing: they move with the tides to where they can find more favorable conditions. Some animals prefer very wet conditions, while others prefer dry conditions, and still others can tolerate both dry and wet. Finally, describe the five intertidal zones found at the rocky shore, describing the wetness versus dryness typically found in each zone. Replicate the visual on the previous page on the board to provide students a visual aid of how the intertidal zones are arranged.

Aligned Standards

Next Generation Science:

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

5-ESS2-1. Develop a model using an example to describe ways in which the geosphere, hydrosphere, biosphere, and/or atmosphere interact.

Ocean Literacy:

Principle 5: f. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, etc.

Principle 5: h. Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast. These patterns influence distribution and diversity.

Explore (25-30 mins): Tell students they are each going to play the role of a different rocky shore animal. They will each get a "Critter Card" describing their animal, and how well they can cope with wet and dry conditions. It will also tell them what zones they can be found in throughout the day: at Low Tide, at Mid Tide (between high and low tides), at High Tide, and at extreme high and low tides. Hand out the Critter Cards. Depending on your class size, you will have 2-5 students playing the role of each creature. Give students a few moments to review the information on their Critter Card.

Next, show students the "intertidal zone" – the activity area you set up earlier. Tell students you will be announcing the tides as they change in your "intertidal zone". Point out the various intertidal zones, ensuring students know where each is and that the labels are clearly visible.

Begin the activity at "Mid Tide". Tell students it is now Mid Tide, and they should begin by finding their correct intertidal zone for that time of day. Then, tell students that the tide is rolling in. Use or adapt the following narrations: *The tide is coming in. Slowly, the water creeps up the rocks, filling empty tidepools, reaching higher and higher until – HIGH TIDE!* Once High Tide is announced, students should change zones based on where their animals would now be found. Then, the tide begins to recede again: *Water levels begin to fall. The upper rocks become uncovered as the tide goes out, washing down to pool in the Mid Intertidal Zone – MID TIDE!* Now students should move to the intertidal zone where they are found during Mid Tide, the time between High and Low Tide. Continue on to Low Tide: *The tide is going out more and more. Water is left behind in the tidepools to warm in the sun, as the sea washes out along the Lower Intertidal zone – LOW TIDE!* Once again, students should move to the zone their animal is most comfortable in during this tidal phase.

After this first round, students should have the hang of it, and you can introduce the Super Low and Super High tides. Tell students that unlike normal low and high tides, which happen twice daily, these extreme tides happen only rarely, when the Sun, Moon, and Earth are positioned just right. You don't need to elaborate on this now, but tell students they will learn more about how this works later. These extreme tides can move animals far beyond their normal range. At Super Low tides, the Subtidal can become exposed to the air, and at Super High tides, the Splash Zone can become quite wet. Go through the tide cycle again, this time including the Super Low and Super High tides. Encourage students to note where and how the organisms move during these extreme low and high tides.

Repeat the tide cycle as many times as you would like, perhaps speeding up your announcements to add an element of "racing" across the activity area (but remind them this process takes many hours in nature!).

The following chart shows the correct location of each Critter during each tidal phase:

	Super Low Tide	Low Tide	Mid Tide	High Tide	Super High Tide
Harbor Seal	Subtidal	Subtidal	Subtidal	Splash Zone	Lower Intertidal
Hairy Hermit Crab	Subtidal	Lower Intertidal	Mid Intertidal	Upper Intertidal	Splash Zone
Ochre Sea Star	Lower Intertidal	Mid Intertidal	Mid Intertidal	Upper Intertidal	Upper Intertidal
Purple Sea Urchin	Subtidal	Lower Intertidal	Mid Intertidal	Mid Intertidal	Upper Intertidal
Rockfish	Subtidal	Subtidal	Subtidal	Lower Intertidal	Mid Intertidal
Giant Pacific Octopus	Subtidal	Subtidal	Lower Intertidal	Mid Intertidal	Upper Intertidal

Explain (5 mins): Ask students to share their observations about how the "critters" moved as the tides changed. Were they able to observe any patterns? Students may be able to note that in general, animals moved down into the lower zones during low tides, and up into the upper zones at high tides. During most of the tide cycle, most of the organisms were somewhere between the Subtidal Zone and the Upper Intertidal. This is because most rocky shore organisms are adapted to some degree to living underwater and so cannot survive in the driest Splash Zone. One exception to this pattern is the Sea Lion, which basks on the rocks in the Splash Zone at High Tide, and is able to swim into the Lower Intertidal during Super High tides.

Expand (5 mins): Ask students to think about how rocky shore animals that cannot move – such as barnacles and mussels – cope with the changing tide conditions. What might they do to stay wet and cool during low tides? Spend a few minutes brainstorming, but acknowledge it's alright if they don't know the answer – they will learn more about these organisms' adaptations during a later activity.

Evaluate: Can students name the five intertidal zones found at the rocky shore? Are they able to describe the conditions found at each, and how these conditions change throughout the day as the tides go in and out?

"MOVING WITH THE TIDES" CRITTER CARDS

Print this page double-sided with the following page. Make enough copies so that each of these six "critters" has an even number of students playing it. Cut out along the dotted lines.

Harbor Seal

You are a marine mammal who likes to be in the water, except for when you're sunning yourself on the rocks.

Super Low Tide: Subtidal Zone
Low Tide: Subtidal Zone
Mid Tide: Subtidal Zone
High Tide: Splash Zone
Super High Tide: Lower Intertidal Zone

Purple Sea Urchin

With your spiny shell, you are safe from most predators, but must stay underwater for survival.

Super Low Tide: Subtidal Zone
Low Tide: Lower Intertidal Zone
Mid Tide: Mid Intertidal Zone
High Tide: Mid Intertidal Zone
Super High Tide: Upper Intertidal Zone

Ochre Sea Star

With your suction-cup "tube feet" you move along the rocks, following the tides and your favorite food – mussels!

Super Low Tide: Lower Intertidal Zone
Low Tide: Mid Intertidal Zone
Mid Tide: Mid Intertidal Zone
High Tide: Upper Intertidal Zone
Super High Tide: Upper Intertidal Zone

Hairy Hermit Crab

You borrow shells from snails for protection, but still need a lot of water so you don't dry out!

Super Low Tide: Subtidal Zone
Low Tide: Lower Intertidal Zone
Mid Tide: Mid Intertidal Zone
High Tide: Upper Intertidal Zone
Super High Tide: Splash Zone

Rockfish

Since you use your gills to breathe underwater, you need to stay submerged to survive!

Super Low Tide: Subtidal Zone
Low Tide: Subtidal Zone
Mid Tide: Subtidal Zone
High Tide: Lower Intertidal Zone
Super High Tide: Mid Intertidal Zone

Giant Pacific Octopus

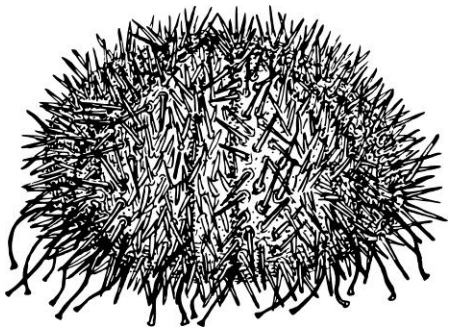
You need to stay wet, but you're able to crawl out of the sea and into the rocks hunting for crabs and fish.

Super Low Tide: Subtidal Zone
Low Tide: Subtidal Zone
Mid Tide: Lower Intertidal Zone
High Tide: Mid Intertidal Zone
Super High Tide: Upper Intertidal Zone

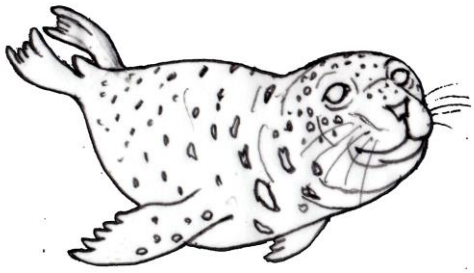
"MOVING WITH THE TIDES" CRITTER CARDS

Print this page double-sided with the previous page. Make enough copies so that each of these six "critters" has an even number of students playing it. Cut out along the dotted lines.

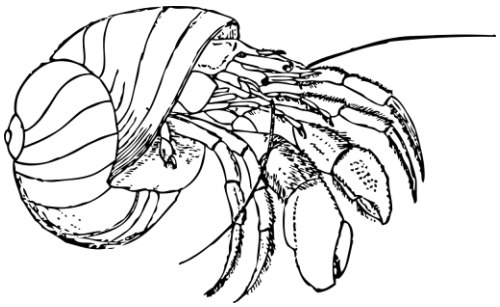
Purple Sea Urchin



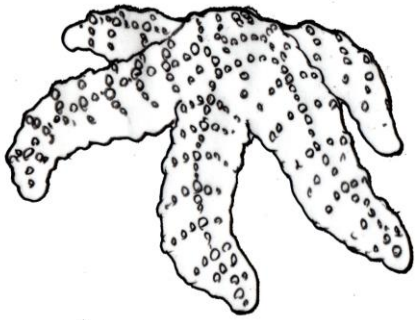
Harbor Seal



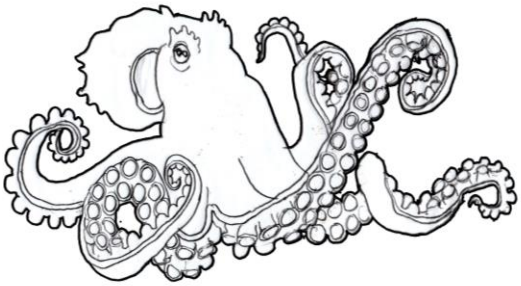
Hairy Hermit Crab



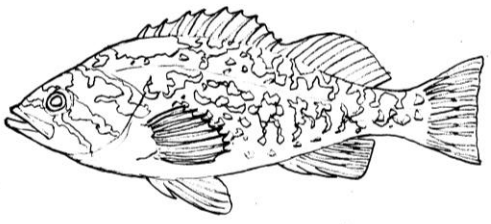
Ochre Sea Star



Giant Pacific Octopus



Rockfish



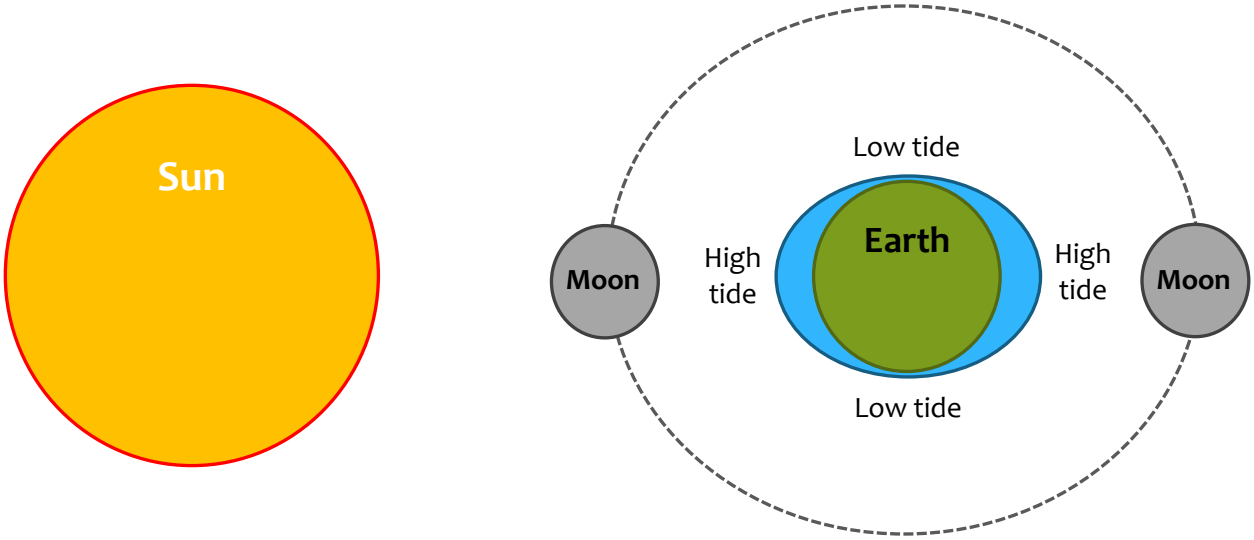
D.Q. 2: HOW DO TIDES WORK?

BACKGROUND INFORMATION

Tides are caused by the change in position of the Sun, Moon, and Earth relative to each other every day. The rise and fall of water along our shores is due to the changing gravitational forces exerted by the Sun, as the Earth moves around it, and the Moon, as it moves around the Earth. Tides are created because these huge bodies act as magnets on each other, pulling at each other's surfaces. Because water is liquid, it can actually be pulled and stretched away from Earth's surface by these gravitational forces.

Whether it is a high tide or low tide, and how MUCH of a high or low tide, all depends on the positions of the Earth, Moon, and Sun relative to each other.

Spring Tides

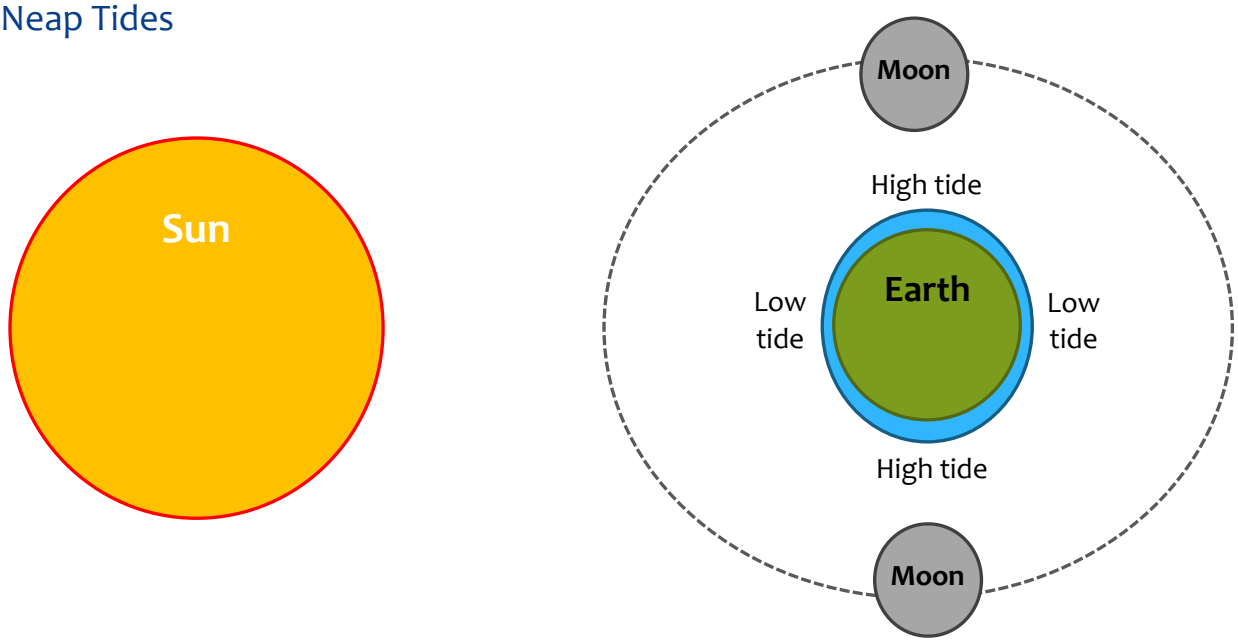


When the Sun, Moon, and Earth are lined up in a straight line, both the Moon and the Sun are exerting a gravitational force on the Earth that pulls water away from Earth's surface. At the same time, the Sun and Moon are also pulling at the Earth itself, which pulls the planet *away* from its water on the opposite side. Thus, when the Sun, Moon, and Earth are lined up, it is high tide on both sides of the Earth which are lined up with the Sun and Moon, and low tide on the other sides. When all three planets are exactly lined up and their combined gravitational forces are at the maximum – at the Full Moon and the New Moon – we have *spring tides*, which cause extremely high and extremely low tides.

LEARN MORE!

Check out Keith's Moon Page and NOAA for animated visuals and more information.

Neap Tides

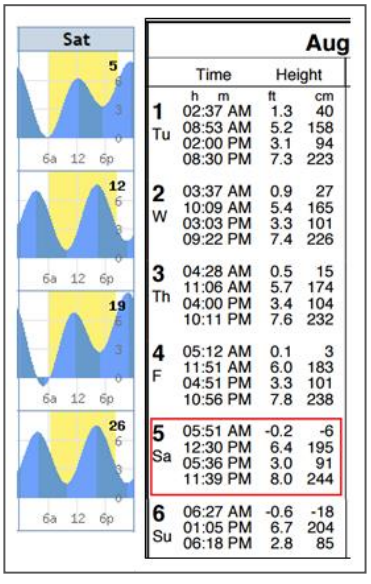


When the Sun, Moon, and Earth are perpendicular to each other, the gravitational forces of the Sun and Moon on the Earth are pulling in opposite directions and thus, they somewhat balance each other out. Water does not get pulled away from Earth's surface as dramatically, and thus, high tides are not as high and low tides are not as low. And while the Sun is a huge body and thus has a lot more gravitational force in general, it is much farther away from the Earth than the Moon. So for us, the Moon actually has a stronger tidal impact than the Sun. When all three planets are exactly perpendicular at the Quarter Moon phases, we have *neap tides* – very little change in water levels from high to low tide.

Because the Earth is also rotating around the Sun, all of these positions happen twice per day; thus there are two high tides and two low tides every day.

When is the best time to visit the tide pools?

When planning a trip to the rocky shore, it's important to first consult a tide chart or tide table. These tools predict what times the high and low tides will occur each day. It's best to visit the rocky shore when the tide is at its lowest, so that more of the tidepools are exposed and accessible. This is also the safest time, because the crashing waves will be furthest from shore. When reading tide charts, they will provide both times and heights. The average water line is considered zero; thus, a positive number denotes raised water levels, while negative numbers indicate very low water levels. The larger the number, the higher the tide. When water height is close to zero or negative (a "negative tide"), that's the best time to go to the beach!



D.Q. 2: HOW DO TIDES WORK?

STUDENT ACTIVITY: THE SUN, THE MOON, AND THE TIDES

Time: 30-45 minutes | **Materials:** Space for all students to sit in a circle and move around

Now that students know a little about how the tides affect rocky shore organisms, it's time to learn how tides work and why they happen! In this activity, students will use their bodies to model how the changing positions of the Sun, Moon, and Earth create tides.

Engage (5-10 mins): *What is gravity?* Elementary students should be familiar with this word, but it will be helpful to review. *Gravity* is the force that pulls an object towards the center of the Earth. It's why we can stand on the surface of Earth and not float away into space, and why a ball falls to the ground when it is released. It's not actually falling, but being pulled down by Earth's *mass*. The larger an object's mass, the more gravity it exerts. That's why astronauts on the Moon must bounce along slowly rather than walk as they can on Earth – the Moon is much smaller than the Earth, and thus has much less gravity pulling the astronauts down.

TIP: Use a video as part of your introduction to help visualize concepts, such as this one (a good overview) or this one (a simple animation).

Aligned Standards

Next Generation Science:

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.

Ocean Literacy:

Principle 1: c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of Earth's rotation, the Sun, and water density differences.

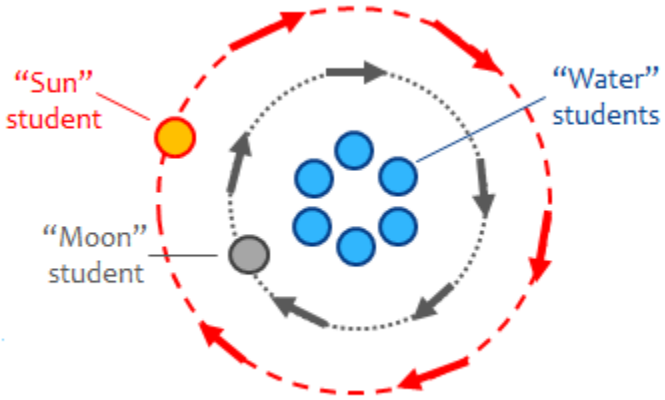
Though the Moon is small, it is large enough and close enough to Earth to have a strong gravitational force on Earth's surface. And because Earth, too, is exerting a gravitational force on the Moon, the Moon is trapped in an orbit, circling around the Earth once every month. Our oceans are stretched and pulled towards the Moon as it circles around our planet. This rise and fall of the oceans towards the passing Moon is what causes the rise and fall of water along our shores known as *tides*.

Explore (10 mins): For the first part of this activity, have students sit on the floor in a tight circle. These students represent the oceans on Earth's surface. Select one student to play the Moon and ask him or her to walk slowly around the outside of the circle. Tell students to lean their bodies towards the Moon as it passes; this represents the gravitational pull of the Moon on the oceans, causing the water to rise. After one or two revolutions of the Moon, pause and explain that it's a little more complicated than that. The Moon is also pulling on the Earth itself – pulling it AWAY from its oceans on the side opposite the Moon! This causes higher seas on the opposite side of the planet, too. Have the Moon walk around the circle again, only this time, have students by the Moon lean *towards* him or her as they pass, and

have students on the opposite side of the circle also lean back, *away* from the Moon. Continue until students can see the pattern of where sea rise occurs relative to the Moon.

Explain (5 mins): Explain that the students who are leaning out – either by the Moon or on the opposite side – represent the areas on Earth where it's high tide. The students *not* leaning out represent areas of low tide.

Expand – *for older or more advanced students only!* (15 mins): Introduce a complication to this pattern: the Sun! The sun is much, much bigger than either the Moon or the Earth, but it is also much further away. Therefore, it exerts a gravitational force on Earth, though a weaker one than the Moon. But it's strong enough that when joined up with the Moon's gravity, it causes a noticeable change in the tides.



Pull another student from the circle to play the Sun. Begin by placing the Sun next to the Moon so that all three planets are lined up. Explain that when the planets are lined up this way, there is an extra strong force on Earth's oceans – have the students closest to the Moon and Sun, and on the opposite side, lean ALL the way back to show the increased pull. When the planets are lined up this way, tides are extra high; these are called *Spring Tides.*

Next, have the Sun move around the circle so that the Sun and Moon are at a right angle to each other. *(Note that the Sun doesn't actually move around the Earth – the Earth moves around the Sun – we are just doing it this way to demonstrate!)* Ask students which way they think they should lean when the Sun and Moon are positioned this way. They will probably be torn about whether they ought to lean more towards the Sun or towards the Moon – and they're correct! When the planets are at a right angle like this, the gravity of the Sun and the Moon are competing, and the forces more or less balance each other out. Tell the students to lean towards the area between the Sun and Moon (or away from, on the opposite side), but only a little. When the planets are arranged this way, there is not much change in water levels even at high and low tides – these are known as *Neap Tides*.

Finally, ask both the Moon and the Sun to walk around the circle, and challenge students to lean towards or away from the planets as they pass without your guidance. The Moon should walk more quickly than the Sun to demonstrate that the Moon rotates around Earth much more quickly than the Earth rotates around the Sun (one month versus a year).

Evaluate (5 mins): Are students able to correctly demonstrate the gravitational forces of the Moon and Sun on the oceans without your guidance? Can they describe this process aloud?

FIELD TRIP 1: OREGON COAST AQUARIUM

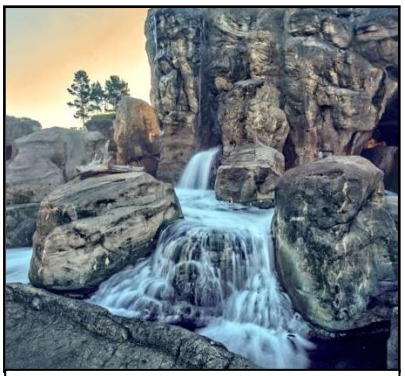
A field trip to the Aquarium helps to build student knowledge and understanding in a safe, accessible environment. It's a great way to both reinforce classroom learning and to prepare for forthcoming activities. While we have placed the field trip here ideally between the first two and last two Driving Questions, you may also opt to visit the Aquarium:

- *At the very beginning* – as an introductory and knowledge-building experience
- *At the very end* – to review knowledge gained and connect it to real animals and ecosystems that students can see and touch

Some teachers choose to combine their field trip to the Aquarium with their field trip to the beach on the same day. This can be a good strategy, because it means only one day of out-of-school time, and because Oregon Coast Aquarium is near a number of excellent tidepooling spots. If you choose to do both on the same day, we recommend you consult the tide charts and schedule your Aquarium visit during the time of highest tides, so you can be at the beach during low tide – the best time for tidepool viewing.

At Oregon Coast Aquarium, there are a number of galleries that directly relate to the activities in this curriculum, as well as opportunities for more structured student learning: check out our self-guided student activity book for Grades 3-5. **Enourage students to look for animal adaptations to life at the rocky shore, especially features which help them to withstand crashing waves!** We also have a number of lab programs aligned to various grade levels and topics, several of which relate to rocky shores ecosystems. "It's A Rough Life" explores the many ways tidepool residents are adapted to their extreme habitat. For younger students, "Coastal Comparisons" is a fun way to compare and contrast rocky shore versus sandy shore organisms. "Feeding Frenzy" focuses on marine food webs – a great way to explore the connections between the organisms they have been learning about, and an opportunity to discuss human impacts.

Our *Rocky Shores Gallery* is the most relevant exhibit to this curriculum, for obvious reasons! This gallery holds a total of 15 exhibits, including habitats for crabs, brightly-colored rockfish, and a wide range of sea stars, limpets and other invertebrates.The centerpiece of the Rocky Shores Gallery is our touch-pool. Staffed by volunteers, this exhibit lets visitors gently interact with tide pool residents like ochre stars, gumboot chitons and anemones. A simulated tidal surge tank allows visitors to watch what happens beneath the waves when the tide rolls in and out. Just outside this Gallery, a quiet rocky pool occasionally comes to life with crashing waves and splashing droplets.



Click here to get started planning your field trip to Oregon Coast Aquarium!

D.Q. 3: WHAT LIVES AT THE ROCKY SHORE?

BACKGROUND INFORMATION

Adaptations

You know now that the tide pools can be a tough place to survive. It won't come as a surprise that the organisms that live there must be just as tough. Rocky shore animals have a number of adaptations to survive the crashing waves and changing conditions. Some of these adaptations we can easily see; others are contained within the animal's physiology. The most visible adaptations of tide pool can be organized into three common categories:

Things that BEND

Animals like the Green Anemone pictured here are very flexible, allowing them to bend and sway with the currents rather than being broken by them. The ability to make their bodies rounded also allows water to flow over and around them more easily. Other tidepool organisms that are bendy and rounded include chitons and sea palms.

Things that STICK

Animals like the California Mussel pictured here are able to keep a very strong grip on the rocks to avoid being swept away by the waves. These mussels have glue-like byssal threads that attach them to the rocks, but other animals use suction-cup tube feet (sea stars) or a strong muscular foot (snails). Many seaweeds have holdfasts which grasp the rocks like vines.

Things with HARD SHELLS

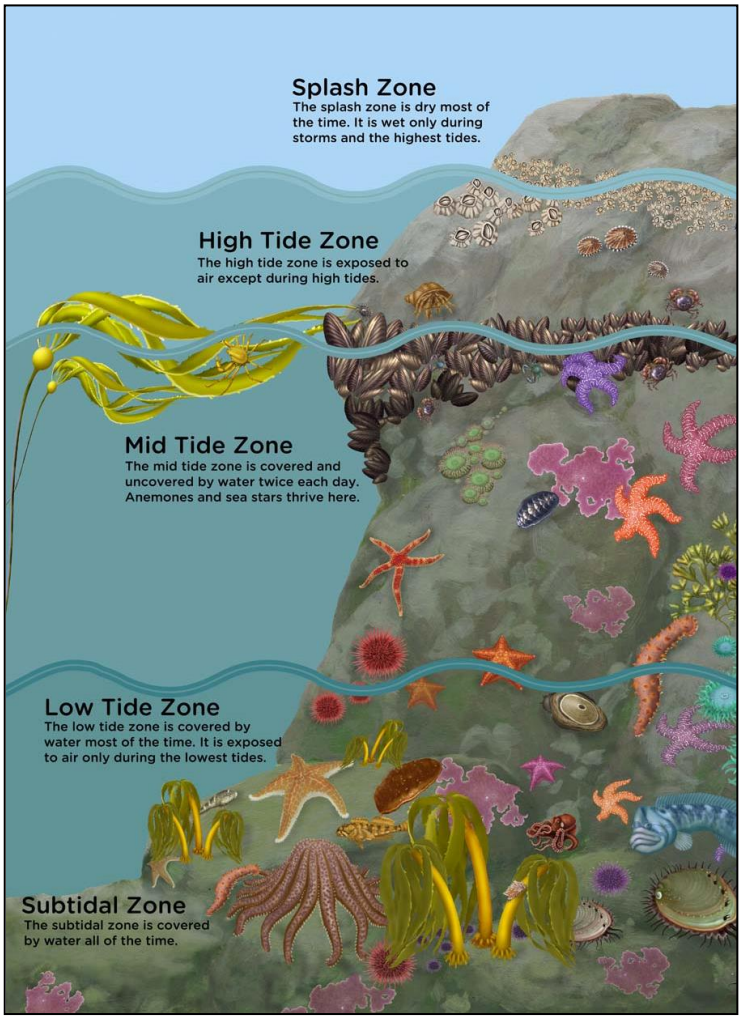
Animals like the Purple Urchin pictured here have a hard outer layer to protect them from both predators and the debris that can get washed in by waves. Some like the urchin have spines, while others such as shore crabs, barnacles, and hermit crabs have shells. Others, such as limpets, have hidden shells which are revealed when their mantles (soft body parts) are pulled in.

LEARN MORE!

Discover more species and adaptations at Monterey Bay National Marine Sanctuary

Different zones, different organisms

Life at the rocky shore is arranged by tidal zones, based on each species' adaptations and limitations. Some of these species are permanent residents in that zone, while others move in and out of different zones with the tides.



Splash Zone: You will find few tidal animals in this area because there is little water – it is only sprayed by the highest waves. However, it's a good area for spotting birds and marine mammals. Species commonly found here include the Black Oystercatcher, California Sea Lion, and Herring Gull.

Upper Intertidal: Animals in these areas have special adaptations which allow them to move between terrestrial and aquatic ecosystems, since this zone is dry except during high tides. Species commonly found here include the Giant Acorn Barnacle, Pickleweed, and the Proliferating Anemone.

Mid Intertidal: In a healthy intertidal area, this zone is rich both in diversity and numbers of organisms. It is covered by water with each high tide and revealed with each low tide. Species commonly found here include the California Mussel, Green Anemone, California Sea Cucumber, and Ochre Sea Star.

Lower Intertidal: Most of the animals in this area are not adapted to long exposure to air, since this zone is generally covered by water. Species commonly found here include the Featherboa Kelp, Grunt Sculpin, Red Urchin, and Hairy Hermit Crab.

Subtidal Zone: Underwater except during the most extreme low tides, this area is generally accessible only to SCUBA divers. The species living here are purely marine and cannot survive exposed to the air – with the exception of the Giant Pacific Octopus, which often crawls out onto the rocks to hunt in the tidepools. Other species commonly found here include the Sunflower Star, Bull Kelp, and Rockfish.

D.Q. 3: WHAT LIVES AT THE ROCKY SHORE?

STUDENT ACTIVITY: INVENT A ROCKY SHORE CREATURE

Time: 40-50 mins | **Materials:** Craft supplies (see pg 24); internet connection and screen to view video and slideshow of tidepool animals

In this activity, students invent a new species which can withstand the tough conditions in a tidepool, inspired by real tidepool organisms and their adaptations. This activity works best after your Oregon Coast Aquarium field trip, where they observed firsthand several tidepool animals and their unique features.

Engage (10 mins): Remind students that waves bring both vital resources (food, water, salt, cool temperatures) and challenges (big crashing waves, driftwood and other debris, predators) to animals living in rocky shore environments. Tidepool animals use a variety of physical features and behaviors to help them survive in this habitat.

Using the "Exploring Oregon's Tide Pools" slideshow at Oceanscape Network (right side of page, click to enlarge), ask students to name some adaptations that tidepool animals use to survive. These may include the ability to *stick* with a muscular foot, byssal threads, or tube feet which helps them hold on to the rocks and not get swept away; a *hard shell* which provides protection from big crashing waves and any debris that might be in the water; the ability to *bend* which helps them have a better grip on curved and bumpy rocks, and to flex with the waves; and a rounded body shape, which allows water to easily flow over and around them. Note that most rocky shores animals use a combination of these abilities to survive!

Then, have them watch this video of crashing waves in a tidepool and ask them to describe what they noticed. Write down these descriptive words on the board. Would they be able to survive in these conditions without being washed away?

Aligned Standards

Next Generation Science:

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Ocean Literacy:

Principal 5: d. Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms that do not occur on land.

Principle 5: f. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, etc.

Tell students they are going to design a tidepool animal they think could survive crashing waves without falling apart or being washed away. You can choose to have students work individually or in small groups. They should use real tidepool animals for inspiration, so remind them that they can refer to the slideshow and the list of features you created as a class. Distribute the crafting materials or give instructions for collecting them from the front.

NOTE: This activity comes from the Oregon Coast Aquarium education program, "Get A Grip".

Suggested crafting materials (use things that simulate bending, sticking, a hard shell, etc.)**:**

- Suction cups
- Play dough
- Tape
- Glue
- Velcro
- Yogurt cups
- Cardboard
- Pipe cleaners
- Hot glue sticks
- Plastic eggs
- Popsicle sticks
- Toothpicks
- Felt or fabric
- Whatever else you have on hand!

Tips on collecting materials

- Start early! Ask other teachers and/or students to bring in recyclables from home.
- Ask the cafeteria if they have any materials they can save.
- Raid the recycle bins at school.

Explore (20-25 mins): Move around the room as students to create their creatures, encouraging them to think creatively and to make predictions about what might happen to their organism if a big wave hit it. If time and resources allow, have students test their creations by placing them in a tub or sink filled with a few inches of water. Use a dustpan or their hands to create "waves" and see how their design holds up. If it falls apart, have students think about why it didn't work and what they could do to improve the design. Build, test, and rebuild designs for as long as time allows!

Explain (5-10 mins): Have students demonstrate their species designs to their classmates, highlighting the ways their organism stands up to waves and its other adaptations for survival. Ask students to relate these structural characteristics to real tidepool animal adaptations and features.

Expand (*if time allows*)**:** Discuss how, like animals, people have to be able to survive challenges in their own "habitats". Ask students to think about things buildings have to withstand (wind, rain, fire, etc.) so that humans can live and work safely inside. What are some ways people build buildings to be strong and stable? If time allows, take a tour of the school and look for safety features such as fire sprinklers and fire extinguishers, explore windows and doors to see how rain and cold is kept out, look for rain gutters and drains, etc. Compare the structures you see to any similar animal features you have discussed, or the ways that students designed their own creatures.

Evaluate: Do students reference prior knowledge and vocabulary gained throughout this unit? Are they able to describe what they learned through the design process and how that was applied to changes they made to their species? Do they use detail or specific examples when describing ways their design reflects real tidepool animal adaptations?

D.Q. 4: HOW CAN WE CARE FOR ROCKY SHORES?

BACKGROUND INFORMATION

Current issues facing this ecosystem

People visit the tidepools to enjoy the natural beauty, wild waves, and fascinating animals that live there. But they don't always realize the impact that their actions can have on these organisms. Being stepped on can injure or kill animals, even if they look like rocks or have hard shells. People prying animals off the rocks and moving them around can also have a devastating impact: they may be injured when pulled off the rocks, and you can inadvertently move them away from their zone of moisture, salinity, or temperature tolerance to somewhere they cannot survive. Once unattached from the rocks, these animals are also at risk of being washed away. Simply removing rocks or seaweed from a tidepool can also endanger animals, because these materials provide shade and protection for the organisms living beneath. Trash left behind by visitors can also harm wildlife.

What can we do to help?

When visiting the rocky shore, we should all follow **good tidepooling manners***:*

- *Watch your step!* When moving around, keep an eye on your feet and step carefully. Avoid wet rocks, seaweed (which can be slippery), and barnacles (which can puncture thin-soled shoes). Doing so will also help avoid hurting yourself and animals.
- *If you pry, it will die!* Many rocky shore organisms survive the crashing waves by attaching themselves firmly to the rocks. Pulling them off can injure these animals, and leave them vulnerable to being washed away. Never pry or tug on organisms.
- *Touch gently!* Use only one or two fingers to gently touch tidepool creatures. Do not poke them or push on them.
- *Leave no trace!* If you move seaweeds, rocks, or other materials to look beneath them, always return them exactly the way you found them. And never litter!
- *Don't take it home – alive OR dead!* Any living things you take home will quickly die. Left at the beach, these things could be become food or habitat for other organisms. It's illegal to collect these things at many Oregon beaches.
- *Clean it up!* Bring along a trash bag to remove litter each time you visit the beach.
- *Never turn your back on the waves!* Unusually large waves, known as "rogue waves", can occur unexpectedly and sweep you out to sea. Always keep your body facing the sea so you can keep an eye on the waves and make sure they don't get too close.

D.Q. 4: HOW CAN WE CARE FOR ROCKY SHORES?

STUDENT ACTIVITY: TIDEPOOL OBSTACLE COURSE

Time: 15 mins for prep, 45-50 mins for activity | **Materials:** list of "good tidepooling manners" from previous page; props representing tidepool animals and litter (see below for list); open floor space; sidewalk chalk (if doing activity outside) or masking tape (if doing activity inside)

In this activity, students will learn how they can take personal responsibility to care for the environment and its creatures when visiting the tidepools by following "good tidepooling manners". They will navigate through an obstacle course with items representing trash, tidepools, and sea creatures, demonstrating the proper choices they should make for each.

Prep (before students arrive) (15 mins): Set up the obstacle course. You may choose to set this up in an open space in your classroom, or outside on an open paved area. There are a number of ways you can design your obstacle course: for younger students, a traditional hopscotch layout works well, while for older students you may want to make it more complex. Use the sidewalk chalk, if outside, or masking tape if inside, to lay out the course that students should follow. Mark some areas with a large X to represent a tidepool full of water. How challenging you make it should be based on the age and abilities of your students (*see next page for an example*). Finally, set out your props throughout the obstacle course. You will need items to represent both tidepool animals and human trash, such as:

- Pictures of tidepool animals, printed and cut out, OR
- Toys to represent animals (rubber duckies etc.)
- Plastic bags, water bottles, soda cans, chip bags, etc.

Engage (10 mins): Ask students if they have to follow certain rules or manners around their house. Ask them to share what some of those rules for good behavior are (these may include manners at the dinner table, with their siblings, etc.). Tell students that when they go to the tidepools, there are certain manners they must follow as well. These guidelines for good behavior help to keep both them and all the creatures living there safe. Then, using the list on the previous page, introduce the rules for "good tidepooling manners". Engage students by asking them to volunteer their own ideas for proper behavior when visiting the rocky shore.

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.

Ocean Literacy:

Principle 6: g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Oregon Environmental Literacy:

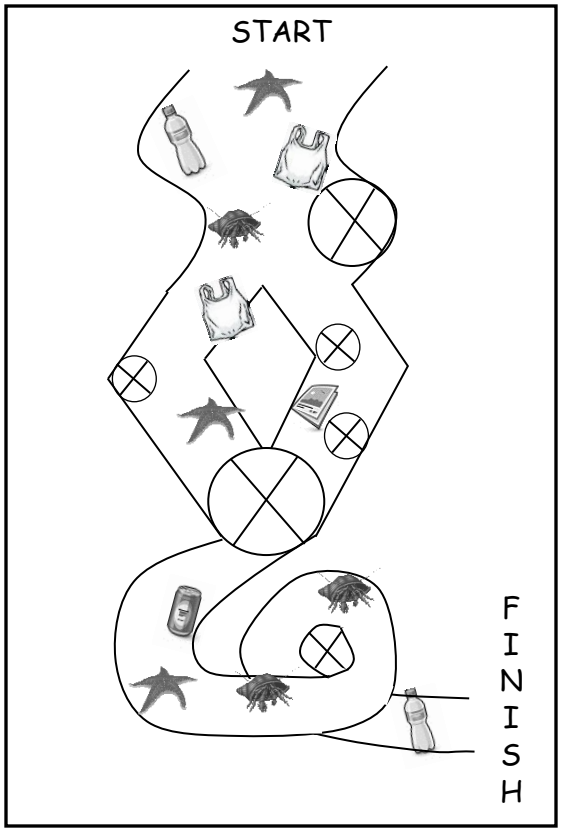
4b. Develop self-confidence in their effectiveness as citizens by understanding how their own actions affect environmental quality and sustainability.

Explore (30 mins): Have students gather around the outside edges of the obstacle course. Tell them they are going to pretend it's the real rocky shore. Point out the X's, the trash, and the pictures or objects representing the animals, and tell students what they each represent. Tell students they are going to take turns navigating the obstacle course, following the rules for good tidepooling manners that you just went over. For the obstacle course, this means:

- *Watch your step* – don't step on any of the "critters", or in the "tide pools"
- *Touch gently* – they can look at and touch the "critters", but not pick them up or move them
- *Leave no trace* – anything they accidentally kick or displace must be moved back to its original position
- *Clean it up* – each student should collect as much trash as they can along the way
- *Never turn your back on the waves* –designate one side of the room as the "ocean" and tell students they can never have their backs turned to it

Monitor each student as they go through the obstacle course and encourage the other students to help you enforce the rules. If they break any of the above rules they are disqualified (or you may allow them to start over, if time allows).

NOTE: To make the activity more exciting for older students, make it a competition! Time each student as they go through the obstacle course; the fastest time wins. Alternatively you can award winners for the most trash picked up. For younger students, you may wish to encourage careful rule-following rather than speed.



Explain (5 mins): Once all students have had the chance to go through the obstacle course, review the "good tidepooling manners" once more. Tell them that they will need to remember these rules when they go on their field trip to the rocky shore, and encourage them to share these manners with friends and family. Ensure that students understand *why* they should follow these rules – they are important both for their own safety, and to protect the environment and living things.

Expand (5 mins): Ask students what else they can do to help care for rocky shores. Ideas may include sharing the "good tidepooling manners" with their community, not bringing anything that could become litter to the beach, not feeding the birds or other animals at the beach, etc.

Evaluate: Can students recall all of the "good tidepooling manners"? Can they explain why they are important?

FIELD TRIP 2: TO THE ROCKY SHORE

Suggested sites for field trips

The Central Oregon Coast has a number of great tidepooling sites. Near Oregon Coast Aquarium, check out Seal Rock State Recreation Area or Yaquina Head Outstanding Natural Area. Both sites have restrooms and picnic facilities. Yaquina Head also has an Interpretive Center featuring rocky shore ecosystems, a great indoor alternative for high tides or poor weather. Wherever you go, be sure to check a tide table and schedule your visit during the lowest tide possible for best tidepool access!

The Oregon State Parks and Recreation department has created an interactive map of tidepooling sites, with accompanying tide charts, descriptions, and driving directions. You can also explore tidepooling sites with our Oceanscape Network's interactive map – just click on the different locations to view pictures, videos, and interesting historical facts. For more information on any of Oregon's coastal State Parks, with FAQ's and brocures, visit the Oregon State Parks website. Or give them a call at (541) 563-8500 – Park Rangers and Interpretive Specialists are always happy to talk to educators!

Preparing your students

Reserving plentiful time to prepare your students for their field trip will help reduce confusion and potential safety issues, as well as focusing them on their learning goals. Send home a list of things students will need to bring for the field trip, including:

- ✓ Rain gear: waterproof jacket and pants, if possible
- ✓ Sturdy shoes, such as sneakers or hiking boots – NO SANDALS!
- ✓ Warm layer, such as a fleece or sweater
- ✓ Sunscreen
- ✓ Hat
- ✓ Sunglasses
- ✓ Water bottle
- ✓ Field notebook

Emphasize the importance of these items by describing the conditions at Oregon's rocky shores: they are usually cold, windy, and wet, no matter what time of year it is. You may want to raid your school's lost-and-found for extra jackets and rain gear for students who forget or do not have these items.

Before leaving for your field trip, emphasize the importance of safety on this field trip. Review the "good tidepooling manners" discussed in the *Tidepool Obstacle Course* activity. We strongly recommend providing chaperones with a list of these rules as well, so they can help with student management at the beach and model good behavior.

At the beach

There are a number of activities you can do once you get to the beach, depending on your time and resource availability. Whatever activities you decide to do at the beach, **be sure to begin with time for free, unstructured exploration.** This will allow students to work out their energy and satisfy their natural curiosity and impulse to explore. When you feel students have had sufficient time to discover on their own and become comfortable with their surroundings, then you can gather the group and facilitate the structured activities.

The simplest activity is to allow students to independently explore, searching for tidepool creatures and identifying them once they are found. If this field trip occurs at the end of the unit, and after your Aquarium field trip, students should be able to identify the most common species. If you feel they may need an identification aid, there are a number of free tidepool field guides available online that you can print: check out this one from Oregon State Parks or this one from Cape Perpetua Scenic Area. If you have the funds to purchase field guides, we recommend the Pocket Naturalist Guide to Northwestern Seashore Life, which is both waterproof and lightweight. You can buy this online for between $5-$8; purchase enough copies for every 2-3 students to share.

Aligned Standards

Next Generation Science:

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.

Common Core Math:

3.NB2. Fluently add and subtract within 1000.

3.MD3. Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories.

3.G2. Partition shapes into parts with equal areas. Express the area of each part as a unit fraction of the whole.

Ocean Literacy:

Principle 7.b: Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes.

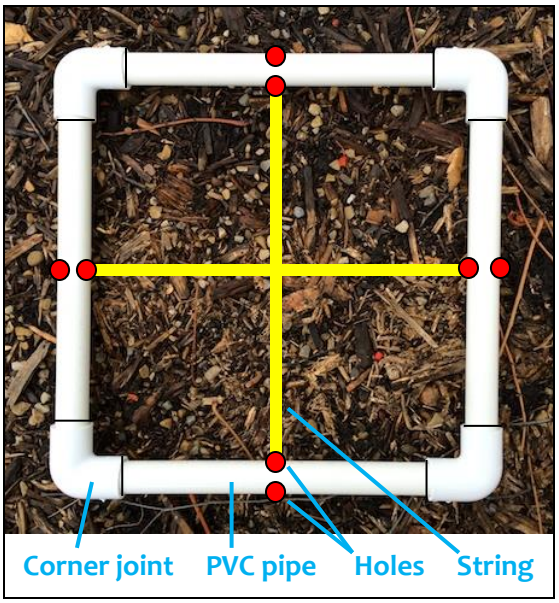
Activity Idea 1: Counting biodiversity using quadrats

A *quadrat* is a square plot used by ecologists to isolate a standard unit of study area. Scientists use quadrats to understand the populations of a large area by counting the number of organisms found within the quadrat in several different sample spots. Often, the quadrat is divided into smaller squares within it. This is useful in calculating percent coverage of certain species, such as plants or invasive species. This information helps scientists to understand the health of an ecosystem, and is used to develop plans for ecosystem restoration or management.

You can easily create your own quadrats with inexpensive supplies. You will need:

- Four ¾ inch pipes of equal length (between 16-20 inches)
- Four ¾ inch 90° corner ("elbow") joints
- Sturdy twine or rope
- A drill

Making a quadrat



- Create your square by attaching the pipes together with the corner joints. If desired, use glue to permanently secure the pipes to the joints.
- Use a ruler and permanent marker to mark the half-way points on each pipe to divide the quadrat into four equal squares.
- Drill a small hole at each of the halfway points, through both sides of the pipe, on each of the four pipes.
- Draw the string through the first set of holes and securely tie it off. Pull the other end of the string through the holes directly opposite, and tie it off so the string is taut. Repeat this process for the remaining two sets of holes.

NOTE: If time and resources allow, you can even have students work in small groups to create their own quadrats!

Lay the quadrats (one per every 3-4 students) on top of the rocks or over a tidepool, being careful that they aren't sitting on any sensitive creatures. Have students work in groups to identify all of the types of organisms they see within the quadrat using their field guides.

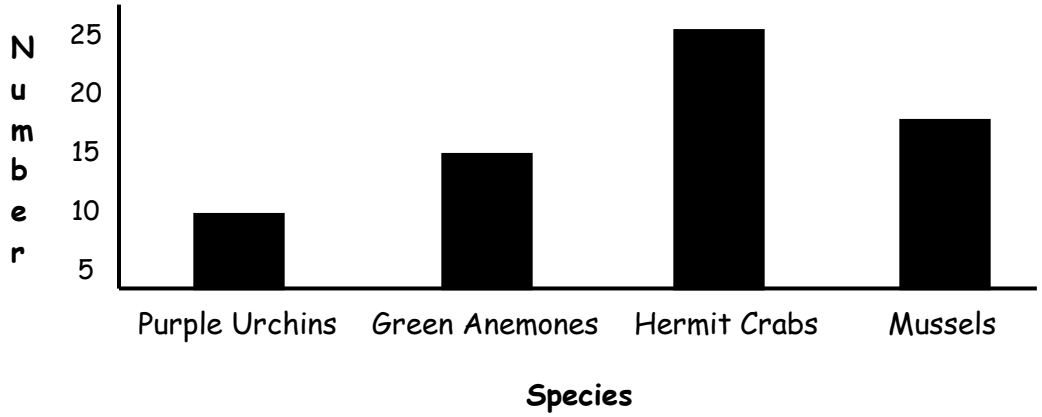
Then, have students count and record the number of individuals of *each species in each square*. At the end, they can calculate the *total number* of individuals of each species by adding up their results from all four squares. Below is a template for how students can set up their page and record their data:

TIP:
Draw this on the board and have students copy it into their field notebooks BEFORE leaving for your field trip!

Square A		Square B	
Species	Number	Species	Number
Square C		**Square D**	
Species	Number	Species	Number

Totals (A+B+C+D)	
Species	Number

To extend math practices back in the classroom, collect and combine all student data, displaying class totals on the board. Then ask students to create a bar graph displaying the results:



Ask students which species were the most common, and *why* they think those species were most common. Answers should be based on *adaptations* and *tidal zones* (i.e., if sampling took place in the Upper Intertidal Zone, species such as the Acorn Barnacle which have adaptations to prevent drying out should be most common). Help guide student understanding based on the activities from this unit they have already completed.

Activity Idea 2: Water quality sensors

Use digital tools, known as probes or sensors, to measure abiotic factors in the tidepools such as salinity, temperature, and dissolved oxygen. If your school does not already have these, they may be borrowed from your local STEM Hub Trailer. If your school is located in Tillamook County, kits may also be obtained from the Tillamook Estuaries Partnership. These materials should come with instructions for use. Be sure to familiarize yourself with these first, and ideally, do a test run to try them out. Explain to students how these sensors are to be properly used.

Instruct students to take water quality measurements in both the Upper Intertidal Zone and the Lower Intertidal Zone (and in between, if they wish). **SAFETY TIP: Be sure to keep a close eye on the students in the low tidal zone, making sure they don't have their backs to the ocean and that they don't get too close to the waves. "Rogue waves" can suddenly sweep in much higher than expected, knocking people over or sweeping them out to sea. Assigning a "lookout" student or chaperone can help prevent this.** Have students take turns with the sensors, and have them record their data in their field notebooks.

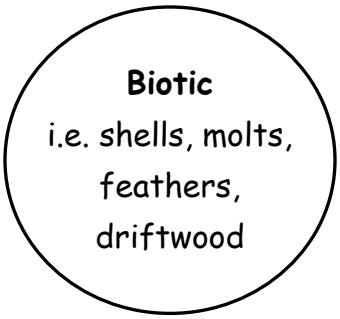
After students have had time to experiment with the sensors and record their data, gather the group together to discuss. Ask them to share the differences between the different tidal zones. Then, ask them *why* they think there were differences. Refer back to the "Moving with the Tides" activity to discuss the changing conditions at rocky shores, both in the different intertidal zones and at different times of day.

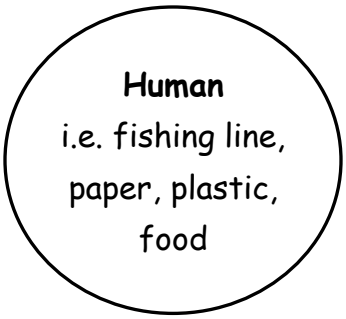
If tides are bad…

Sometimes, it's not possible to schedule your field trip during a period of low or negative tides. If you're at the beach when the tide is too high to observe many creatures, there are alternative activities you can do. Here are some more ideas:

Activity Idea 3: Kelp Surfing. "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. Have students record their findings in their field notebooks.

Activity Idea 4: Circles in the sand. Ask students to collect and categorize things they find on the beach. Draw two large circles in the sand, labeled *biotic* (living or once-living things), and *human* (man-made items). Give students time to collect as much as they can, and sort what they found into the two circles. **SAFETY TIP: Be sure to warn students not to pick up anything that looks unsafe, such as glass or sharp objects, and ensure chaperones carefully monitor the activity.** After re-gathering the group around the circles, discuss what they found, pointing out any surprises or mistakes. These may include things students may not identify as biotic but were once living (such as shells and sticks) and potentially confusing items (such as bits of trash that might look like living things or vice-versa). Point out the amount of trash versus living things they found, and use this to reinforce what they learned about caring for rocky shores during the "Tidepool Obstacle Course" activity. Complete the activity by asking them to collect all of the items from the "human" circle into a trash bag. You can even sort out what is recyclable and what is not for proper disposal.





WRAP-UP AND REFLECTION ACTIVITIES

By the end of their *Exploring Oregon's Rocky Shores* unit, students should be able to explain how tides work; identify common rocky shore organisms and explain their adaptations; understand how they can care for rocky shore habitats and creatures; and feel a greater sense of connection to rocky shores. The following activities will help you to assess the knowledge and understanding students gained, and to further foster that sense of connection to the beach – perhaps the most important outcome of all, because it encourages ongoing interest and care for rocky shores.

Rocky Shores Drawing, Part 2

At the very beginning of this curriculum, students drew their ideas of what a rocky shore looks like. Now, after completing all of the classroom activities and field trips, ask students to do the same exercise and draw the rocky shore again. Just like before, allow them to draw freely without any teacher guidance for some time.

Assess student learning by comparing their original drawings with the new drawings. Changes to look for include:

- Labeling of organisms and/or the intertidal zones
- Significant animal adaptations clearly drawn
- A greater number and diversity of rocky shore organisms
- Evidence of tides, such as crashing waves and the Sun/Moon
- Presence of human impacts, including trash or people

Invite students to compare their own drawings to reflect on, and gain pride in, all they've learned. Engage them in a discussion of what stayed the same and what changed.

Free-Choice Writing Exercise

Engage students in an open-ended writing exercise that allows them to express their learning and reflect on their experiences. Allow students to choose what format they wish to write in: a poem, a short story, or a brief essay. The only restriction is that their writing must involve either *something they learned about the rocky shore* or *how the rocky shore makes them feel* – or both! If you wish, this could be given as a homework assignment to allow students more time to develop their thoughts and imagination. Have students share with their peers by reading works aloud, or displaying works somewhere in the school.

Aligned Standards

Next Generation Science:

5-ESS2-1. Develop a model using an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Common Core for English Language Arts:

College and Career Readiness for Reading – 7: Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

College and Career Readiness for Writing – 3: Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

Ocean Literacy:

Principle 5: f. Ocean ecosystems are defined by environmental factors and the community of organisms living there.

Principle 6: c. The ocean is a source of inspiration, recreation, rejuvenation, and discovery.

BIBLIOGRAPHY OF LINKS & ADDITIONAL RESOURCES

Pages 5-6

Oregon Parks and Recreation Department: https://www.oregon.gov/oprd/NATRES/Pages/RS_main.aspx

Nurseries for juvenile animals: http://www.academia.edu/24822309/Intertidal_pools_as_alternative_nursery_habitats_for_coastal_fishes

Marine Reserves: http://oregonmarinereserves.com/

Help restore populations in surrounding waters: http://www.oregonmarinereserves.org/ecological-benefits-of-reserves

Native peoples on the coast: https://oregonhistoryproject.org/narratives/this-land-oregon/the-first-peoples/the-first-peoples/#.WV1J9YTyuUk

Beaches used as a highway: http://www.beachconnection.net/news/beachhi022816_1028.php

Oregon Beach Bill: http://www.opb.org/news/article/50th-anniversary-of-oregons-beach-bill/

Check out the NGSS website: https://www.nextgenscience.org/

Consult the Oregon Common Core Standards: www.ode.state.or.us/go/commoncore/

Framework for Ocean Literacy for Grades K-12: http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/

Pages 7-8

Oregon Environmental Literacy Plan: http://oelp.oregonstate.edu/oelp-plan/oregon-environmental-literacy-plans

Project-Based Learning: www.bie.org

Resources Page: www.bie.org/resources

Pages 10-11

Video: https://www.youtube.com/watch?v=Az2Ct1tUAEM&feature=youtu.be

NOAA Ocean Explorer's Virtual Tidepool: http://oceanexplorer.noaa.gov/edu/learning/player/lesson10/l10_ex.html

Page 12

Oregon Coast Aquarium's Oceanscape Network: http://oceanscape.aquarium.org/explore/general_articles/tide-pools

Oregon Tide Pools: http://oregontidepools.org/tidalzones

Pages 18-19

Keith's Moon Page: http://home.hiwaay.net/~krcool/Astro/moon/moontides/

NOAA Tides: http://oceanservice.noaa.gov/education/kits/tides/media/supp_tide06a.html

Consult a tide chart or tide table: http://www.tides.net/oregon/

Page 20

Narrated tides video: https://www.youtube.com/watch?v=5ohDG7RqQ9I

Animated tides video: https://www.youtube.com/watch?v=NqDEaFjIXPw

Page 22

Self-guided student activity book for Grades 3-5: http://aquarium.org/wp-content/uploads/2016/05/Grades-3-5-Updated-2016.pdf

Lab Programs: http://aquarium.org/education/on-site-school-programs/

Rocky Shores Gallery: http://aquarium.org/exhibits/rocky-shores/

Click here to get started planning your field trip to Oregon Coast Aquarium: http://aquarium.org/visit/field-trips/

Pages 23-24

Find information for all the species listed on this page and more at: http://oregontidepools.org/speciesguide/

Monterey Bay National Marine Sanctuary: http://montereybay.noaa.gov/visitor/TidePool/species.html

Find information for all the species listed on this page and more at:

http://oceanscape.aquarium.org/explore/general_articles/tide-pools

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"Exploring Oregon's Tide Pools" slideshow on Oceanscape Network: http://oceanscape.aquarium.org/explore/general_articles/tide-pools

Crashing waves video: https://www.youtube.com/watch?v=Az2Ct1tUAEM&feature=youtu.be

Page 30

Seal Rock State Recreation Area: http://oregonstateparks.org/index.cfm?do=parkPage.dsp_parkPage&parkId=147

Yaquina Head Outstanding Natural Area: https://www.blm.gov/learn/interpretive-centers/yaquina

OPRD interactive map of tidepooling sites: http://oregontidepools.org/popular_tidepools/map

Oceanscape Network's interactive map: http://s3.amazonaws.com/oceanscape-production/file_assets/files/000/000/137/original/Oceanscape_Network_Oregon_Tide_Pool_Locations.pdf?1421357855

Oregon State Parks website: http://oregonstateparks.org

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Field Guide from Oregon State Parks: http://oregonstateparks.org/index.cfm?do=main.loadFile&load=_siteFiles%2Fpublications%2Ftidepool082936.pdf

Field Guide from Cape Perpetua Scenic Area: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5329431.pdf

Pocket Naturalist Guide to Northwestern Seashore Life: http://www.waterfordpress.com/products/pocket-naturalist-guides/regional/northwest-seashore-life.html

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STEM Hub Trailers: http://oregoncoaststem.oregonstate.edu/resources/kits

Tillamook Estuaries Partnership: http://www.tbnep.org/education-kits.php

Additional Resources

Oregon Tide Pools – Field Trip Tips: http://oregontidepools.org/teach

Video – PBS Studios' "The Intertidal" (great short introductory video for students): https://www.youtube.com/watch?v=DR1gP5S6Bsk

Oregon Conservation Strategy – Rocky Intertidal Zone: http://oregonconservationstrategy.org/oregon-nearshore-strategy/habitats/rocky-intertidal/

Hatfield Marine Science Center – Rocky Intertidal Lab Program: http://hmsc.oregonstate.edu/sites/hmsc.oregonstate.edu/files/visitor-center/education-programs/docs/previsit_rocky_intertidal.pdf

Oregon Coast Education Program – Coastal Education Modules: http://www.pacname.org/oregon-coast-education-program/

Northwest Ocean Observing Systems (NANOOS) – Historical and live data by region and category: http://www.nanoos.org/products/products.php

Wild Classroom – Intertidal Biome: http://www.thewildclassroom.com/biomes/intertidal.html

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