Tide Pool Survival

Birch Aquarium

This activity outline was developed for use in a variety of informal venues. By design, it provides the content, pedagogy and strategy necessary for implementation by both the novice and experienced informal educator. It is expected that this outline will be adapted and improved upon by the user. We welcome your feedback!

Synopsis of the Activity

Visitors observe live tide pool animals and use clues from pictures and/or drawings to discover what life is like at the rocky seashore. Using their animal observations and clues, visitors make predictions about the features and behaviors each animal has to help it survive at the rocky seashore.

This activity includes sets of questions you might use to facilitate conversations and discoveries. As the facilitator, don't feel you need to guide the learner through all these questions. As always, go where the learner's interest and expertise takes the two of you.

Audience This activity is targeted for K-3 students and their parents, but is suitable for all ages.

Setting This activity is best implemented in a classroom that has access to live tide pool animals, at a tide pool exhibit, or even in an actual tide pool, but can be done anywhere that the visitors can have access to animals in small containers, i.e., on a cart on an open museum floor.

Activity Goals

- Make hypotheses about an animal's features and behaviors that allow it to survive in its habitat through observations and interactions with live animals.
- Use scientific processes to investigate a question.
    - Make observations, predictions, inferences, and explanations based on evidence and discuss ideas with others.

Concepts

- Animals living at the rocky seashore experience many different changes in a day including, crashing waves, and being covered and uncovered by ocean water.
- Animals living at the rocky seashore have features and behaviors that allow them to escape predators.
- Animals at the rocky seashore have a variety of features and behaviors that allow them to survive crashing waves and changing tides.
- We can make inferences about the features and behaviors an animal uses to protect itself through careful observation of the live animal.

Ocean Literacy Principles

5. The ocean supports a great diversity of life and ecosystems.
    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.
    f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy." Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
    h. Tides, waves, and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.

Materials

- Plastic tubs large enough to hold 2-3 different animals
- Seawater
- Aerator and pump
- Tide pool animals such as a sea star, turban snail, and/or sea cucumber
- Towels for drying hands
- Picture tiles or drawings of physical and biological factors at the rocky seashore: low tide/high tide, waves, wind, sun, air, predators, people etc.
- Picture or poster of tide pools at the rocky seashore
- Hand lenses for examining organisms
- Butcher Paper or wipe boards
- Markers
- Books about the rocky seashore

Prep Section

Make sure you have all the materials you need to safely house the animals, i.e., tanks, aerators, ice packs. Consider having multiples of each animal to rotate them in and out to prevent overstressing the animals.

Procedure and Set-up

Transfer the tide pool animals into the plastic tubs. Arrange picture tiles around the setting.

Guiding Questions

What do you notice about the animal?
What do you observe the animal doing?
Have you ever been to the rocky seashore or explored tide pools?
What do you know about rocky seashores? Where/how did you learn about them?
What types of things might an animal need to protect itself from at the rocky seashore?
What makes you think that?
What body parts or features could the animal use to protect itself? How? What makes you think that?

What kinds of behaviors could the animal use to help protect itself? How?
What other animals in the tide pool or rocky seashore might have a similar way to protect itself? Can you show me what you mean?

Activity Description
Note: *The learner's experience with this subject, their interest and general personality will vary, so be flexible. Be open to their areas of interest and lines of questioning and thinking and don't hesitate to try a new approach.*

Following is a sample of how to proceed through the activity, but instead of a sample conversation there is a progression of groups of questions. The questions below should be part of a conversation that you have with the learner, so you can start anywhere and move freely from one group to another based on the visitors' experiences and interests. As you read through these questions, you may think of other ways to phrase the same idea based on the responses the visitor may give and questions you might use to follow-up the visitor responses.

Remember to be flexible with the visitors' interests. If someone approaches and is drawn to a particular animal or makes a particular observation, don't start by asking them what they notice, but instead, start with their observation and then move to looking at other features. Many of the following questions are framed "What do you think…" This is so that the visitor can share and investigate the idea with you without concerns that their answer may be "incorrect."

<u>Free exploration</u>
Invite visitors to investigate some animals that live in a tidepool. As they observe, ask them to share any observations they have about the animal. Ask them to first just observe with their eyes. Tell them that in a moment they can gently touch the animals.

Guide visitors as they observe with the following questions.

- What do you notice about this animal? (Have the visitor show you)
- What do you find interesting about it?
- What do you observe the animal doing? (You might want to share with the visitor that this is also called behavior)
- Have you ever seen any other animals like this one before? Where did you see it?
- Where do you think it lives?
- What about it makes you think that?

Invite visitors to gently touch and/or hold the animals gently. Use the following questions to guide visitors in making new discoveries and observations.

- What does it feel like when you touch it?
- What new observations can you make about it? (Have the visitor show you)
- What do you observe it doing when you touch it? (How does it behave?)
- What do you find interesting about it now?
- Does the animal behave differently when you hold it?
- What surprised you about this animal?

Habitat Discussion

Ask visitors if they think they know where these animals live. Ask a followup question such as: what makes you think that? In your discussion, ask the visitors if they can think of another word for an animal's home (habitat). If necessary, explain that a tide pool is the habitat that these animals live in. Show them the pictures of tide pools at the rocky seashore. Explain that sometimes the rocky seashore is covered with water (high tide) and sometimes it is not (low tide). Explain that a tide pool is a depression or pool in the rock that holds water even when the tide is out and most of the rocky seashore is no longer covered with water. Ask the visitors some of the following questions:

What do you observe in the pictures?
What are some of the things that might happen in a habitat like this?
What clues did you use to figure this out? (Tell them another word for clues is evidence)

Physical and Biological Factors at the Rocky Seashore

Show the visitors the pictures of some of the physical and biological factors at the rocky seashore including crashing waves, sunshine, changing tides, and predators and tell them that these are some of the things (biological and physical factors) that animals living here might have to deal with. Ask the visitors to describe what they observe in the pictures, guiding them with the following questions:

What do you notice about these pictures?
What are some things that rocky seashore animals might have to deal with that you didn't think about before?

Explain that there are many physical and biological factors that can affect an animal's survival in a tide pool. As you discuss this idea with them, write down their suggestions of additional factors on a piece of butcher paper or a wipe board. (Optional depending on the age of the visitor, you might want to add a quick sketch of what they suggest.) Some of these suggestions might include (depending on the age and experience of the visitors): waves, temperature, salinity, dessication, predation, people trampling or collecting, and competition for space. Once you've written down their suggestions, point out that some of these factors come from other living things (predators, people and competition), and some come from non-living things (waves, sun, tides). Ask them if they can sort the factors by living and non-living, and what their evidence is for sorting them that way.

Making Predictions about Features and Behaviors

Direct the visitors to one of the touch tank animals, allowing them to gently touch and hold the animal again. Have them look at the picture tiles again and make a prediction about how the animal protects itself from one or more of the factors. Encourage them to investigate the animal by gently touching the animal (to feel for rough skin, hard shell, etc.), and with the facilitators help have them examine the underside of the animal (for tube feet, muscular foot, etc.). Encourage the visitors to draw a conclusion and answer the scientific question asked at the start: how does the animal protect itself from this factor at the rocky seashore?

As they make observations, guide them with the following questions:

How do you think it could survive _____ (factor)?
Do you see anything on the animal's body that could help it survive__ (factor)?
How does _____feature help it survive _____(factor)?
Why do you think that? What is your evidence?
What about this feature helps it survive _____ (factor)?
Does it have any other features that help it survive that factor?
Does that feature help it survive another factor, too?
What makes you think that?

Encourage the visitors to share their ideas with each other and to challenge each other if they have different ideas. Facilitate their discussions and encourage them to make further observations about the animals.

Wrap Up
Ask visitors how they might be surer about their ideas? Some ways they might suggest include asking experts, going to visit the rocky seashore and making observations in nature, watching a video, setting up experiments or using the Internet or a book. (Optional: have books and field guides available for visitors to use.)

Ask visitors if they think that the animal that they have been observing could survive in a different habitat (you might want to give them an example of a specific habitat, i.e., sandy beach, deep sea). Ask them why or why not. Point out that we can often predict or guess how an organism survives in a particular habitat by carefully observing an animal and its features and behaviors, and using those observations as evidence, similar to what they have just done.

Ask visitors to think about how people visiting a rocky seashore and tide pools might affect the animals living there. Facilitate a discussion with the visitors about their ideas. Ask them if they think that maybe people could be considered to be a factor that animals have to deal with. Ask them to consider some ways that we might reduce our impact on the animals living in this habitat.

Related Activities/Extensions/Modifications
Provide an opportunity for the visitors to investigate an additional organism and to make predictions about behaviors or features that might allow it to survive at the rocky seashore.

Provide an opportunity and materials for the visitors to do simple observation experiments such as creating waves, or hiding places and observing what the animal does over time.

Compare tide pool animals to animals from other marine habitats, i.e., wetland, sandy beach, kelp forest, etc. Provide students with pictures of these habitats and some of the associated physical factors.

Provide journaling materials (paper, pencils, crayons) for visitors to record their observations about tide pool animals and the features and behaviors that allow them to survive there. Visitors can compare how two different animals are adapted to survive crashing waves or changing tides at the rocky seashore. **Additional Resources**

- *The Most Excellent MARE Teacher's Guide to the Rocky Shore* by Dr. Robin Milton Love
- Local field guides

Background

The following is a generalized list of some of the environmental factors affecting organisms living in tide pools and some of the features and behaviors (adaptations) they have that allow them to survive.

- Salinity changes
    - Closing up tightly
    - Withstand wide range of salinity
- Temperature changes
    - Closing up tightly
    - Ridges – e.g. on some snails help them to radiate excess heat
    - Color- light colors reflect sunlight and decrease heat
    - Withstand wide range of temps
    - large body size which means less surface area relative to volume and so most of the organisms body does not heat up
- Drying out when the tides are low
    - Closing up tightly – Barnacles, mussels, and periwinkles are only a few of the animals that can tightly close their shells to prevent the air from drying them out when they are out of the water. Later, when submerged again, they can open back up and allow the water to come back in.
    - Creating a seal against a moist rock surface - snails
    - Hunkering down – Crabs hide in wet places under rocks. They can be exposed to air for short periods of time as long as they stay moist.
    - Moving to deeper water or living in tide pools – Sea stars, sea urchins, and crabs collect in tide pools during low tide.
    - Swimming away – Large fish swim to deeper waters.
    - Secrete mucus to seal in the water – anemones, mollusks
    - Withstand water loss until tide returns – chitons can withstand 75% water loss; some seaweeds can withstand 90% water loss; organisms can recover quickly when the water returns.
- Crashing Waves
    - Byssal threads of mussels; these are anchoring threads made of protein secreted from a gland in the foot and attached to rocks or other surfaces.
    - Large, muscular foot to hang on tightly – mollusks
    - Tube feet to hang on tightly – echinoderms
    - Cement –barnacles
    - Holdfast- kelp; root-like structure that attaches to rocks
    - Thick shells
    - Fins shaped like suction cups – Gobies

    - Low profile- stay close to the rock – chiton
    - Domed surface for water to flow over
- Competition for space
    - Attach to each other
    - Effective means of dispersal – being the first to occupy new patches of open space; larvae, spores
    - Rapid reproduction
    - Holding on
    - Removing other organisms already there – barnacles loosen other animals from the rocks; owl limpets (Lottia) remove intruders from their territory
    - Grow over competitors, reducing their sunlight
    - Growth in different zones
- Protection from predators (biotic)
    - Shells
    - Tests
    - Exoskeleton
    - Spines
    - Stinging cells
    - Camouflage
    - Pincers/Chelae
    - Hiding under rocks

Additional Background:
(The following is adapted from "Down at the Rocky Seashore," by Robin Milton Love, MARE Teacher's Guide to Rocky Seashore)

Intertidal organisms face many biotic challenges, such as finding food, avoiding predators, or resisting diseases. They also face the added dimension of inhabiting an environment with extreme non-living, or abiotic, conditions. In one respect the intertidal zone is totally different from all other land and water communities. It is exposed to water part of the time and dry at other times. Because the water environment is so different from the air, intertidal organisms face an almost bewildering range of conditions in the course of a day, a season or a year.

As the tide rises and falls, an organism is alternately drenched and dried. When this happens the organism's temperature can decrease rapidly as cold water splashes its sun-warmed body or, alternately, it can heat up as it is exposed to the air. Breathing is also going to be a problem. What works in water (gills) may not be very effective in air, and what works in air (lungs) just can't cut it in water.

Rain and other freshwater are stressors, too. A body responds differently when in salt water (water tends to leave it), than in freshwater (water tends to go into it). How can an organism cope with these very different environments?

Then there is wave shock, the remarkable powerful force of crashing water. How does a typical organism not get swept away or crushed? Waves also send water splashing up into the high intertidal. But, unlike tides, they do this unpredictably. Organisms high up in the intertidal can't depend on large waves every day and must be able to withstand prolonged periods of drying.

The BIG Factors:

Tides: Obviously, tides are a major (perhaps the major) controlling force in many intertidal habitats, because they dictate how long organisms are under water. Tides are rhythmic, predictable, periodic changes in the height of a body of water. The tides are caused by a combination of the gravitational pulls of the sun and moon and the centrifugal force caused by the rotation of the Earth/moon system. Throughout the year, tides vary in their heights, and the highest highs and lowest lows occur together during the new and full moons, when the moon and sun are directly aligned with the Earth. These extreme tides are called *spring tides*, which comes form the Old English word *springen*, meaning to jump or move quickly. Spring tides occur every two weeks and alternate with less extreme, or *neap*, tides.

Tidal patterns (how often highs and lows occur within 24 hours) and ranges (the difference between high tide and low tide water levels) differ in different parts of the world. Some areas, such as much of the east and west coasts of the United States, usually have two high and low tides per 24 hours. These are *semi-diurnal tides*. On the other hand, Gulf Coast states tend to have one high and one low tide (*diurnal tides*) during the same period. Tidal ranges vary dramatically depending on the shape of the water basin the tides flow through. The narrow Bay of Fundy, in New Brunswick, Canada, has tides of about 50 feet. This does not mean that the water goes inshore 50 feet. It means that it rises in height that amount. So if the land is pretty flat, the sea might flow inshore for miles before reaching the necessary elevation. Tidal ranges for much of the west and east coasts of the United States are around 6-8 feet. The Gulf Coast tides are narrower, perhaps a foot or two.

Waves: Waves also play a major role in deciding what organisms live where. Not only can waves knock organisms off their perches, they (along with tides) dictate how high up into the rocky intertidal water will splash. Far more territory gets wet during a 6-foot tide with 10-foot storm waves, then with a 6-foot tide and one-foot placid waves. Though they help determine sea life along all shores, waves are particularly important along much of the Pacific Coast, where wave size varies a great deal. The size of waves depends on several factors. The most important is the size of the area a wave travels through without being hindered by islands or undersea ridges. The more wide open an area, the larger the waves that can be generated. If you stand on the shore anywhere from Cape Flattery, northwest Washington to Pt. Conception in central California, there is absolutely nothing between you and the Aleutian Islands. That is a long way and it allows some fearsome waves to form. Of course, wind velocity is also important, which helps explain why waves tend to be higher during storms. On much of the Gulf Coast, waves tend to be small, and they are a factor only during hurricanes and other storms. Because waves have such a profound effect on sea life, any protection from their power alters the makeup of the animals and plans living in the habitat. For instance, along the Pacific Coast, wave-swept rocks are home to the powerfully-built sea star *Pisaster* (or ochre star), which can hang on even when slammed by direct hits from huge waves. In the same vicinity, but in protected tide pools, lives the more delicate bat star, *Patiria*, which can barely hold its own in very mild surges.

The shape of the coastline has a large influence on wave action. The rocky shores of open coasts, where waves come to shore unimpeded, tend to have somewhat fewer plants and animals than habitats in protected coasts, where the force of the waves is

deflected somewhat. More commonly, coastlines tend to be at least partially protected, by offshore kelp beds, reefs, or by irregularities (such as indentations) in the coastline. Somewhat protected rocky shores are usually chock full of goodies, because compared to the open wave-swept habitats, they are an easier environment in which to live.

Rock position and location are also important factors. Because waves and tides have such a large influence on the environment, not all places in the rocky intertidal are identical. Generally, the higher up the intertidal you are, the more extremes (in wetness, waves, wind, etc.) you will face. Moreover, vast differences in these conditions may occur even on a single rock. For instance, the top of the rock is drier and more subject to wave action than a crevice. The southwest-facing part of the rock (which faces the sun most of the day) is drier than the north-facing side (which tends to be in shadow). The crevice is probably drier and more wave-swept than the under parts of the rock. And the deep pool next to the rock is continually wet and probably quite protected from many waves. Commonly, different organisms will be found in these different areas, even if they are inches apart.

Substrate: The type of substrate found in the intertidal also effects what lives there. For instance, granite is pretty tough stuff, it takes a lot of waves and a lot of water to begin to crack, chip or flake it away. On the other hand, sandstone or shale is (relatively speaking) pretty delicate; crevices, holes and cracks develop quickly. These openings provide habitat for many animals which cannot live on open rock. Therefore these softer substrates may have a greater variety of organisms than ones found on harder surfaces. On the Gulf Coast, there are few natural rock outcroppings. Take heart, however, for there are an abundance of rock jetties and dock pilings to choose from. These structures often provide homes for a myriad of organisms.

A few ways organisms survive in the rocky intertidal: Let us assume that rocky intertidal organisms face two major problems: drying out (and that includes changes in temperature as well) and being dislodged and killed by wave action. How do organisms cope with these problems?

Drying out: Location in the intertidal is the main way animals find their drying out comfort zone. If they like it drier, they live higher up; if the like it wetter, further down. Even within a zone, there are differences in wetness and organisms take advantage of this. Crevices, cracks, and holes are shady and often contain pockets of water; here you will find those animals which prefer a bit more moisture. In fact, these slightly wetter areas allow organisms that would usually be found in the lower and wetter intertidal to live higher up. Intertidal organisms, particularly those high up the intertidal, often have shells which can be tightly closed or skins that are particularly thick. Both of these can trap water and help provide protection from evaporation. Some anemones cover themselves with bits of shells and rocks to provide shade.

Wave action: First, as with protecting against drying out, almost all the animals that live in heavy surf have hard shells or tough skins. Many of these organisms have evolved clever ways to hang on in surge conditions. Sea stars have tube feet, mussels have special tough threads with glue on the ends and barnacles have a cement so effective, even in a wet environment, that dentists are thinking about using it to keep fillings in place. Other organisms find places where waves are disrupted or blocked. Periwinkles, limpets and other snails tend to congregate in partially protected crevices. Sea urchins, hermit crabs, and sea slugs, to name a few, all tend to live in protected pools.

At the extreme are boring clams with shells resembling files. They bore into rocks and live their lives sealed off from the environment, except for a small hole, through which water and food travel.

As you go down the intertidal, from the high and dry to the low and wet, you will encounter different species. These aquatic organisms arrange themselves by the amount of time they can tolerate being out of the water. In the highest intertidal, the splash zone, animals may be out of the water for days between high tides (and/or large waves) high enough to cover them. By the same token, in the lowest of the intertidal, animals may be uncovered for only a day or two a year. Every species has a unique set of environmental requirements. This is the basis for zonation, the occurrence of organisms or groups of organisms with the same requirements, in specific areas. In the case of the rocky intertidal, some zones are so well-defined that they can be seen all around the world.

Vocabulary

- Adaptation = a feature or behavior of an organism that helps it survive in its habitat
- Habitat = an animal's home where it gets everything it needs to survive.
- Tide pool = depressions or holes at the rocky seashore where seawater pools after the tide has retreated
- Low tide = the lowest point of the water line during a tidal cycle
- High tide = the highest point of the water line during a tidal cycle
- Living or biological factors = e.g. predators and competition for space
- Non-living or physical factors = e.g. sand, waves, heat, changing tides
- Predator = an organism that feeds on other organisms
- Salinity = a measure of how much salt is in the water
- Dessication = the loss of moisture; extreme drying