CORAL RESTORATION FOUNDATION™

Gamete and Greet

with Science, Art, Math, and Language Arts Extensions

ADAPTED FROM NOAA: CORAL SPAWNING

Objective

Students will learn about the spawning habits of stony coral and will test if there is an advantage to mass spawning via a statistical model.

Overview

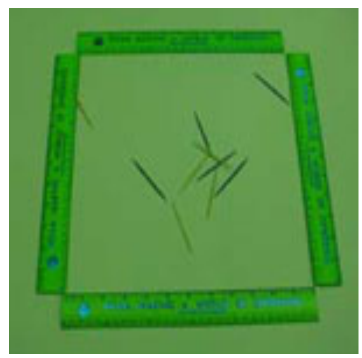
Many organisms reproduce during a limited season. These patterns are specialized to aid the survival of each particular species. But reef building corals carry this pattern to an extreme, with nearly all the colonies on a reef spawning in a single night, and neighboring colonies spawning just a day or two apart. Is this an advantage for the corals? Is there a way we can test this pattern of reproduction statistically?

Background Information

Why do corals spawn at once? One of the most spectacular events to occur on reefs is the annual synchronized spawning of corals. This mass reproduction only happens once a year. It involves colonies and species of coral polyps simultaneously releasing tiny eggs and sperm bundles from their gut cavity into the water. By expelling the eggs and sperm at the same time, the coral increases the likelihood that fertilization will take place. The phenomenon – which only happens at night – resembles an underwater snowstorm. When an egg is fertilized by a sperm it develops into coral larva called a planula that floats around in the water for several days or weeks before settling on the ocean floor. After the planula has settled in a particular area it starts to bud and the coral colony develops.

Materials (for each group)

- 50 pennies
- Square area on the floor between ¼ and 1 meter sides



Vocabulary

- Spawning
- Planula
- Fertilization
- Brooding
- Broadcast spawning
- Eutrophication

Standards

SC.K.L.14	SC.2.L.16	SC.4.L.16	SC.6.L.14	SC.912.L.14
SC.1.L.14	SC.2.L.17	SC.4.L.17	SC.6.L.15	SC.912.L.15
SC.1.L.16	SC.3.L.14	SC.5.L.14	SC.7.L.15	SC.912.L.16
SC.1.L.17	SC.3.L.15	SC.5.L.15	SC.7.L.16	SC.912.L.17
SC.2.L.14	SC.3.L.17	SC.5.L.17	SC.7.L.17	

Preliminary Phase

Find out what the students already know.

Teacher talk:

- *So how do completely new coral colonies get started? That first coral polyp has to come from somewhere!*

Teacher allows a respectful discussion on the subject. Remind the students that the coral are sessile, meaning that they have no mode of locomotion in their adult life.

Teacher talk:

- *Reef-building corals reproduce in many different ways, but in order to make a completely new and genetically different offspring, all corals must go through three basic steps. First, **gametes** (male and female cells) are produced. Then, the gametes must be released by the parent corals. Finally, the gametes must combine in the process of **fertilization** and form a **planula**, or "baby coral." It is this newly formed planula that is the first building block needed to start a completely new coral colony. Let's look at how the process works.*

Focus Phase

The students explore examples of the concept.

Teacher talk:

- *After the gametes are produced, the next step can occur in two ways, brooding, or broadcast spawning. In **brooding**, only male gametes are released into the water. These cells are taken in by female coral animals. Fertilization occurs inside the female coral, and a small planula develops inside it. This planula is released through the mouth of the female coral and drifts or crawls away to settle elsewhere and grow into a new colony. In **broadcast spawning**, which is much more common, both male and female gametes are released into the water at the same time, and fertilization occurs when they meet in the water column or at the surface. These gametes often float up in little packets, which are greedily sought by predators as the perfect meal.*

Exploration Phase

The students exchange, debate, and test ideas.

Teacher talk:

- *What are the advantages to each type of spawning? Which is better?*

Teacher makes a list of both Brooding and Broadcast Spawning on the board. Ideas are taken from the class to make a list to be used in the application section. Then, students vote on which is the “best” method.

Application Phase

The students apply their rules to new situations.

Teacher talk:

- *Let’s talk about some problems that these gametes meet upon being released. First, in broadcast spawning, the gametes often float up in little packets, which are greedily sought by predators as the perfect meal. At first, this method of reproduction may seem inefficient, since many of the gametes will not encounter another gamete and simply die or be eaten by predators in the water, but there are many important advantages in this method.*
- *The corals spawn synchronously (at the same time). So many gametes may be released into the water that they can form slicks on the surface, which can even be seen from a low-flying airplane. With so many gametes released at once, predators can only eat a small portion before they are full. If the gametes were released over a longer time period, a single predatory fish might hang out by one coral colony and eat every single one of the gametes it releases. Also, with such high numbers, there is a higher chance that male and female gametes of the same species will meet and fertilization will take place. This increases the overall success of reproduction.*
- *But, can we prove that it is better to spawn all at once? Wouldn’t it be the same if 5 different corals spawned one night for five days rather than 25 spawning all at the same night?*

Challenge Phase

The students take their application to a real-world situation

Teacher begins Teacher selects an area of the floor to do your experiment. This area can be inside or outside, depending on the weather. An area should be marked off for each group. In both parts of the experiment, the class will be representing the potential reproduction of an equal number of coral colonies. In both parts, the same total number of gametes is released, but in the first part, the reproduction is spread out over five nights. In the second part, the reproduction occurs all in the same night.

The first series will represent spawning activity, which is spread out over 5 nights. Scatter five of the pennies inside the study area. They represent five gametes that have been released by coral colonies into the water at one time. Heads up is female, and tails is male. Stand back, and toss a penny one at a time into the study area. Each time you toss a penny, record whether it strikes another penny or not, but leave it in the study area. Include any collision between two different gametes (heads and tails) as a "fertilization". When you are finished, pick up the five pennies you tossed in, and repeat the experiment. Keep track of the total number of fertilizations (head/tail collisions) in each of your five trials by recording them. This represents the potential reproductive success of corals, which spawn over a five night period.

In the second series, place 25 of the pennies inside the study area. These represent corals that all spawn on the same night. Then one at a time, toss the remaining 25 pennies into the area, leaving them where they land in the study area. Record the total number of times pennies collide with opposite gametes.

Teacher talk:

- *Which part of the experiment yielded the greater number of collisions? Try to explain why the number of collisions was not equal.*
- *Based on this model, which mode of reproduction would be more successful for the corals, reproduction in a single night or over a longer time?*
- *This model suggests that coral gametes only survive in the water for a single night if they are unfertilized. How would results change if the gametes survived for a much longer period?*
- *Like most simplified models, this is a little unrealistic. What are some factors in the natural environment that affect the success of coral reproduction but are not accounted for in our model?*

Synthesis Phase

The students take their overall understanding to the next level.

Teacher talk:

- *It's not easy being a **planula**, looking for a place to settle down on the reef. Humans are part of the cause of their struggle.*
- ***Pollution** from land-based sources is a primary cause of coral reef degradation throughout the world. In the Caribbean, for example, approximately 80 percent of ocean pollution originates from activities on land.*
- *As human populations expand in coastal areas, development alters the landscape, increasing **runoff** from land. Runoff often carries large quantities of sediment from land-clearing, high levels of nutrients from agricultural areas and sewage outflows, and pollutants such as petroleum products and pesticides.*
- ***These land-based sources of pollution threaten coral reef health**.*
- *Excess nutrients result in poor water quality, leading to decreased oxygen and increased nutrients in the water (**eutrophication**). This can lead to enhanced algal growth on reefs, crowding out corals and significantly degrading the ecosystem.*
- *In addition, sediment deposited onto reefs smothers corals and interferes with their ability to feed and reproduce.*
- *Finally, pesticides interfere with coral reproduction and growth.*
- *Sewage discharge and runoff may also introduce pathogens into coral reef ecosystems.*
- ***Oxybenzone** is also known as benzophenone-3. It's a white solid that has the interesting ability to absorb ultraviolet light. Oxybenzone is a broad-spectrum sunscreen that absorbs both UVA and UVB light rays. It's produced synthetically by a chemical reaction. A recent study focused on the effects of oxybenzone on a coral named Stylophora pistillata. The results were published in 2015. The research team looked at the effect of oxybenzone on coral larvae and adults. They made the following discoveries, which were published in the Environmental Contamination and Toxicology journal. Under lab conditions, oxybenzone transformed the coral larvae, or planulae, from a motile state to a deformed and sessile state. The chemical caused the coral to make an enlarged skeleton and to become encased in it. The researchers stated that **oxybenzone is "a skeletal endocrine disruptor" in coral**.*

Extension 1 – Sudsy Spawning (SCIENCE)

ADAPTED FROM REEF RELIEF: BUBBLE REEF

Materials

- Bubble Solution
- Bubble Wands

Instructions:

1. Teacher Break the class into two groups: Corals and Predators
2. Give each "Coral" bubble solution and wands. They will be representing broadcast spawning.
3. The "predators" will be other sea creatures feasting on the coral outputs, but they can only "eat" while the bubbles are in the air. If the spawned larvae land on an object and sticks, they can no longer be fed upon.
4. Some bubbles will pop when they land. This represents coral planula that land on substrate that isn't suited for growing.
5. Discuss with the students the amount of coral output that is created, versus how much is eaten by predators, versus how many actually survive.

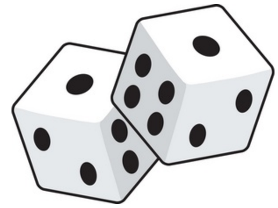
Extension 2 – Planula Play (LANGUAGE ARTS)

Ask the students to write, direct, and act in a play about the life of Penelope Planula, from spawning, to dodging predators, to settling down and growing a new reef. This activity can be extended for an entire semester, by including costume design and inviting family, friends, and other classes to view this play.

Extension 3 – Probable Planula (MATH)

ADAPTED FROM SEA WORLD: A CHANCE AT SUCCESS

Materials



- Dice (2)
- Score Card

Instructions:

1. Lead students in a discussion about what things might limit where coral reefs develop. Ask them to name some of the conditions they know reef-building corals need in order to survive such as right water temperature; clear, shallow water; strong wave action to bring in nutrients. Write these on the board. Explain to students that a site must meet these criteria for a reef to successfully establish and thrive.
2. Show students the dice and explain that they'll be playing a game in which they'll all be coral planula in search of a settling site. Each student will roll the two dice three times, once for each survival factor.
3. Explain that to survive, they must roll one of these numbers when casting the dice for that condition:
   - Temperature = 4-10 (2-3 too cold, 11-12 too hot)
   - Substrate/depth = 2-8 (9-12 too deep)
   - Wave action = 7-12 (1-6, too weak to bring in nutrients)
4. Place the score sheet on an overhead, or have a student keep score on the board.
5. Invite students up one at a time to roll the die. (Or to shorten time, students can work in student groups.) Be sure to state what factor they're rolling for each time.
6. At the end, depending on the level of the students, calculate the percent of success.
7. Remind your students that corals release thousands of eggs and sperm, some which develop into planula. Do they think all the planula survive? Why not? Explain that the reproductive process leans toward high numbers to allow for high mortality. Many planula are eaten by marine animals before they settle and attach to the bottom. By producing hundreds of thousands of eggs at a time, a coral polyp increases the chance that one of its offspring will mature and reproduce, the measure of a species' survival success.

Probable Planula Scorecard

NAME	TEMPERATURE			DEPTH		WAVE ACTION	
	Too Hot	Just Right	Too Cold	Just Right	Too Deep	Too Weak	Just Right

Extension 4 – Spawnglobe (ART)

ADAPTED FROM NOAA'S FLOWER GARDEN BANKS NATIONAL MARINE SANCTUARY

Materials

- Plastic jars with screw on lids (8-10 oz.)
- Oil-based modeling clay
- Watercolor paintbrushes
- Wavy pipe cleaners
- Scissors
- Large mixing container (>8 qts)
- 4 gelatin packets (unflavored) (makes 24 cups)
- Water
- Spoon
- Blue food coloring
- Plastic stuffing pellets
- Teflon tape

Instructions:

1. Use various colors of modeling clay to create a small reef of boulder corals on the inside of each jar lid. Press firmly around the outer edges to make it adhere to the lid.
2. Use the handle end of a paintbrush to poke shallow holes into the "corals" to represent the individual coral cups found on the surface of a coral colony.
3. Cut a pipe cleaner apart between each of the fluffy segments. Fold each segment in half and press the folded end into the "reef" at various intervals to represent Christmas tree worms (3-4 per reef).
4. Make gelatin mixture. The following makes ~24 cups:
   - Sprinkle gelatin over 6 cups of cool water in mixing container. Bring 18 cups of water to a boil, and then add it to the contents of the mixing bowl. Stir mixture until gelatin is thoroughly dissolved, then allow it to cool completely.
5. Add a few drops of blue food coloring and stir until color is uniform.
6. Fill jar with the blue liquid. Leave room for displacement by the coral colony.
7. Add 1 tbsp of plastic pellets to the jar. These represent the sperm and egg bundles released by corals during sexual reproduction.
8. Screw the lid onto each jar, with the reef attached, and adjust the liquid level accordingly.
9. With jar on table, remove the lid and place a single layer of Teflon tape around the screw threads (this will help prevent leakage). Screw the lid onto the jar.
10. Shake up the jars and turn them upside down so that the lids are resting on the table.