Sea of Cortez: the Reef Community Simulation Game

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Steinbeck Institute 2018

Purpose: This lesson includes a coral reef ecosystem simulation at Pulmo Reef on the southern shores of the Gulf of California as described in the novel *The Log from the Sea of Cortez* that is maintained by a carnivorous sea star (*Heliaster kubiniji*) and is designed for a high school Biology class but could also be utilized in a Zoology or Environmental Science setting for high school students or a Life Science setting for elementary or middle school students.

Objectives:

1. Relate ecosystems to biodiversity and populations.
2. Identify complex interactions within ecosystems.
3. Relate cause and effect to changes in ecosystems.

NGSS:

3-LS4-4: Biological Evolution: Unity and Diversity

Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

MS-LS2-4: Ecosystems: Interactions, Energy, and Dynamics

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5: Ecosystems: Interactions, Energy, and Dynamics

Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

HS-LS2-2: Ecosystems: Interactions, Energy, and Dynamics

Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-6: Ecosystems: Interactions, Energy, and Dynamics

Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions; however, changing conditions may result in a new ecosystem.

HS-LS2-7: Ecosystems: Interactions, Energy, and Dynamics

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Pre-Lab Activity:

Read Chapter 10 in *The Log from the Sea of Cortez* concerning Pulmo Reef, and answer the following questions:

1. What types of organisms were collected at the Pulmo Reef collection site?

2. What precautions did they take during the collection process to prevent injury?

3. How were specimens collected and preserved?

Hypothesis:

Procedure:

1. Cut out and color the following: 6 orange carnivorous *Murex* snails, 30 blue rock oysters, 30 yellow barnacles, 30 purple limpets, and 30 green herbivorous/opportunistic snails.
2. Select 50 organisms at random and place them on the Sea of Cortez grid serving as a rocky shoreline coral reef ecosystem. Each organism must be placed on a numbered square on the rocky shoreline. Always place the carnivorous orange *Murex* snails first, starting at the box labeled "1." Next place the blue rock oysters on the grid, then the yellow barnacles, then the purple limpets, then the green snails all in a numerical order of 1-50. Although the herbivorous snails, barnacles, limpets, and oysters do not eat one another, they do compete for available space. If one of the more competitive species quickly reproduces, it will push other populations out of the ecosystem.
3. Count the number of each type of organism and record the data in the space marked "Initial Population" for Generation 1 in the table.
4. Using the Feeding Chart located in this lesson, roll the dice once to determine the next meal of the starfish (round up if there is half of a prey item). Remove the organisms (colored cutouts) consumed by the starfish.
5. Roll the dice again to determine the action of **each** of the carnivorous snails as in roll once for each carnivorous snail present.
6. Before the next round, the organisms will reproduce. Use the following rules to determine the correct number of each species after reproduction:
   a. The blue rock oysters will double their number
   b. The yellow barnacles, purple limpets, and green herbivorous snails will add one organism for every two individuals present

c. The orange carnivorous *Murex* snails will add one organism for every four individuals present
d. If one of the populations does not meet the requirements for reproduction, add one individual to that population.

7. After adding the appropriate number of individuals, record the new population in the space marked Initial Population for Generation 2 in the table.
8. Following the procedure established in Step 2, place the carnivorous orange snails first, then the blue rock oysters, then the yellow barnacles, then the purple limpets, and then the green herbivorous snails in numerical order. If there is not enough room to place all of the individuals, adjust the initial population of the species that is "crowded out."
9. Repeat Steps 4 through 8 to simulate events through Generation 4. Record your data in the table.

Feeding Chart			
Starfish		Carnivorous Snail	
1	Starfish Eats One Half of the Largest Population	1	Carnivorous Snail Dies - Remove One
2	Starfish Eats One Half of the Largest Population and One Orange Carnivorous Snail	2	Carnivorous Snail Eats One Yellow Barnacle
3	Starfish Eats One Half of the Largest Population and One Blue Rock Oyster	3	Carnivorous Snail Eats One Blue Oyster
4	Starfish Eats One Half of the Largest Population and One Yellow Barnacle	4	Carnivorous Snail Leaves - Remove One
5	Starfish Eats One Half of the Largest Population and One Purple Limpet	5	Carnivorous Snail East One Blue Oyster
6	Starfish Eats One Half of the Largest Population and One Green Herbivorous Snail	6	Carnivorous Snail Eats One Yellow Barnacle

Data:

Species Population Through Generations																																								
	1st Gen.		2nd Gen		3rd Gen.		4th Gen		5th Gen.		6th Gen		7th Gen.		8th Gen.		9th Gen.		10th Gen.		11th Gen		12th Gen		13th Gen		14th Gen.		15th Gen.		16th Gen.		17th Gen.		18th Gen.		19th Gen		20th Gen	
	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F
Orange Carnivorous Murex Snail																																								
Blue Rock Oyster																																								
Yellow Barnacle																																								
Purple Chiton																																								
Green Herbivorous Snail																																								

Analysis:

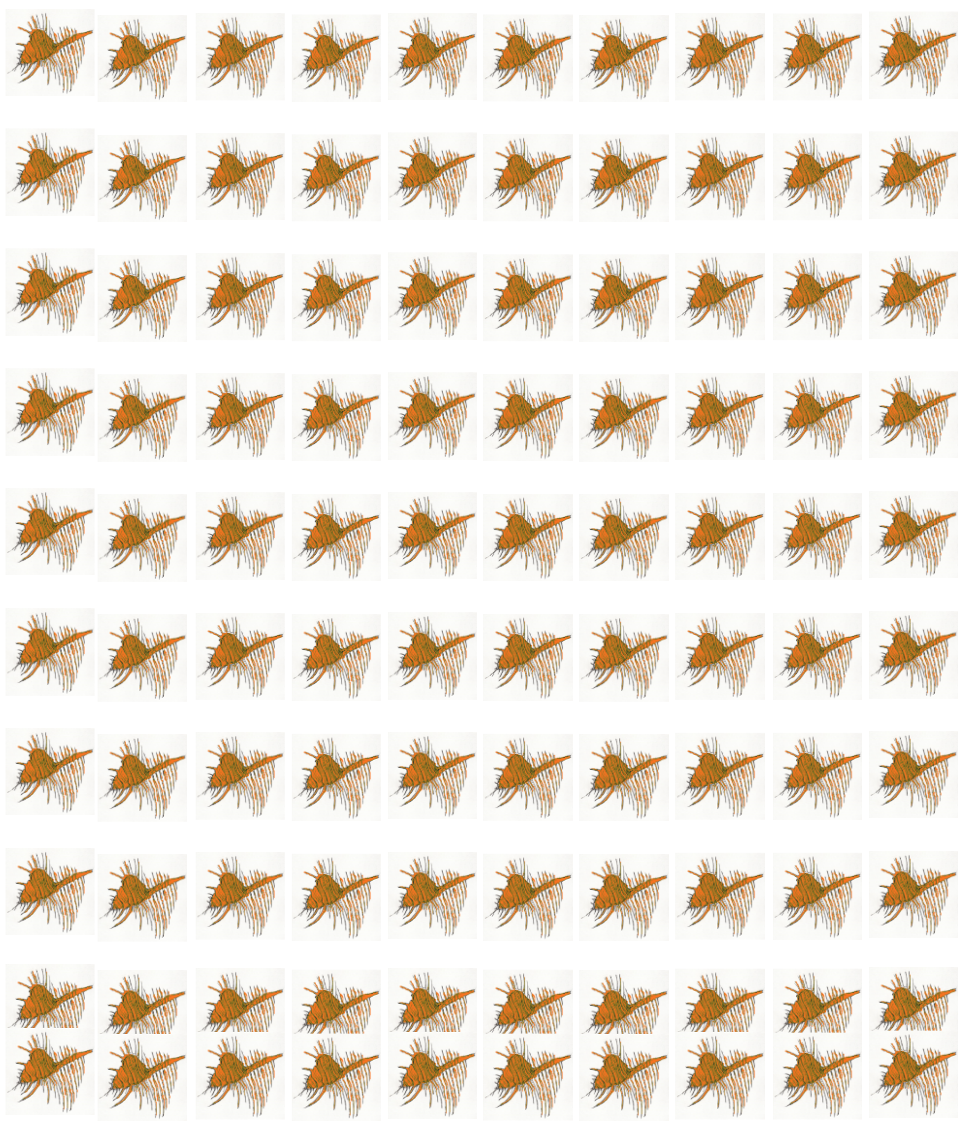
1. Draw a graph of all five of the reef populations over 20 generations. Make sure that the x and y axis and plot points are appropriately labeled to identify all species data.

2. In the simulation which organism possesses traits that enable it to exploit the coral reef environment more efficiently than the other populations in the community? Explain.

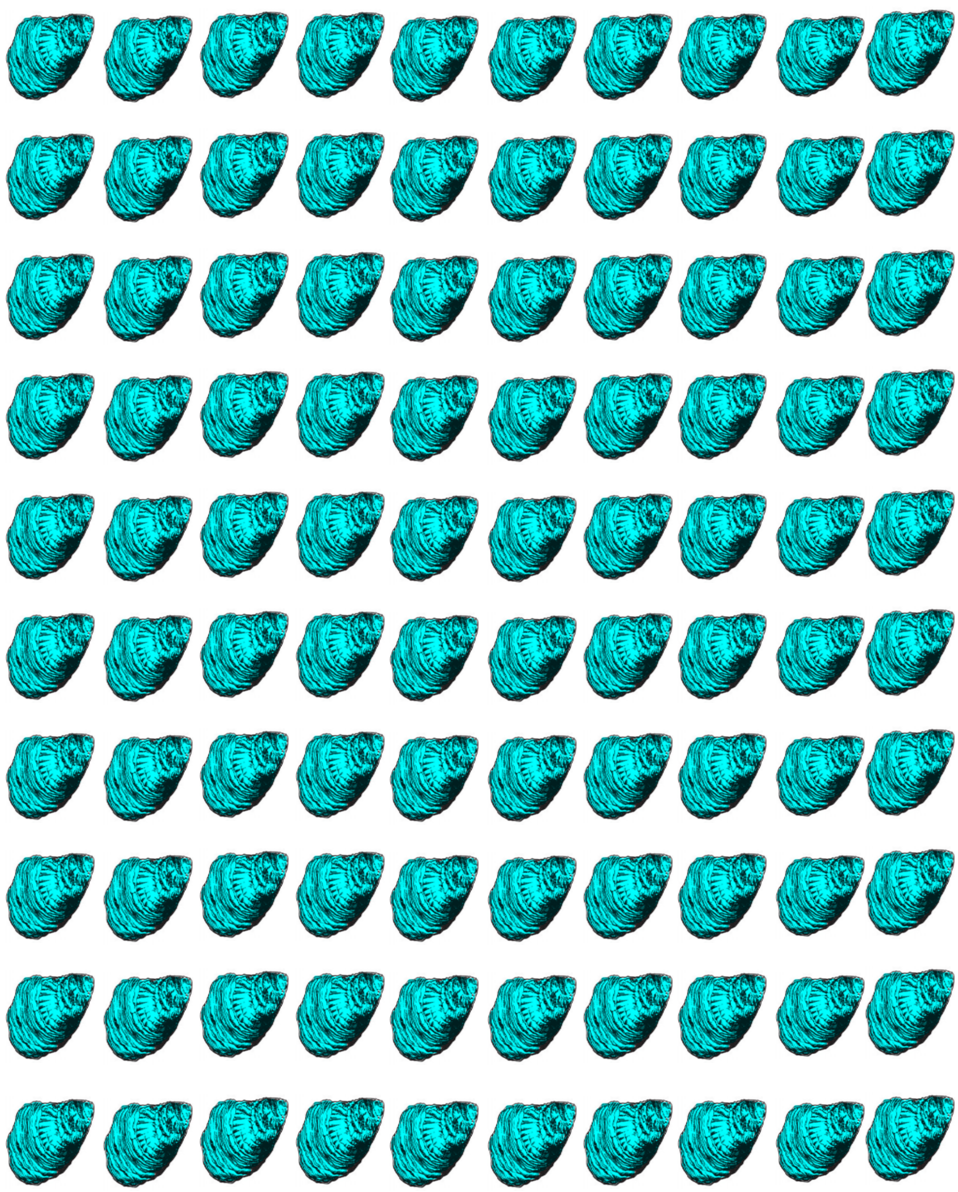
3. Compare the change in the diversity of the reef community in generation 1 to generation 20. What caused this change?

4. Ecologist Robert Paine once stated, "Local species diversity is directly related to the efficiency with which predators prevent the monopolization of the major environmental requisites by one species." Does your data support this hypothesis? Explain using data from your observations.

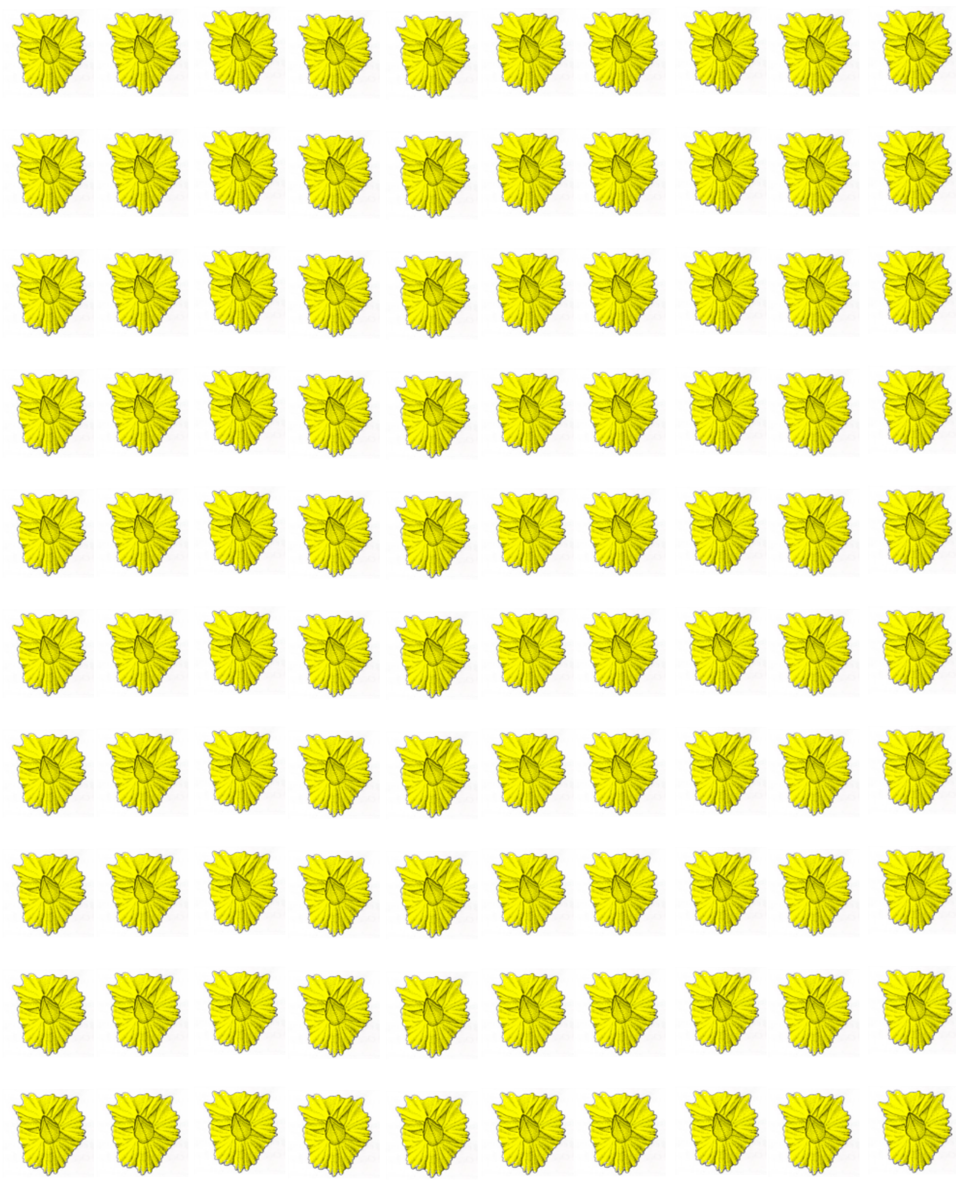
Orange Carnivorous Murex Snails: *Hexaplex nigritus*



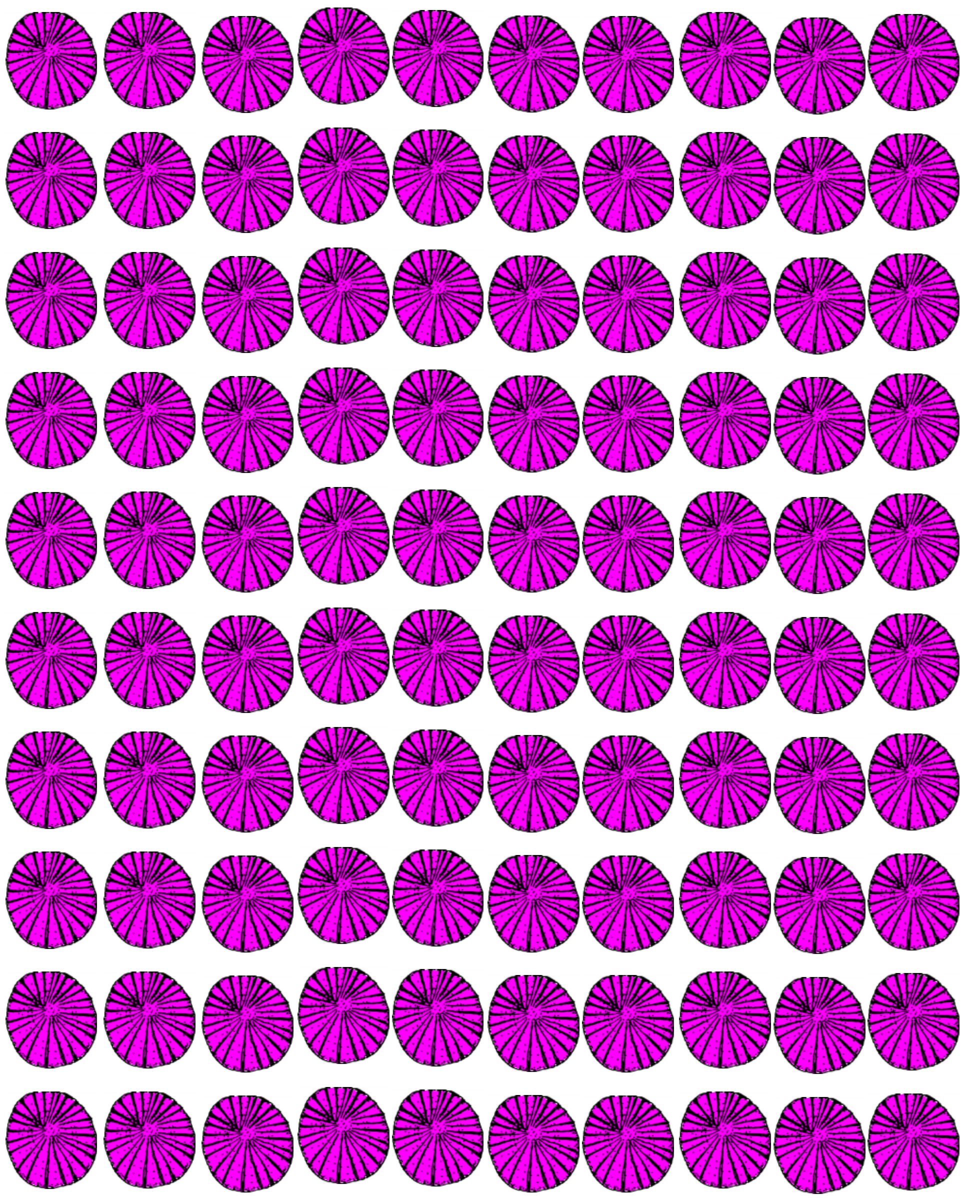
Blue Rock oyster: *Saccostrea*



Yellow Barnacles: *Tetraclita*



Limpet: *Lottia atrata*



Herbivorous or Scavenger Snails: *Cypraea albugnosa*