Swimming Upstream Without a Ladder:

Dams and Pipes and River Shrimp Movements

Meet Dr. Benstead:

I like being a scientist because I am excited about the natural world and want to help *conserve* it for future generations to enjoy.

Dr. Benstead

Meet Dr. Pringle:

I like being a scientist because I like working outside, in the stream, getting my feet wet. I also like doing research that will help conserve the environment.

Dr. Pringle

Meet Dr. March:

I like being a scientist because I enjoy learning how natural systems work. Also, for part of the year my office is a beautiful stream!

Dr. March

Meet Dr. Scatena:

I like being a scientist because I like the challenge of trying to understand how natural systems work so that we can manage and preserve them for future generations.

Dr. Scatena

Glossary:

conserve (kän **sürv**): To avoid wasteful or destructive use of something.

species (**spe** sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

migrate (**mi** grat): To move from one place to another.

larval (**lär** väl): Relating to the wormlike feeding form that hatches from the egg of many insects or animals that changes form when it becomes an adult.

tropical (**träp** i käl): Of, in, or like the tropics. The tropics is the region of the earth near the equator.

maturity (muh **toor** uh te): The state of being fully grown or developed.

ecosystem (e ko sis tem): Community of plant and animal species interacting with one another and with the nonliving environment.

dependent (duh **pen** dent): Relying on.

algae (**al** je): Simple plants that have no true root, stem, or leaf and that usually grow in water or on damp surfaces.

population (päp yoo **la** shun): The whole number of individuals of the same type occupying an area.

life cycle (lif **si** kul): Stages in the development of an organism.

fish ladder (fish **lad** er): A series of small dams built in streams or rivers. These function like steps to enable animals to swim upstream.

simulate (**sim** yuh lat): To create the appearance or effect of something for purposes of evaluation.

analyze (**an** uh liz): To study or examine carefully.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

Accented syllables are in **bold**.

Thinking About Science

Although scientists sometimes work alone, they usually do their research with other scientists. Even if they live in different areas of the Nation or the world, they find ways to work together. In this study, scientists from the University of Georgia worked together with a Forest Service scientist in Puerto Rico to study a special kind of shrimp. In your classroom, you sometimes work with other students. When you do this, you are like a scientist who works with other scientists. Can you name two reasons why it is a good idea to work with others when you are learning something new?

Thinking About the Environment

Many animal *species* spend part of their life in one location and part of it in another place. When that happens, the animal is said to be migratory. Animals usually *migrate* to a place more favorable for reproduction. People often think of birds when they think of migratory animals. In this study, the migratory animal is a river shrimp. When it is in its *larval* stage, the shrimp larvae drift from streams in high *tropical* mountains to areas near the coast. There they grow beyond the larval stage. When they are ready to become adults and reproduce, the juvenile shrimp swim back upstream to where they were born. When the juveniles encounter barriers such as waterfalls, they crawl over them to continue their upstream journey. When they get upstream, they grow into adult shrimp and reproduce. Their offspring drift back downstream with the current, and the cycle begins again.

Introduction

Tropical streams provide many benefits to people and animals. For river shrimp that spend part of their life in the mountain streams, the streams provide a place to reproduce and develop. River shrimp are important to the streams as well. They eat the *algae* in the streams and help to turn dead matter, such as fallen leaves, into small particles. When they swim and crawl in the streams, they stir up the water. This enables the stream to wash away any soil and other things that may have settled into the stream bed.

Thinking About Ecology

In an area, the individuals of a species live in close relationship with other living things and with the nonliving environment. This relationship determines how many individuals there will be, how fast they will grow, and how many individuals of different ages there will be at any one time. Living communities plus the nonliving environment make up what we call an ecosystem. Humans often alter the nonliving environment. This alteration can affect a species by changing their numbers, changing how fast they grow, and changing how many different individuals there will be of different ages. In this research, a species of river shrimp was studied. The shrimp depend on both mountain rivers and coastal wetlands to live and reproduce. Humans had altered the river environment by building a dam and placing a pipe to carry water from the river to provide water for humans. Because all living individuals have a close relationship with their environment, any change in the environment can cause a change in the life of the individual and the group of individuals. The scientists wanted to know how the dam and pipe were affecting the river shrimp, which must move up and down the river to survive.

Figure 1. Dam on the Río Espíritu Santo in Puerto Rico.

Tropical streams also provide people with the fresh water they need for drinking, cooking, and washing. Because more and more people are living in tropical areas, more water is needed. To provide water for people, small dams are often built in tropical streams (Figure 1). This creates a small pool of water. The water is diverted from the small pool into a pipe that carries the water to cities where people use it. Unfortunately, the pipe also carries many of the shrimp larvae out of the stream. That means fewer larvae are able to get downstream to the coastal zone. When the juveniles swim back upstream, the dams can sometimes prevent them from swimming far enough. When that happens, the shrimp cannot reproduce. In this way, the population of shrimp is reduced more and more over time. The scientists in this study wanted to find a way to protect the shrimp population while continuing to provide water for people.

Reflection Section

- If the scientists do not find a way to protect the shrimp population and still provide water for people, what do you think will happen to the shrimp population in the future?
- If you were the scientist, how would you study the population of migrating shrimp?

Method

The scientists studied a mountain stream near a dam on the Rio (**re** o) Espiritu (eh **sper** eh tu) Santo (**sän** to) on the Caribbean (kä **rib** e un) National Forest in Puerto Rico (Figure 2). To find out how many shrimp larvae were flowing into the pipe, the scientists put nets into the water. First, they put nets in the water above the dam and counted the total number of larvae floating downstream. They also put a net in front of the pipe and counted the number of larvae in their net. From this method, they knew how many larvae would have flowed into the pipe and how many would have floated over the dam. To find out how many juvenile shrimp were returning upstream, the scientists put a net into the water below the dam. They counted the number of juveniles below the dam by counting how many were caught in the net. Because shrimp larvae float downstream in the evening and at night, the scientists collected their information in the evening and at night. They collected information every third evening, for a total of 24 evenings.

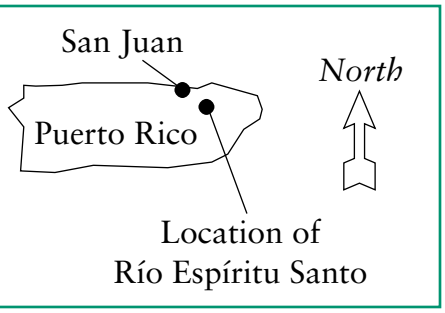


Figure 2. Location of the Rio Espiritu Santo.

Reflection Section

- Instead of collecting their information on just one evening, the scientists counted the number of shrimp larvae on 24 evenings. Why do you think it is important to count the number of larvae on more than one evening?
- How do you think that the scientists knew that shrimp larvae float downstream during the evening and night, rather than during the daytime?

Average downstream flow of larval shrimps in a typical day. Each column represents hourly data beginning at 5:00 pm and ending at 7:00 am of the next day.

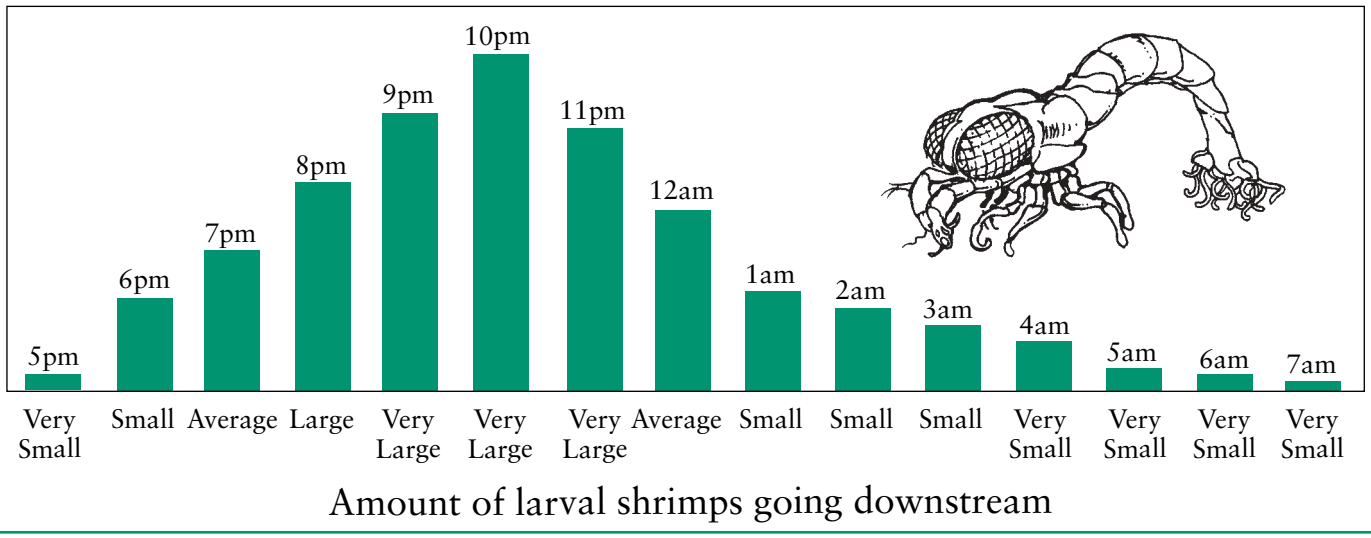


Figure 3. The average amount of shrimp larvae floating downstream at different times of the day.

Results

The scientists discovered that most shrimp larvae float downstream between 8:00 p.m. and 12:00 a.m. (Figure 3). The average percentage of larvae floating into the pipes was 42 percent of the total number of larvae floating downstream (Figure 4). The scientists also found that the dam often prevented the juvenile shrimp from swimming upstream. This meant that many juvenile shrimp were trapped below the dam, waiting for a chance to climb over the dam. With so many waiting below the dam, fish who feed on the juvenile shrimp were able to eat larger numbers of the young shrimp than they normally would have.

Reflection Section

- In what ways did the dam and pipe disrupt the normal *life cycle* of river shrimp? What other things (animals, plants, or the stream itself) were impacted as a result of this?
- How could the scientists' information be used to help the river shrimp? What do you think the scientists recommended?

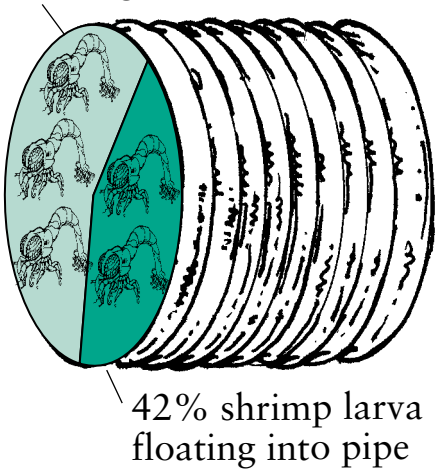


Figure 4. The average percentage of shrimp larvae floating into the pipe and down to the wetlands.

Implications

The scientists recommended that the water pipe be closed every evening between 8:00 p.m. and 12:00 a.m., or at least for some of the hours when most of the larvae are floating downstream. That way, most of the shrimp larvae could float downstream to the wetlands without getting caught in the pipe. In addition, people would still be able to use the water from the streams. The scientists also recommended that the small *fish ladder* that had been built be repaired so that river shrimp could use it again (Figure 5). That way, the juvenile shrimp could climb over the fish ladder to get back upstream. If these recommendations are not followed, the population of fresh water shrimp will probably continue to decline in tropical streams where dams exist.

Figure 5. Fish ladder on the Río Espíritu Santo. The fish ladder is on the far right, below the people. It looks like a ramp in this photo.

Reflection Section

- Although the scientists' suggestions may help protect the shrimp population and still allow people to use the stream water, some people may not want to follow the suggestions. Can you think of reasons why people may not want to follow these suggestions? (Hint: Everything costs money to build and take care of. Who would pay for the fish ladders?)

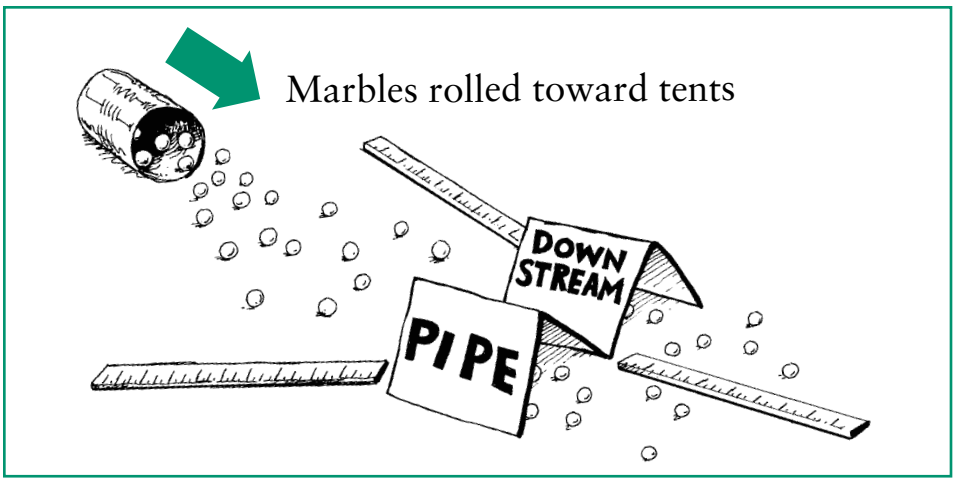
- Do you think that the scientists' suggestions are a good compromise between protecting the river shrimp and providing water for human use? Why or why not?

Discovery FACTivity

For this FACTivity, you will answer the question: What is the difference between having a 50 percent chance of having something happen, and having less or more than a 50 percent chance? You will use marbles to show how some river shrimp get caught in the pipes, and other shrimp are able to drift downstream. In the study you just read, each shrimp had just over a 40 percent chance of floating into the pipe, and almost a 60 percent chance of floating downstream (that means that if 10 shrimp were floating downstream, 4 would go into the pipe, and 6 would float downstream). Look again at Figure 4. Fortunately for the shrimp, each one had better than a 50 percent chance of drifting downstream.

In this FACTivity, each shrimp will have a 50 percent chance of floating into a pipe, and a 50 percent chance of floating downstream. Each station that you construct will *simulate* a stream with a pipe. You may make three or four identical stations, with six to eight students per station. For each station, you will need 3 yardsticks, 1 piece of 22- by 28-inch posterboard, 100 marbles, and a coffee can. Cut the posterboard along its width into two equal-sized pieces and fold each piece in half to make tents. Write "downstream" on one tent, and "pipe" on the other. Place the tents side by side, and lay one yardstick on each side of the tents. Place the third yardstick between the tents, at the back (see diagram on page 12).

Three students will be stationed behind the tents. One student will catch and count the marbles coming through one tent, the other will catch and count the marbles coming through the other tent. A third student will record the number of marbles coming through each tent. You may use the chart below as an example to record your observations. Place the 100 marbles (simulating 100 shrimp) in the coffee can. Another student, standing about 6 feet (or 2 meters) back, will gently roll the marbles toward the tents. The student should aim for the center of the tents. Do not roll them too hard—remember, they are shrimp floating downstream! The students behind the tents should catch and record the number of shrimp floating "downstream" and the number floating into the "pipe." The shrimp that floated into the pipe will die. The shrimp that floated downstream should be taken back upstream and rolled toward



the tents again. Every time you roll the marbles, the marbles represent the offspring of the shrimp that successfully returned upstream to reproduce. Continue to roll the marbles until all of the shrimp have died (rolled into the pipe). Now that you have made and recorded your observations, you will need to *analyze* them. Calculate the percentage of shrimp going into the pipe each time. How many times does it take for all of the shrimp to drift into the pipe? Now calculate the average percentage going through the pipe by adding the numbers in second column and dividing them by the number of rolls. This tells you the overall average percentage of shrimp drifting through the pipe.

Record the average percentage of your shrimp drifting through the pipe. Compare your percentage to the percentage that the scientists found in their study (42 percent). Why do you think your percentage is different than 42 percent? What is different about your experiment and the stream's flow? If you rolled your marbles straight down the middle, your overall percentage should have been close to 50 percent. Was it? If not, what may have caused your percentage to be different? Why do you think each shrimp in the Rio Spiritu Santo had better than a 50 percent chance of drifting past the pipe?

Sample form for recording your observations. Begin with 100 marbles

	# through pipe	% through pipe	# floating downstream	% floating downstream
1st roll	32 (for example)	32 or .32	68	68 or .68
2nd roll	Begin with 68 marbles – Record #	# through pipe divided by 68	Subtract number through pipe from 68	Divide # floating downstream by 68
3rd roll	Begin with # floating downstream			
4th roll				
5th roll				
6th roll				
7th roll				
8th roll				
9th roll				
10th roll				

From Benstead, Jonathan P., March, James G., Pringle, Catherine M. and Scatena, Frederick N. (1999). Effects of a low-head dam and water abstraction on migratory tropical stream biota. *Ecological Applications*, 9(2): 656-668.