Skittle Cores

Background

Dr. Sam Bowser has conducted research in Explorers Cove, Antarctica since 1984. Dr. Bowser's team dives beneath the Antarctic ice to study foraminifera. Forams are single-celled protists that live in all the oceans of the world. Foraminifera lived long before the dinosaurs roamed the Earth, yet they still live today on the bottom of the seafloor (benthic), in the water column (planktic), or attached to rocks or other hard substrates. These microorganisms are significant because of their abundance, diversity, and worldwide distribution. They are sensitive to their environment, which makes them "watchdogs on the environment", or a lens on the past and the present. They are climate change detectors. Forams must live in a world conducive to their survival, so they depend on many abiotic and biotic factors. Foraminifera rely on specific parameters to meet their needs. Abiotic (non-living) factors, such as water temperature, salinity, pH, sunlight, oxygen, pollution, rocks, glacier scouring, sediment, and even the size of the sand grains may adversely affect the life of a foram. Living organisms, such as plants, animals, and other protists are biotic factors that provide nutrients and shelter for a thriving community, or hasten the demise of others. Both, abiotic and biotic factors, could affect the foram population in an area. *The Skittle Core activity was born from a student's question to Dr. Bowser: "Why do scientists take sediment cores?"* Since scientists can't count every foram in the ocean, they must sample the population. By doing a simulated activity with skittle-laden brownies, the students "*do the math*" to extrapolate the data to project the "foraminiferal population" in areas the size of a school's gym, which is roughly the size that Dr. Bowser samples to make comparisons from year to year within the region of New Harbor, near the Ross Ice Shelf in Antarctica.

Objectives

- Students will work in teams of six to collect "core samples" from their region (cake/pan of brownies).
- Students will collect their own data from their individual core to compare with their own team, as well as with other regions (cakes from other teams).
- Students will extrapolate the data by "doing the math" to project the foram/skittle population in an area the size of a gym: The students will find the area of a circle and rectangle; round numbers to the nearest whole number or the nearest tenth; find the x,y coordinates; find the percent; determine factors to estimate or project the population; find the mean, median, and mode; and graph data.
- The students will learn the difference between "population" and "population density", as well as discuss science concepts: Limiting Factors (abiotic/biotic), carrying capacity, benthic, planktic, adaptation, clustering, and patchiness in the oceans.

Grade Level

5-8 (Modifications and pretesting have been made for K-12 students in Tennessee, New York, Massachusetts, and Vermont)

Time Required: 2-4 class periods

The math skills and the study skills (listening/following directions/focus) that students bring to the lesson will determine the pace and length of this activity.

Materials for each Team

Prepared pan of Skittle-laden Brownies:
(brownie mix in a 9 x 13 pan, 2-3 packages of skittles, 16 oz. tub of chocolate icing)
Coring tools: Orange juice can (12 fl. oz. or PVC pipe coupler (diameter ~ 7 cm)
Small paper plates
Toothpicks to extract the forams/skittles
Paper towels
Calculators
Metric rulers or measuring tapes to measure the core, cake, and gym
Prepared "Lab Sheets" for this study
Graph Paper and colored pencils for optional extended activities
Prepared Circled labels (~ three-fourths inch) A1, A2, A3, A4, A5, A6 to represent each core sample for "Cake A". Do the same for "Cake B", (B1, B2, B3…), as well as "Cake C", and "Cake D" .

Note: If students cannot have chocolate or food products, then modeling clay or moist potting soil and different colored beads or beans may be substituted for the skittles and brownies. Skittles work better than M & Ms for this activity because they hold their shape and color.

Preparation

Parent or student volunteers will be needed to make one cake per group of six students, so that each team can have their own sampling site. This works well because it enables the students to compare their own cores within their sampling site, as well as with other regions (other cakes in the classroom). Each team will need one coring tool, a large spoon or tool to push the core from the coring tool, and a set of labeled circles. Each student will need a paper plate, metric cm ruler, calculator, toothpick, paper towel, and a set of lab sheets.

Preparation for brownies: The brownies must be left uncut in the pan, so students can get core samples. Bake the brownies according to the package in a 9 x 13-inch pan. Cool slightly and gently press skittles into the cake to randomly cover the surface of the cake. Do not overlap the skittles, but lay them next to each other before covering with icing. Each student will need a core sample and a calculator. (Students may share a core sample and a calculator, but they gain more if they have their own).

Engage

Show students Dr. Bowser's DVD of a diver collecting a core sample from beneath the ice at the bottom of the seafloor at New Harbor, Antarctica. Discuss the DVD, as well as show photos/bios of a sampling of five foraminifera species that Dr. Bowser's team studies in Antarctica. The five colored skittles represent these five species of foraminifera. There are over 4000 *extant* foram species *living* today. Dr. Bowser chose five species to represent the benthic species that he studies in Antarctica. Photos and information on these five species may be downloaded from "Starsand" at http://www.bowserlab.org/starsand/starking.html.

The students may also find information about foraminifera from Dr. Bowser's web site: www.bowserlab.org, as well as the Antarctic field guide: http://scilib.ucsd.edu/sio/nsf/fguide. (Protoctista), and Tina King's journal entry: http://tea.armadaproject.King/11.20.2001.html.

The lab sheets were designed to be flexible enough to allow for time constraints within the class period. It may be helpful to collect the core data first, and then relate the science. On the first day, it works well to show the DVD and discuss Dr. Bowser's research along with the *stars* of the show, the five foram species. If time permits on this day, it is helpful to do the prepared "Lab Sheet A" to find the area of a core.

Math: Finding the *area of a circle* may be an introduction for fifth graders and a review for middle school and higher. Remind the students that the *formula* for finding the area of a circle: pr^2. Have the students use their calculators to do the math: (p = 3.14) times (radius squared). If the radius is 3.5 cm, then 3.14 x (3.5 x 3.5) = 38.465, which rounds to 38 sq. cm.

Science: *Why do you think it is important for Dr. Bowser to know how many foraminifera live in an area?* Possible answers: It helps scientists know how the ecosystem is doing from one year to the next. Scientists can determine if the population is going up or down (thriving or declining). If the students have already learned about food chains and food webs, they may discuss the role forams plays in the food web, or how one organism can affect other organisms, too. The polar regions are in many ways like a canary in the coal mines or windows on our environment. Students also need to realize that we literally have one ocean because the oceans are connected. We are a global world, so if organisms are being affected in one part of the world or ocean, it may one day affect their own backyards (e.g., climate change, pollution).

Explore

Since the scientists can't count every foram in the ocean, and the students can't count every skittle in their cake, they must "do the math" to extrapolate or project data. The students must know the area of their own core, the area of their cake, and the area of the gym in order to estimate how many foraminifera could be in the sampling area. The students will explore why this is important for scientists to know.

The Skittle Core Activity provides the students with the opportunity to apply math skills to real world application and to help students see that math is an integral part of science and life. The students will learn that "doing the math" is needed in order to read the data and to understand the science.

Procedure

1.) The students must compare the area of the sample size (core sample) to the area of the whole cake. It works well to take the area of the core sample (Lab Sheet: 1A-D) on the first day, and then take the area of the cake on the second day (the same day as the students collect and eat their own core sample). Before the students take their core from their sample site, the team will measure and record the area of their cake on the second page of their lab sheet # 2.

2.) The students will find the ***factor*** of how many times bigger their whole cake is than their core sample by dividing the *area of the cake* by the *area of the core sample* (Lab Sheet # 2). Students will round the factor to the nearest whole number.

3.) **Getting a core sample**: Each student will collect their own core sample. (e.g. For Cake A: The students will record their core sample by its label A1 (or A2, A3, A4, A5, or A6). *If only five students are on the team, the students will still take a core sample for A6 to be calculated later with their summary.* The other core samples will also be labeled by the cake (A, B, C, or D) and the number (core sample 1, 2, 3, 4, 5, or 6). At this point, the students are ready to get (and eat their core sample), so the labeled circles enable students to get the core and mark the location for the x,y coordinates at the time of the coring. Once the label is put in the cake pan in the middle of where the students took their core, then students may come back later to measure the coordinates. *(It would be torture to make the students wait to eat the core sample after measuring the coordinates, so first things first).* The students will record the measurements for step #3 (x,y axis) after recording their data on Lab Sheet #4).

a.) The students will gently push and twist the coring tool into the cake. (The students must allow for six cores to be taken from the cake). As the core is twisted and pulled from the cake, the student will use a spoon to push the cake sample from the coring tool unto the paper plate.

b.) The student will then put their labeled circle (e.g. A1) on the spot where the core had been taken. The students help each other get their core, and then each student uses a toothpick to extract the skittles from their own core. *It's important to remind the students NOT to eat the skittles until after they have recorded and verified their data with their teammates.* (Lab Sheet #4)

4.) The students will count and record each of their colored skittles on Lab Sheet #4. The students may then eat their core sample.

a.) Next, the students will use their data from their core sample to find the ***percentage*** of each color (foram species). Remind the students to divide the number of the specified *color* (species) by the total number of *skittles* (foraminifera) found in their core sample (e.g. 3 red skittles divided by a total of 9 skittles = 33%.) The student's *percentage* of total forams should be close to 100%. One common mistake: If a student uses a calculator to show 2 divided by 10, the answer will show 0.2. Some students will write 2%, and then be puzzled as to why their total percentage isn't anywhere close to 100%. Let the students make this mistake before reminding them that 0.2 is 20%. ***This mistake can lead to a valuable teachable moment.***

b.) The students will also calculate and **record the estimated number of forams** in the cake by multiplying the ***"factor"*** *found on Lab Sheet #2* by the number of that species in the core sample. (e.g. If the factor is "19" – meaning that the cake was determined to be 19 times bigger than the core sample, and if a student found 6 red skittles in their core sample, then their estimated number of *red* skittles (*Astrammina rara)* projected to be in Cake A would be (19 x 6) = 114 red skittles. Based on this same data (Lab Sheet #4), if the student had a total of 20 forams in their core sample, then the estimated total of forams in the whole cake would be 380 forams (20 x 19 = 380). The math helps promote and generate active discussion between the team members as the students make comparisons between their data, especially if one student has more skittles in their core.

This is the time to lead students to the science by getting them to see beyond the simulated skittles to the very organisms (forams) that they represent. What could this data tell scientists? The teacher may lead the discussion toward patchiness in the ocean, and how organisms are distributed by the factors that enable species to thrive in one area and not in another.

NOTE: The fifth grade that pretested this activity requested that a separate "worksheet" be made to help figure the percentages and estimated forams, since they were just learning how to figure out percentages. They said that it helped to have the space to do the work and to see the results of their math. ***Hence, a separate "super-sized" Lab Sheet 4 has been provided****. This worksheet (also labeled #4) is optional for students, but the fifth graders felt that it was important to include this "super-sized worksheet" as an option for other students to use with this section of the activity.*

c.) If the students have the time on this day, then they may go back to Lab Sheet #3 and draw and label the circles inside the "box" to indicate the location of each of the cores taken from their sample area (Cake). The students will measure and record the x, y coordinates by labeling the x-axis (horizontal line across the bottom) and the y- axis (the vertical line). It also helps to have the students draw a dot and label the point of origin (lower left side of the box), so they can remember the direction to begin each measurement. Remind the students to first measure *across* (x-axis) by starting at the left side and measuring across the page to the middle of the labeled circle in the cake pan that indicates the location of their core. The students will record their core sample (e.g., A2 = 15.5 cm , 16 cm) and label x, y under each measurement to reinforce their learning.

5.) **Summary of Sample Area:** The students will work as a team to compare and summarize the six core samples taken from their sample area (Cake). The students will use statistics to understand the science.

a.) First, the students will work as a team to ***record the data*** from each individual core sample in their sample area. The students will list each core and the total number of each species found in their cores. (e.g. A1: 8 red; 4 yellow; 5 green; 1 orange; 6 purple for a total of 24 forams found in core sample A1). The students will do this for each core sample, and then calculate and record the total of *each species* (skittle color) and the *total of skittles* in "Cake A".

b.) Next, the students will calculate the ***mean, median, and mode*** for each of the species. Again, since the fifth graders were just learning this skill, they requested a separate "Worksheet" to figure "Mean, Median, and Mode (See worksheet: *Step 5: Calculation Lab Sheet*). This separate sheet allowed the students to list the numbers in order from least to the greatest before figuring "mode" and "median". It was also helpful to have the students write out the calculation for finding the mean. (Some students had trouble remembering that "mean" is "finding the average".) By writing out the sum of the numbers divided by the number of the core samples (e.g., 31 red skittles divided by 6 cores = 5.1666), the students could round to the nearest tenth to find the mean. (= 5.2).

6.) The students will also find the average number of all the species per core by finding the mean: The students will use their summary chart and divide the total species per cake by the number of cores in the cake (e.g., 137 ÷ 6 = 22.83, which rounds to 23 red skittle (*Astrammina rara)* per core.

7-9.) **Understanding the Science behind the Math: See "Explain"**

10.) The students will make a ***prediction*** based on the data they have so far and record the prediction of how many forams would fit into an area the size of the gym.

a.) The students will refer back to the first page (1D) to find the area of the core sample. The students will record the area (38 sq. cm) in the space provided on 10a.

b.) The students will ***find the area of the gym floor*** by multiplying the length times the width in meters converted to the nearest centimeter. (It is helpful to have a group of students measure this the day before, or if time doesn't allow, feel free to use the following measurements of a gym floor: (Length: <u>2610 cm</u> x the Width: <u>1700 cm</u> = **Area of the gym floor**: <u>4,437,000 sq. cm</u>.)

c.) To calculate ***how many core samples would fit into the gym***, the students will divide the *area of the gym* floor (Lab Sheet 10b) by the *area of the core sample* (Lab Sheet 1D).

11.) **Population Sampling**: To estimate the population of forams in an area the size of the gym, which is about the size of the area Dr. Bowser might sample in Antarctica, the students will use the chart on Lab Sheet #11 to record the "m*ean*" for each species listed from the Summary Sheet (Lab Sheet #5).

a.) Then the students will multiply the *mean of each species* (skittle color) by the *number of core samples* that would fit in the gym (10c) to ***determine the projected population*** of ***each species***.

b.) The students will total the **population sampling for these five foram species** (based on the math extrapolated from the *skittles (* forams) in their *cake* (sample area) to determine ***the projected population that would fit in an area the size of a gym***.

12.) **Population Density:** The students will find the population density for these forams by dividing the *total population sampling* on Lab sheet #11 by the *area of the gym floor* recorded on Lab Sheet # 10b. (e.g. 2,662,197 ÷ 4,437,000 = 0.59, so the projected population density of forams per sq. cm in an area the size of the gym would be rounded to 0.6.) It is helpful to have the students use a metric ruler to draw a square centimeter in the space near this section on the lab sheet. This will help students visualize a square centimeter when they record the *total population density* in the box on this page. Population density helps scientists determine if organisms are clustering (clumping) together.

Explain

1-2: To extrapolate or project data, the students must first do the math to find the ***factor*** in order to compare how much bigger one area is than the other.

4. The students benefit by comparing individual core samples within their sample area (Cake). One student might only have 9 skittles, and the next person might have 20. This gives an opportunity to talk about limiting factors that might affect organisms to thrive in one area and be absent in another. Having three or four cakes in a classroom also helps students to compare the data from each cake. The absence of data may also be significant, as well as generate questions as to why organisms might not be present.

5. **Why do students need to use statistics, "mean, median, and mode", to determine what is happening in an area? Which statistic is most important and why?** Students seem to understand grades, so it might help to explain this concept by referring to why grade reports might help students and parents. The students' grades are determined by finding the mean. If a student made the following math grades: 30, 90, 90, and 100, the mean would be about a 78. The grade report would show a "C" average. Finding the mean would be most helpful to quickly assess how the student is doing, especially if the student had 25 grades, or if a scientist had pages of data. If a student came home with a "C", or if the scientist saw an anomaly, the first thing a parent or a scientist would want to know is why and how this happened. They would investigate further. This is why median and mode are also important- These statistics can give more information, if needed. In the case of the math grades, the parents would learn that the student hadn't made all C's. The student actually had only made one low grade with a median (average of the two middle grades) and mode (most often data) of 90. By knowing this information, the parent and student could quickly assess that the student had a good understanding of the math, but needed to go back to that one test to see what had happened (e.g., making careless mistakes, missing a specific skill).
Note: The students need to be reminded to count *zero* as a number when recording mode, median, and mean. Zero does count as a number. It holds a place. (e.g.: 0 Red, 1 Yellow, 3 Green, 6 Orange, 0 Purple) For the following numbers: *0, 0, 1, 3, 6*, the "mode" is "0"; the "median" is "1", and the "mean" is "2".

7.) **Why do you think it is important for scientists to take more than one core sample in an area?** Possible answers: The scientists might find an abundance of different species in one area, but not in another area. This might encourage further investigation or help scientists see the distribution of species from one area to the next, as well as one year to the next. The scientists can also monitor seasonal changes to see if glacial melting, or input of freshwater into a marine ecosystem is changing the distribution (where and how many are located in the area) or the species composition (which species are living in an area). Some species are more dominant in some areas, so the factors contribute to what live in an area.

8.) **What are the limiting factors (biotic or abiotic) that could affect the foraminifera in Explorers Cove, Antarctica.? What could limit certain species from living in an area? Listed are some of the factors that fifth graders came up with during our brainstorming/ class discussion.**

Abiotic Factors (non-living) that could affect organisms in an area:
- Temperature (water/air)
- Sediment, rocks, sand
- Ice (Iceberg Scouring)
- Oxygen
- Water (freshwater or salty water)
- Light (sun)
- Pollution

Biotic Factors (living):
- Fish and other animals
- Algae and other plants (blocking light or providing for photosynthesis)
- Humans
- Other organisms, like protists
- Bacteria (forams eat it)

9.) **Why do you think it is important for Dr. Bowser to take core samples from the same area from one year to the next?** It is important for scientists to see changes in an area over different years to see if the area is healthy and if the population is changing, and if so, why these changes may be occurring.

12.) **Population Density:** This would make a difference when thinking about ***carrying capacity*** to determine if a region could support the number of organisms in an area. (e.g., How many cows could live on an acre of land? How many people could be sustained in an area the size of New York City versus the state of Montana?) Students seem to understand this concept best if population density can be put in terms that they understand. The fifth graders best understood the difference between population and population density when they could see that the population in our classroom was 24 students. If a tornado came and the population of our classroom (24 students) tried to get into our closet, the population density would matter because the same population of people would try to get into a smaller area! The population would be denser in the closet than in the classroom or gym, despite the fact that the population remained the same.

Extend

The students may use **graph paper** to draw grids to help visualize population density. For example, to understand 0.6 forams per sq. cm, the students may use graph paper and draw a box around 10 cm squares (5 x 2 array). After putting 6 skittles anywhere within the array, the students will draw skittle- sized circles on the graph paper. By comparing the population density from each Cake in the classroom, the students can visualize population density and how organisms taking up 0.6 of the space would be more clustered or clumped together than other areas (cakes) with a population density of 0.2; 0.4; or 0.3. ***Question: Which grid showed the skittles (forams) clustering or clumping together the most?*** *Why would clustering make a difference? How could clustering together affect the population of forams (positive or negative effects)?* The students can also ***record and graph the class data*** to the nearest 50,000 on the ***prepared lab sheet***, as well as transfer it to a ***super-sized graph***: Big Graph Paper, 100ft rolls, 30 inches wide, 2 cm squares (#531108) from http://www.eaieducation.com.

Evaluation:

Lab sheets, graphs, and grids can show a student's understanding, but one of the best ways to evaluate a student's learning is through the class discussion or verbal exchange as the teacher rotates from group to group. It was helpful to put student work on the wall, so the students could explain the process to the teacher, other students and teachers, and to parents at a PTO meeting. The students benefit by working in groups to compare and recheck data. This reinforces the math and the science and encourages learning, even if the students aren't ready for the math skills, yet. This especially works well with special needs students, while also building a stronger foundation for students as they verbalize or help work through the process and skills with other students on their team.