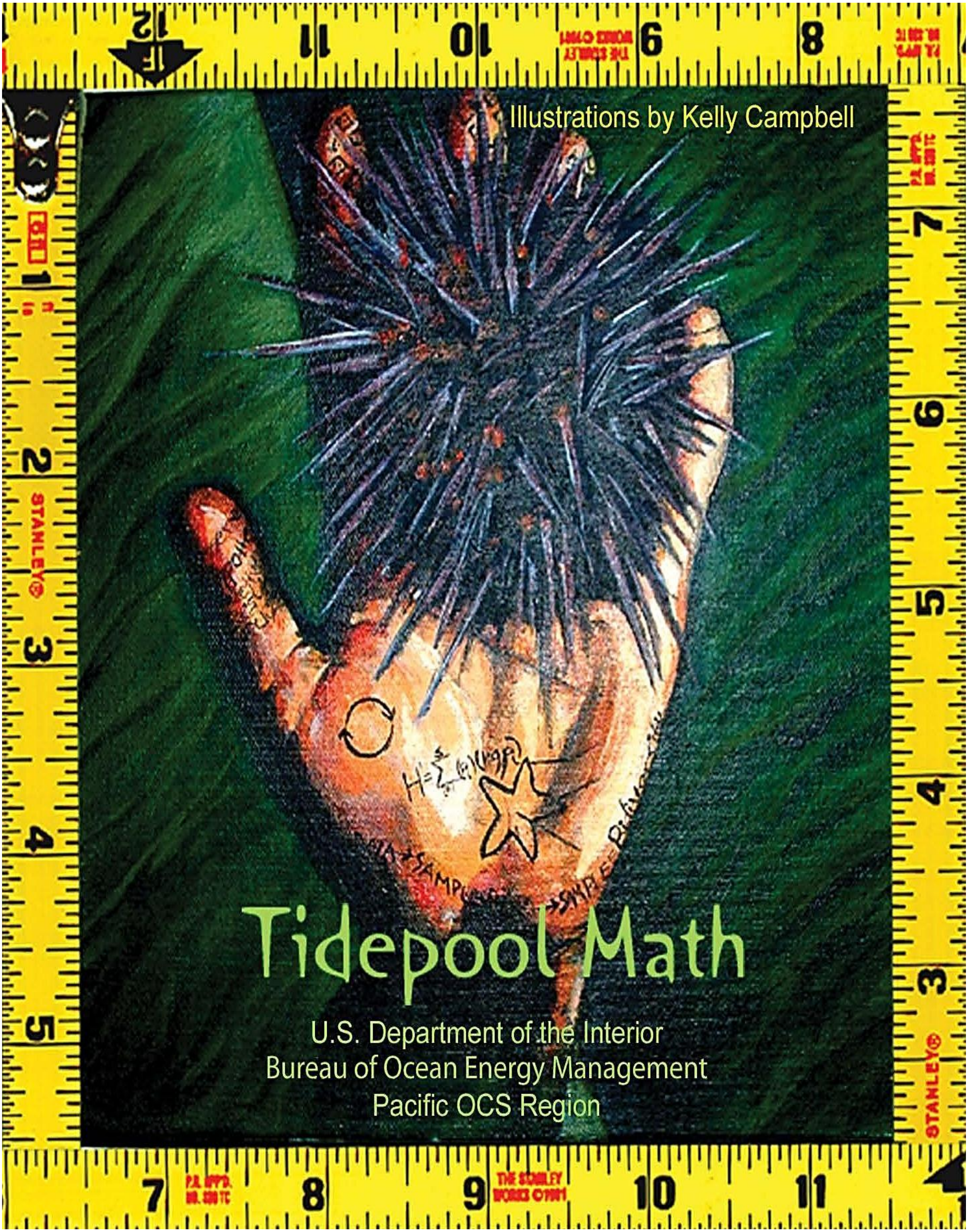


Illustrations by Kelly Campbell

Tidepool Math

U.S. Department of the Interior
Bureau of Ocean Energy Management
Pacific OCS Region

Tidepool Math K-8

Lesson Summary

Students use a plot of a mussel bed to better understand the scientific applications of counting and estimating. They will also learn that their environment is constantly changing, both physically and biologically. Through classroom exercises, they will also learn ways to monitor change in the environment.

Learning Objectives

This curriculum ties in with the CA Math Standards for Grade K-8. Upon completion of this lesson, students will be able to use a mussel bed to:

- Estimate
- Count
- Determine the mean
- Identify outliers
- Sample

This curriculum also helps students :

- Describe a specific environment
- Define variable in an experiment

Process Skills Used in this Lesson

1. Be able to sample animals by counting and multiplying.
2. Describe their classroom environment
3. Observe changes in their local environment.

Background for Teachers

1. Introduction

Math is a skill used by many scientists to study changes in the environment. Simple counts and measurements are commonly used by biologists to monitor changes in habitats, populations and ecosystems. By allowing students to glimpse the application of the math skills they're learning, they may find math "more fun." For example, it is much easier to understand why one must estimate the number of mussels in a mussel bed when confronted with a photo of a rocky bench (a large flat rock) covered with them.

Scientific methods taught in their classroom also take on new meaning when students see how this is done by field biologists to monitor the environment. Observation, recording, considering and eliminating variables in the experimental design, and critical thinking are all natural parts of monitoring a tidepool, a beach or a classroom.

2. Concepts

Several terms and concepts are introduced, including *sampling, estimating, monitoring, variables* **and** *physical* **and** *biological environment.*

To understand what changes in the environment may be caused by man's actions, we have to know how the environment changes naturally. Because the world is so large, we break it up into smaller components for study; the *physical environment (non-living things such as rocks, air, and water)* **and the** *biological environment (living things such as plants and animals).*

Physical environment is often overlooked, yet in many cases, it overwhelms natural systems. In the marine environment, physical forces such as the tides, storm waves, wind, heat caused by the sun, etc. dominate. Living things have been forced to adapt to the many physical changes in the environment.

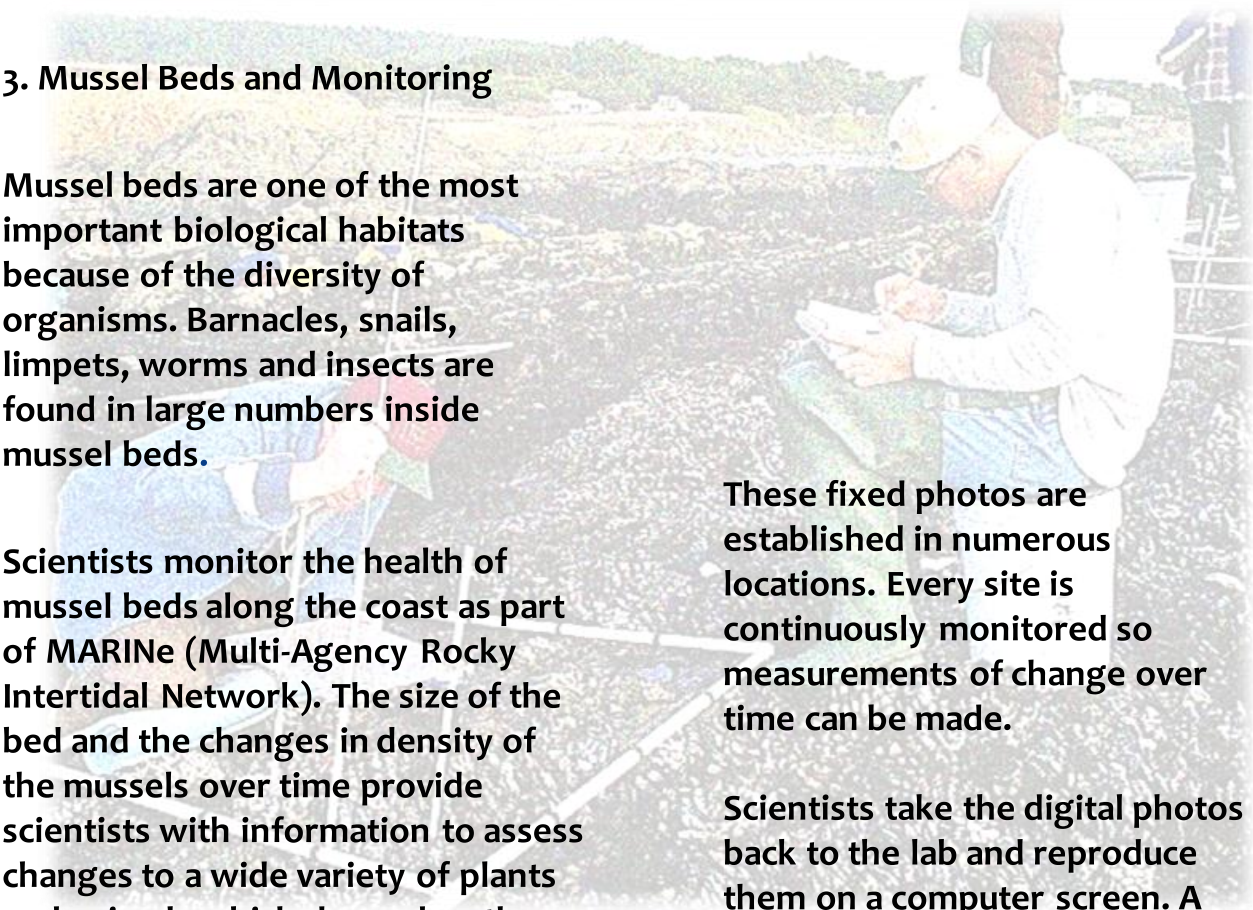
Illustration by
Kelly Campbell

Sampling: selecting and analyzing a subset of elements in order to evaluate the whole. For example, a small group of animals may be selected to evaluate characteristics of the entire population.

Estimating: taking a guess about the size of a group. Guessing the number of beans in a jar would be an estimate. Better methods (i.e. sampling) can be used to improve the accuracy of the estimate. Counting the number of beans in one row and column in the jar (a sample) would improve the estimated bean count.

Monitoring: taking repeated samples in the same way at the same locations over time. Monitoring increases the sample number and allows the scientists to detect change over time.

Variables: Parameters in space and time which are not fixed. Time of year is a variable. Counts of ducks in an area need to be collected at different times of the year to account for seasonal migration.



3. Mussel Beds and Monitoring

Mussel beds are one of the most important biological habitats because of the diversity of organisms. Barnacles, snails, limpets, worms and insects are found in large numbers inside mussel beds.

Scientists monitor the health of mussel beds along the coast as part of MARINe (Multi-Agency Rocky Intertidal Network). The size of the bed and the changes in density of the mussels over time provide scientists with information to assess changes to a wide variety of plants and animals which depend on the mussel beds. Lobsters often feed in mussel beds; many birds and invertebrates, such as sea stars, depend on mussels for food.

Because mussel beds are so large, it is not possible to count the exact number of mussels; scientists rely on estimates based on collecting repeated samples. Photographs are taken in rectangular plots. The plots are initially laid out in a random pattern and are then marked with permanent bolts on the rock. Each time the scientists return, they are able to locate the bold and take photos in the exact same location.

These fixed photos are established in numerous locations. Every site is continuously monitored so measurements of change over time can be made.

Scientists take the digital photos back to the lab and reproduce them on a computer screen. A series of points is overlaid and the species under each point is identified. This measurement will provide the scientist with the percent cover of mussels for that plot.

Often measures of density are also recorded for mussels. To do this, mussels in each plot are counted and recorded either directly in the field, or using a photo of the plot. An estimate of the total number of mussels at a site can be made by multiplying the number of mussels counted in the plots required to cover the mussel beds at an entire site.

California Mussel


Illustration by Kelly Campbell

Latin name: *Mytilus californianus*

Range: Alaska to Baja

Occurs: In the rocky intertidal. On piers, oil platform legs and occasionally subtidal depths of 24m.

Other Information:

Juvenile mussels settle on hard surfaces, often near adult mussels. We study "recruitment" of mussels, the number of baby mussels which settle in an area, by nailing household "tuffy pads" at the site and later counting the tiny mussels that attach to them.

Mussels growing on the offshore platforms can reach sizes exceeding 12-14". This fast growth is enabled by currents that race past the platforms carrying nutrients. Testing of mussels harvested regularly off the platforms for food show that they are several magnitudes cleaner than mussels harvested in mariculture areas along the coast. This is because the water offshore is much cleaner than the water near the coast, where the water is polluted by runoff, sewage and other discharges.

Exercise 1: Using Tidepool plots to Count, Estimate, Determine a Mean, and look for Outliers

Summary	Process Skills
Students use a plot of a mussel bed to better understand the scientific applications of counting and estimating.	• Sample animals by counting and estimating • Provide reasons for changes in their local environment

Instructional Strategy:

Start first by asking the students to count the number of students in their class. Get students to think about what inferences can be made about environmental conditions by counting the number of individuals in an area.

Ask what their conclusions would be if they came to this same classroom and only 5 students were present. Their reasons may include vacation, chicken pox, etc. A critical thinker may suggest that you are counting at the wrong time, say before school.

Show slide of mussel bed, and introduce the importance of mussel beds.

Discuss which intertidal animals depend on them for shelter and food.

- Examples include barnacles, snails, limpets, worms, insects, birds, lobsters, sea stars, and other invertebrates

Discuss why it would be important to know how many mussels are found here.
Discuss why knowing about changes in the mussel bed would be useful.

- The condition of a mussel bed can be a good indicator of the overall condition of the ecosystem in the sampled area. Changes in the mussel bed may reflect changes in the surrounding areas.

Ask what a decrease in numbers might mean.

- They were eaten, they got sick, a big storm pulled them off the rocks, etc. (A student may suggest you are counting in a season when mussels are fewer, this doesn't apply to mussels but is true for other animals).

Classroom activity 1:

Counting Mussels
Materials: Enlarged photo of mussel plot, laminate (2' by 3'), dry erase marker, masking tape
Preparation: Enlarge mussel photo to 2' by 3' and mount on foam board.

- **A. Place photo on floor as if it were a plot of mussels at the shoreline.**
- **B. Overlay laminate**
- **C. Place masking tape over laminate to divide plot into fourths.**
- **D. Ask student to estimate the number of mussels in the total plot and in each square.**
- **E. Have four students each count on square. Mark counted mussels with a dry erase marker.**
- **F. Have each student write the number they counted on the board. Have one student add them up to find the total and have another divide them by four to find a mean.**
- **G. Compare these numbers to the estimates. Compare the mean to the individual counts. Discuss any outliers.**
- **H. Multiply each square total to get four estimates of the entire plot. Compare to total, discuss how much easier it is to count one square rather than the entire plot.**

Note: Younger students may want to count each section of the plot with you. Consider making the photo available to be projected on a screen and counting as a class.
Challenge: Older students could discuss the fact that the plots may not be homogenous- there may be an uneven distribution of mussels within the plot. Some areas may be tightly packed while others may be barren rock. Discuss how you would accurately estimate the mussels in plots that are highly variable. Discuss why counting more than one plot in an area would increase the accuracy of the estimate. Discuss the importance of keeping *outliers* in the data set if the objective is to determine the density of mussels at a highly variable site. In this case all densities found need to be included in determining an overall estimate.
Extra Practice: Have students complete the "Estimating with Sea Stars" worksheet.

Exercise 2: Understanding the Environment through monitoring

Summary

Students will identify the biological and physical environment inside and outside their classroom.

Process Skills

- Describe the biological and physical environments
- Understanding sampling and monitoring.
- Identify controlled variables

Instructional Strategy:

This exercise provides students with increased awareness about the *physical environment.* **Very few people take note of the impact the physical environment has on the changing world. Except for the factors that directly impact the comforts of everyday life, many physical changes in the environment go unnoticed.**

Ask your students to define environment.

- The environment is everything. The two components of the environment are physical and biological. Everything on earth falls into these two categories.

Ask what some physical parts of the environment are.

- Examples include air, sunlight, chairs, etc…

Ask what some parts of the *biological environment* are?

- Examples include humans, plants, etc…

Ask the students what scientists have to do before they can tell if something, like installing an oil platform, will impact the environment?

- They must determine the present conditions and perform continuous *monitoring* in order to the assess the impact.

Monitoring Discussion:

Introduce the term *monitoring* using the example of ducks in a pond.

Introduce the term *variable.* Variables in this case could be time of day, time of year, or temperature outside.

Ask if the environment changes? If a biologist wanted to know about the ducks in a pond, what would be her approach?

- She would go to the pond and watch them

Ask; suppose you went to this pond in December and discovered five ducks swimming in the pond. Would this tell you how many ducks lived there?

- Students may suggest that there could have been a lot more birds but they all flew south for the winter.

Ask would the same five ducks be there tomorrow? Is it possible that other ducks live there but weren't there when the biologist was? How can the biologist get a truer picture of how many ducks live at that pond?

- The biologist has to go back to the same pond over and over again to see what ducks are there. This is called *monitoring*.

Ask what other variables might effect the duck population while monitoring at a particular time.

- Human presence, water or air temperature, maybe ducks forage in a different place when it is very hot or cold.

Discuss what the biologist might find at different times of the day, or different months of the year.

Monitoring Plan:

Have your students write down a possible monitoring plan that would allow them to monitor the ducks at this pond adequately. Have them specify which variables need to be recorded during each monitoring period.

Classroom Activity 2: How does your environment change?

Materials: Journals, pencils

A. Ask two students to step outside the classroom for a few minutes. Help remaining students change on aspect of the physical environment (open a door, move a chair, etc…).
B. Ask the returning students to identify the changes in the physical environment.
C. With journals in hand, ask students to go outside their classroom and record as many items as they can find in their biological and physical environment.
D. Have them compare lists and discuss the importance of being a detailed observer.

Tell the students: After a biologist has made a detailed description of the existing environment, they need to predict what they think can or will happen if a certain project is carried out. They have to look at impacts on the environment; what is going to happen and what activity is planned.
Ask how they affected the classroom environment today.

- Stepped on an insect, introduced new germs, changed number of people in room, etc. These human impacts affect the classroom environment.

When determining the environmental impact in the real world, **the big question is:** is the impact something to worry about? Science and judgment are combined to reach the answer to this question.

Will the effect last a very long time, such as 100 years, or a short time, such as a minute? Will the effect be felt over a large area, or a very small area? Will it affect the entire community or just one particular species?

Ask how they would rate stepping on some ants? The effects in probably felt over a very small area, and given the high number of ants, the population of ants will probably not be affected at all. How about losing several endangered birds? Loss of several endangered birds could negatively affect the entire population, an effect that would be felt over a large area and could require many years to recover.

Estimating with Sea Stars

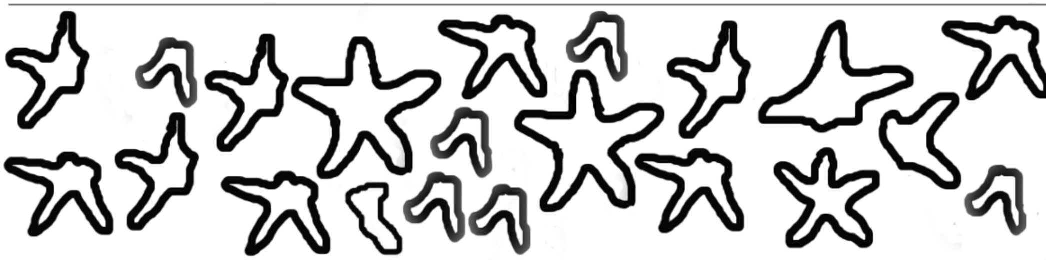
Name_______________

1

Total rays______
Total stars_______

Average rays per star_____

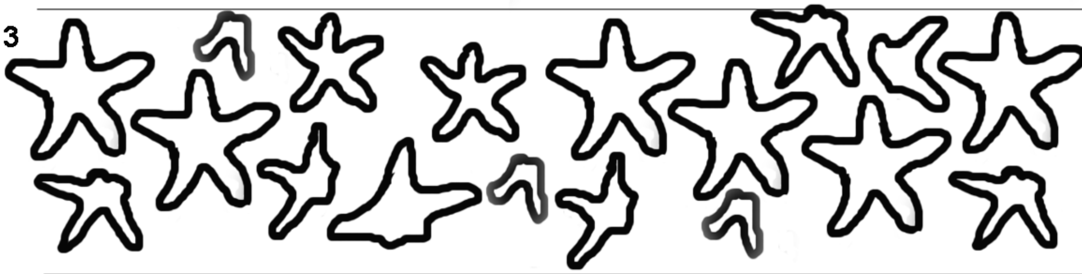
2



Total rays______
Total stars_______

Average rays per star_____

3



Total rays______
Total stars_______

Average rays per star_____

4

Total rays______
Total stars_______

Average rays per star_____

Illustrations by Kelly Campbell

Sea stars have the ability to regenerate broken rays. This adaptation is both a defense mechanism and a mode of reproduction. If a large enough portion of the star is broken off it can develop into a an entire new star.

Count the total number of rays in each sea star community. Find the average number of rays per star by dividing the total arms by the total stars in each community.

What is the average number of rays per star for all four communities?________

How many rays would you expect most stars in community 3 to have?________

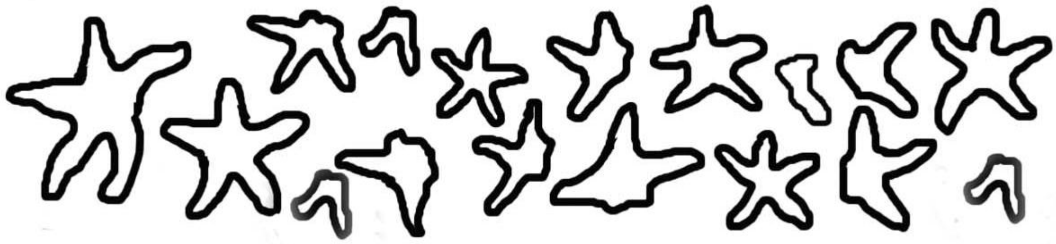
Are there any outlier sea stars?______ How many rays do they have?________

Why is estimating a useful and important tool for scientists?

Estimating with Sea Stars

Name ____________________

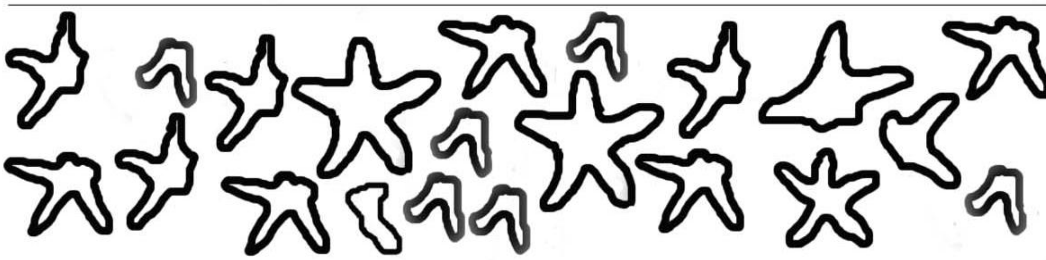
1



Total rays 56
Total stars 16

Average rays per star 3.5

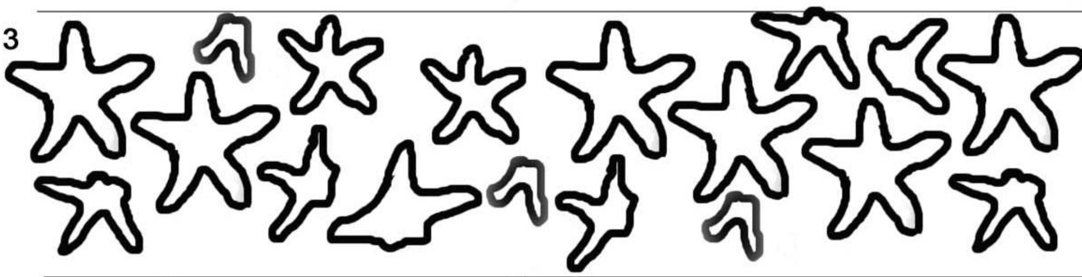
2



Total rays 60
Total stars 21

Average rays per star 2.9

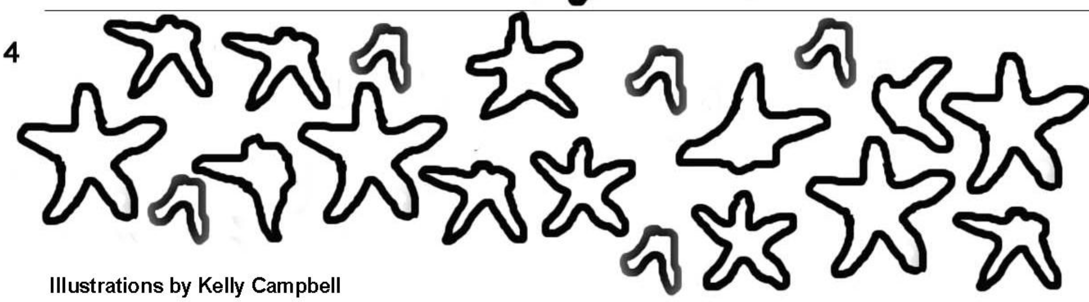
3



Total rays 66
Total stars 18

Average rays per star 3.7

4



Illustrations by Kelly Campbell

Total rays 64
Total stars 19

Average rays per star 3.3

Sea stars have the ability to regenerate broken rays. This adaptation is both a defense mechanism and a mode of reproduction. If a large enough portion of the star is broken off it can develope into a an entire new star.

Count the total number of rays in each sea star community. Find the average number of rays per star by dividing the total arms by the total stars in each community. Depending on math skills, answers can be averages as fractions (rays/stars), mixed numbers or decimals (key has decimals with two significant digits*)

What is the average number of rays per star for all four communities? 3.4

How many rays would you expect most stars in community 3 to have? 3

The average is 3.7, but rays are counted here in whole numbers. The answer must be rounded down to 3.

Are there any outlier sea stars? yes How many rays do they have? 1

Why is estimating a useful and important tool for scientists?

Estimating allows scientist to look at a small portion of an area of interest and make assumptions about the entire area. It also enables them to make generalizations about an area, focusing on the condition of the majority. It can be assumed that stars in population 2 (where average rays is 2.9) may be more likely to lose limbs than stars in population 3 (where average rays is 3.7).

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