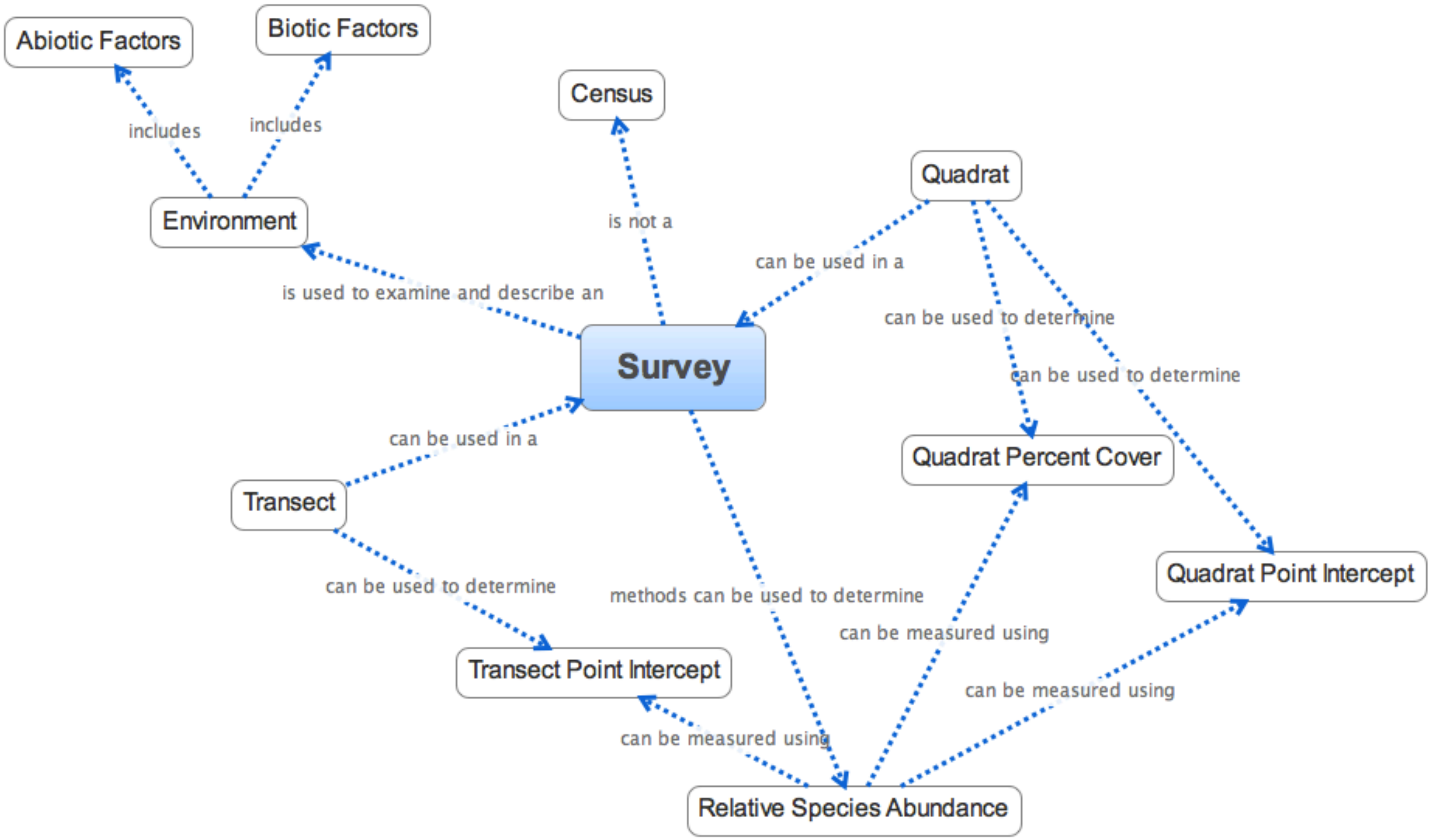
2.1 Sampling for Abundance (SA)



T-SA Fig 2.1 Sampling for Abundance Concept Map

Goals

Students will…

1. Use common ecological sampling tools and techniques
2. Compare and contrast abundance measurements across different sampling methods

Ocean Literacy Principle(s) Addressed

Principle 7: *The ocean is largely unexplored*

Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes. (OLP 7b)

Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems. (OLP 7e)

Standards Addressed

T-SA Table 2.1. HCPS III Benchmarks

Science		
Standard 1	The Scientific Process	Discover, invent and investigate using the skills necessary to engage in the scientific process
6.1.2	Use appropriate tools, equipment, and techniques safely to collect, display, and analyze data	
SC.7.1.1	Design and safely conduct a scientific investigation to answer a question or test a hypothesis	
SC.8.1.1	Determine the link(s) between evidence and the conclusion(s) of an investigation	
SC.MS.1.2	Design and safely implement an experiment, including the appropriate use of tools and techniques to organize, analyze, and validate data	
SC.MS.1.3	Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data	
SC.MS.1.4	Determine the connection(s) among hypotheses, scientific evidence, and conclusions	
SC.MS.1.7	Revise, as needed, conclusions and explanations based on new evidence	

Background and Introduction

Transects vs. Quadrats

In addition to the pros and cons of each sampling methodology listed in the answer key to the Data Analysis and Activity Questions for this activity, Table 1 lists some additional considerations for choosing one of these sampling techniques.

T-SA Table 2.2. General considerations for choosing a sampling technique

	Transects	**Quadrats**
Type of data	Species abundance, physical or chemical measurements at distances along the transect	Species abundance or percent cover, physical or chemical measurements in each quadrat
Type of organism	Sessile and mobile	Sessile
Habitat type	Useful in large habitats that are relatively uniform	Useful in smaller habitats where habitat is mixed
Zonation	Can place transect along gradient through zones	Can place quadrats in previously identified zones
Time	Transects are generally faster but it depends on the study	Quadrats are generally slower but it depends on the study

Random Sampling: Truly Random vs. Haphazard

Conducting surveys using random sampling is an easy way to take into account most of the variation in your plot while at the same time reducing bias and minimizing the effect of any unforeseeable factors that might affect your data. A truly randomized study involves collecting measurements at random locations along a transect line or placing quadrats at random coordinates on a map. In order to do this, the area that you are studying needs to be clearly defined ahead of time. For example, if a scientist is surveying a 20m x 20m intertidal zone, the scientist might need to define a grid system in the area and then randomly choose x and y coordinates to determine where to sample. Sometimes this is not always practical, especially if you do not know a lot about the field site before you arrive. Scientists often attempt to reduce time and effort with haphazard sampling. Haphazard sampling is not systematic, but it is not truly random. For example, to haphazardly sample at the 20m x 20m intertidal site, the scientist might throw a tennis ball behind their shoulder and then place a quadrat where the tennis ball lands. Haphazard sampling is often quicker, but may cause errors because it is easy to introduce bias. Bias would be introduced if the tennis ball was consistently thrown to one side of the site. It is important to consider the costs and benefits of each type of random sampling before using the technique in the field.

Quadrat percent cover squares modification
The quadrat percent cover method is prone to a large degree of error because it requires estimating. One way to address this issue is to use categories or "bins", e.g. 0%, 1-10%, 10-20%, 20-30%, etc. Another way to reduce error is to use the a "squares modification". This modification is also appropriate for younger students who many have trouble estimating the percent cover of something in an area the size of a quadrat.

In the quadrat percent cover squares modification method, scientists imagine all the organisms of one species pushed into a corner of the quadrat and estimate how many *squares* (rather than percentage) that they take up (see T-SA Table 2.3). The total number of squares in the quadrats for the student mock study site is 16, therefore the data columns should add to 16. Organisms that take up less than 0.25 squares are not included in the total. The number of squares taken up by an organism can easily be converted into percentage of total squares.

T-SA Table 2.3. Datasheet for mock study site using the quadrat percent cover squares modification method.

Organism/ Substrate	Transect Point				Total Squares Across All Quadrats	Average Squares Per Quadrat	Average Percent Per Quadrat (%)
	1	2	3	4			
Red			2.5	3.25	5.75	1.4	9.0
Yellow	1.25	.5	1	.25	3	0.75	4.7
Blue	1.0	10			11	2.75	17.2
Green	0.25	0.25	<0.25		.5	0.125	0.8
Sand	13.5	5.25	12.5	12.5	43.75	10.9	68.4
Quadrat Total	**16**	**16**	**16**	**16**	**64**	—	—

Calculating Average Percent Quadrat

There are two ways to calculate the average percent per quadrat. In this example we will work through the last column on the right of T-SA Table 2.3, but this calculation is true for other tables in the activity as well.

1. Take the total squares across of all of the quadrats (e.g. Red is 5.75) and divide this number by that total squares in all of the quadrats (64) and multiply by 100. This method gives you 8.98, which we rounded to 9. This is the method we used in the student text.

OR

2. Take the average squares per quadrat (Red is 1.4), divide this by the number of squares in one quadrat (16) and multiply by 100. This method gives you 8.75, which you can round to 8.8.

Both of these methods are correct, but due to rounding errors the numbers will be slightly different. If your students have slightly different numbers, they can share their methodology. This can also lead to a discussion on rounding errors.

Answers to Data Analysis Questions

1. Which sampling method(s) captured all of the colored circles? Which sampling method(s) did not capture one or more colored circles?

The only method to record the green circles from our mock study site was quadrat percent cover. In this example, the transect point intercept method did not capture any green or red circles. The best sampling method will vary with the goals of the study, field-site characteristics, and the time available to complete the project.

2. Compare the quadrat point intercept and quadrat percent cover data. What are the similarities and differences in category abundance?

There were only slight differences between estimates of circle and sand abundance between the different quadrat methods. The quadrat percentage cover method estimated slightly more sand and red circles in our mock study site than the quadrat point intercept method. The quadrat point count method data show a slightly higher cover of yellow and blue circles.

3. Compare the transect point intercept abundance estimations to the quadrat estimated abundances of these categories. Why does the transect point intercept method overestimate some category abundances while underestimating other category abundances?

The transect point intercept method estimated sand and blue circles to have similar abundances as the quadrat methods, but estimated the yellow circles at the same abundance as blue circles. The quadrat methods had substantially lower yellow circle abundance estimations. The transect point intercept method did not capture the small green circles, but it also did not capture the presence of the larger red circles.

4. Compare the transect and quadrat data to the actual mock study site (Figure 3). Do you think the sampling methods accurately sampled this area? Why or why not?

Answers will vary.

5. What are the pros and cons of each sampling method:
   a. Transect point intercept

Very quick, accurate and easy to replicate, and useful for sampling large, relatively uniform areas, but it misses a lot of information. This method would not work well in small areas with very mixed habitat.

   b. Quadrat point intercept

Gathers more information than point intercept along a transect line, but this method can miss species that are less abundant and not under an intercept. However, just like transect point intercept, it is accurate, easy to replicate, and there is not much room for error as you only count what is under the point.

c. Quadrat percent cover

A little slower, but you get more information. It allows you to account for every species present in a quadrat, but there is some uncertainty and a larger degree of error because you are estimating.

See Table 2 in this teacher guide to additional considerations when choosing a sampling method

6. What are potential sources of error for each sampling method?

Point intercept transects and quadrats miss out on rare items, because they may never be under a point. Percent quadrats rely on estimation, so they are often less precise. Things living under rocks or leaf litter or highly mobile things might be missed no matter what sampling method used.

Common Misconceptions

T-SA Table 2.3. Sampling for abundance misconceptions

Misconception	Explanation
Sampling Methods One method is the "best" way to sample.	A choice of sampling method depends on the study goals and questions. Some methods are better for certain questions or environments, but no method is "best" in all cases.
Sampling Methods Sampling methods are interchangeable.	Sampling methods have different advantages and disadvantages. The choice of sampling methods depends on the goals or study questions, as well as things like environment, cost, resources, etc..
Random vs. Systematic Random sampling is better than systematic sampling (or vis versa)	Both random and systematic sampling are valid ways to sample an area, the choice of method depends on the survey goal.

Activity: Sampling for Abundance – Transects and Quadrats

T-SA Table 2.4. Suggested activity progression, if adhering closely to activity as written with no major modifications, assuming class periods of 40 minutes.

Day	Task
1	Introduction to activity
	Activity (depending on number of students, number of sampling methods, and activity location, this may take two days)
2	Compile class data
	Analyze and/or graph data
3	Discussion comparing and contrasting sampling methods

T-SA Table 2.5. Materials, if adhering closely to activity as written with no major modifications, assuming class of 32 students divided into groups of four (8 groups).

Materials	Quantity	Per	Class Total	Notes on Material Number or Material Modification
Colored cards	Multiple of different colors or types	Class	Multiple	Small index cards, poker chips, pieces of construction paper, or any other small items can be used. Size of items should correspond to quadrat size. Items should be distinguishable by color or other attribute. Different numbers of each item should be used.
Blanket *(optional)*	1 or more	Class	1 or more	Used to create different "substrates" in sample site. Different colors or textures of blankets could represent sand, rock, mud, etc. Rugs, large sheets of paper, shower curtains, or other large pieces of fabric could also be used.
Box *(optional)*	1 or more	Class	1 or more	Used to create different topography in sample site.
Transect*	1	Group	8	
Quadrat*	1	Group	8	
Clipboard*	1	Group	8	One per group if only one recorder per group. More clipboards may be used.
Pencil*	1	Group	8	One per group if only one recorder per group. Mechanical pencils suggested.
Transect Data Sheet	1	Student	32	One person may serve as recorder and data may be later transferred to individual students' data sheets. Customize data sheets depending on the age of your students and the time you have for this activity
Quadrat Data Sheet	1	Student	32	One person may serve as recorder and data may be later transferred to individual students' data sheets. Customize data sheets depending on the age of your students and the time you have for this activity
Skewer *(optional)*	1	Group	8	Depends on design of quadrat. If quadrat is strung, a skewer next to a point intercept can help identify the identification of the "organism" or substrate right underneath the point.
Small Cups *(optional)*	Multiple of different colors or types	Class	Multiple	Cups may be used to represent chemical or physical sensors, such as pH, temperature, or salinity.

***Materials Details**

Transects
When buying or making transect tapes, often called open-reel measuring or surveying tapes by forestry suppliers, choose a length based on the length of the sites you will be studying. For general purposes, 30m should be sufficient. Buy transects that are labeled metrically. Prolong the life of your transects by rinsing them off after each use to remove salt water, sand, and/or dirt. Let them air dry. You can make a transect by tying off string at set distances along a rope.

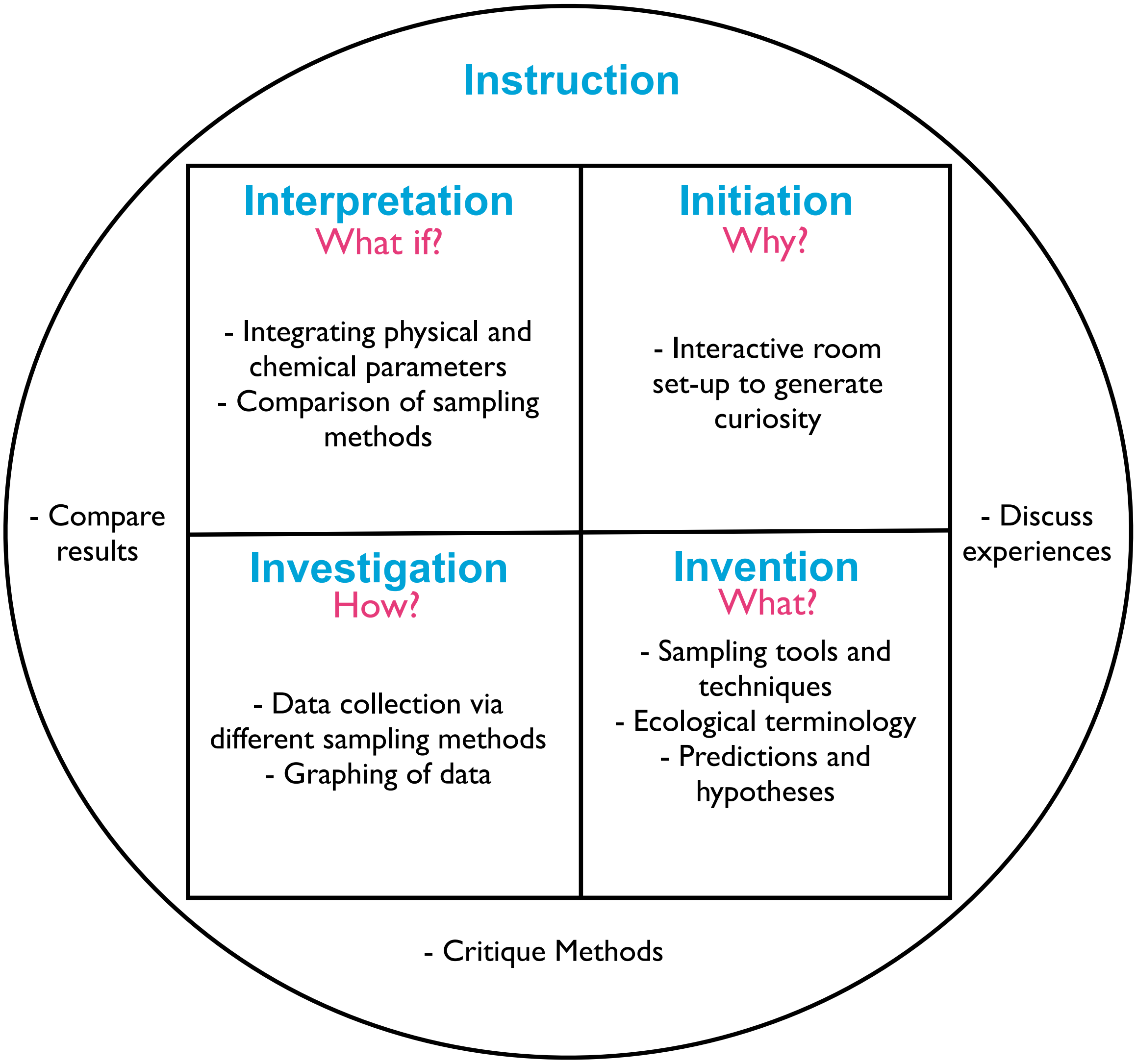
Quadrats
Quadrat size depends on the size of the area and organisms in the area you want to sample. A 0.3 m square quadrat is good for the smaller organisms found in the intertidal. Many coral reef scientists use 0.5 m quadrats, whereas those studying forests often use larger, meter square quadrats. “How to Make a Quadrat” leads you through steps to make a quadrat of any size.

Clipboard and Pencil
Plastic clipboards can get wet and are generally more rugged than particleboard clipboards. If you are taking your students to survey a field site away from school, bring a large number of sharpened pencils. Mechanical pencils always stay sharp. You can attach pencils to the clipboards with string or rubber bands.

Sensors (Cups)
Simple plastic cups can represent sensors. Depending on the abiotic factors your students have been or will be studying, you can determine what each “sensor” measures (e.g. temperature, pH, salinity). You can give each group one of each type of “sensor” or give each group all of the same sensors (i.e. assign temperature to one group, pH to another group, etc.).

Activity Inquiry Prompts
1. How can you use transects and quadrats to describe abundance in the study site?
2. What do you predict about the differences between count methods?
3. Would this technique be useful for all environments? For all organisms?

Planning with TSI



T-SA Fig. 2.2. Planning Sampling for Abundance through TSI phases

Focus Modes(s):

- Authoritative Knowledge
    - Teacher explains how to use (and make) quadrats
    - Teacher explains different count methods
- Description
    - Students use transects and quadrats to describe study area

Procedure

We encourage you to teach each of the three sampling methods in this activity to your students so that they can learn about the pros and cons of each method and compare and contrast the data from each method. However, due to time constraints, you may have to limit the sampling strategies you teach your students. For example, after considering your goals and the age of your students you can choose one quadrat method for them to learn and practice.

Activity Option: Instead of teaching your students about transect and quadrat sampling techniques *before* having them survey an area, teach the methods as they come up in the procedure. For example:

- Show students the study area. Ask how they would survey the area.
  After listening to a few suggestions, introduce transects as a tool to systematically survey the study.
- Have students take transect data and ask if they think it allowed them to accurately characterize the area.
- At this point introduce quadrats and have students sample the area using the two quadrat methods.

1. Create a study site in your classroom or go outside to a study site designated by your teacher.

Students can practice sampling techniques in a classroom or courtyard (Fig.T-SA 2.3).

Photos by J. Philippoff and A. Gundersen

T-SA Fig. 2.3.. Practicing transect and quadrat methods in a classroom and courtyard

In a classroom you can move student desks against the walls and use items like different sizes and colors of paper to represent different species of organisms. Small cards will be harder to survey than large ones, just as small species in the field are harder to survey than large ones, so a mix of small and large cards helps to replicate nature. Do not distribute all items randomly; place some items to be surveyed in clumps or create zonation patterns in your classroom. For complex substrate throw blankets and boxes on the ground and use them to create ridges and crevices.

2. Observe the study site and make predictions. Which category do you think is most abundant? Which category is least abundant?

3. Use your predictions to make a hypothesis about the abundance of categories at your study site.

Divide the class into groups and give each group a transect. Without giving any additional information, ask each group to lay their transects in a location to best survey the area. Most classes come up with a spider-web of transects, crisscrossing haphazardly all over the study site (T-SA Fig. 2.4). Point out that where transects cross, "organisms" at the intersections will be recorded multiple times, falsely increasing their perceived abundance. To prevent this, transects are normally laid parallel to each other (an equal distance apart). Transect length and distance apart will vary based on your study site.

Photo by A. Gundersen
T-SA Fig. 2.4. Spider-web of transects

4. As a class, plan how you will conduct your data collection accurately and in the span of time allocated by your teacher. You will need to make decisions about:
    a. How to place the transect(s)
    b. How long the transect(s) will be and how far apart transects will be from each other
    c. How frequently you will collect transect point intercept data

For example, every meter or half meter. The frequency of transect point intercept data your students should collect will depend on the size of your data site. Transect point intercept data is quick, aim for at least ten data points per transect.

d. At which transect points you will place your quadrat(s)
e. How you will place your quadrat in relation to the transect

For example, centered on the transect point or aligned to the quadrat corner. It does not matter where the quadrat is placed as long as the placement is the same each time among all the groups.

f. How you will standardize your categorization of species and substrates

Standardization is necessary so all students record the same type of data. students should determine how specific their category designations will be as a class. For example, differentiating between different sized sand grains or just recording "sand".

g. How you will place your quadrat in relation to the transect

Transects

Standardization issues to address when students are learning to lay transects:

- *"0" marks on transects should all be in same direction so data sheets are standardized. (When near water, the turning mechanism of the transect should lays out of water to prolong the life of the transect.)*
- *Transects should all have the same side of the tape facing up (metric, if there is an option). All students should collect data along the same distance measurement (metric).*
- *Have your class come up with a standard numbering system for their transects (e.g. the westernmost transect is transect #1).*

Quadrats

Students may choose to place their quadrats any standardized distance along the transect. The more complex and unfamiliar the environment, the more time it will take to collect data. If the environment is very complex, suggest students take less quadrat data to complete the activity on time. For example, quadrats could be placed every half meter, meter, or every other meter apart. This may require modification of the data sheet in the activity.

Group Work

Each group should work along one transect and be responsible for all data collected along that transect. Assign tasks to each group member (e.g. recorder, transect data collect, quadrat data collector, etc.) if appropriate.

Students should take both quadrat point intercept and percent cover data so they can compare methodologies. They can do this at the same time or collect point intercept data first and then percent cover data.

5. If necessary, customize the data sheets to reflect your study site, including transect length and where quadrats will be laid.

The transect data sheet assumes a total transect length of 4m and transect point intercept sampling every quarter of a meter. You can change the designated transect and quadrat points to any standard distance (e.g. every 0.5m, 1m, 2m, 5m, etc.) depending on the size of your study site. Note that this data sheet also includes general information such as transect number, start and end time, and location.

The quadrat data sheet assumes quadrats will be laid every meter along a total transect length of 4m. Write in the most common categories at your study site in the left column of the data sheet. You can change the designated quadrat points to any standard distance.

6. Collect data following the class procedure. Use a skewer to assist in accurately determining what is directly at a transect point or quadrat intercept.

If necessary for clarification of procedure with your class, have two students collect data along one of the transects. If you are in the classroom, record the data on the board so everyone can see the example before the entire class collects data.

Skewers may not be necessary depending on what type of quadrat you have.

7. *Optional:* Your group may be given objects representing physical and chemical sensors, which can measure certain parameters. Determine where you should place your sensor(s) to collect data that will allow you to draw useful inferences about the interaction between the biotic and abiotic factors in the environment.

The crux of this optional extension is the limitation of the number of sensors. For example, lets say each group has been given six cups presenting two each of temperature, pH, and salinity sensors. Working individually, or with other groups, students will have to choose if they want to systematically sample an area (e.g. place sensors at set locations along the transects) or choose locations for their sensors based on the physical or biological data they have collected (e.g. type of substrate or environments rich in species). Similarly, if one group had six temperature sensors, and another had six pH sensors, groups could choose to place their samples in the same or different areas.

It is important to discuss with your students why they placed their sensors at different locations in the study site. There is no right or wrong way to place sensors; placement depends on the questions your students are trying to answer. This simulation is very similar to how sensors are used in the field. Scientists might take one temperature reading for the water in a pond they are surveying, or they may take many readings of the temperature in the pond at many different areas. This information could be used to take calculate a mean water temperature or to look more closely at microhabitats that are characterized by different temperatures.

8. Compile class data.

Students groups can add their data to a class data table or enter their data into an excel spreadsheet to share. To analyze total site percent cover, you can use a data table similar to Table 2. You will need separate, but similar, data tables for quadrat point intercept and quadrat percent cover.

Table 2. Example class data table for quadrat point intercept

	Transect Point Intercept					
Organism / Substrate	**Group 1 Total Points**	**Group 2 Total Points**	**Group 3 Total Points**	**Group 4 Total Points**	**All Groups Total Points**	**Percent (%)**
Total						

9. Analyze, share and present this data.

This section of the procedure was purposefully left vague. Depending on your students' prior knowledge and your goals for the activity, students can construct graphs (e.g. pie, bar, or line), write a lab report, or draw a picture of the study site.

Answers to Activity Questions

1. Explain why your class chose to use the sampling scheme you determined, including the sensors if you used them.

Answers will vary.

2. Why was it important to have a class procedure for data collection? What would happen if you did not follow the class procedure?

Answers will vary.

3. Compare the transect point intercept, quadrat point intercept, and quadrat percent cover data. What are the similarities and differences in category abundance?

Answers will vary and depend on data collected.

4. What are the pros and cons of each sampling method for your study area:
    a. Transect point intercept

Very quick, accurate and easy to replicate, and useful for sampling large, relatively uniform areas, but it misses a lot of information. This method would not work well in small areas with very mixed habitat.

b. Quadrat point intercept

Gathers more information than point intercept along a transect line, but this method can miss species that are less abundant and not under an intercept. However, just like transect point intercept, it is accurate, easy to replicate, and there is not much room for error as you only count what is under the point.

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A little slower, but you get more information. It allows you to account for every species present in a quadrat, but there is some uncertainty and a larger degree of error because you are estimating.

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5. What are potential sources of error for each sampling method?

Point intercept transects and quadrats miss out on rare items, because they may never be under a point. Percent quadrats rely on estimation, so they provide more fuzzy data. Things living under rocks or leaf litter or highly mobile things might be missed no matter what sampling method used.

6. Compare the transect and quadrat data to the actual study site. Do you think the sampling methods accurately sampled this area? Why or why not?

Answers will vary.

7. What is the importance of the information at the top of the transect data sheet (start and end times, location, date, transect line number)?

This information is important when analyzing data (transect line number) and when making comparisons to other sites and over time (date, location, start and end times). If data collected is not standardized, data collected between groups can not be compared.

8. If you had to survey the study site again, what would you do differently? Be specific.

Answers will vary.

9. Different sampling techniques work better in different areas. Think about how you were use transects and/or quadrats to accurately and efficiently sample the following areas to gain the most information about the site:
   a. A crater on Mars
   b. A deep-sea vent
   c. A parking lot

Answers will vary.