WILDCOAST COSTASALVAJE

SAN DIEGO MPA COLLABORATIVE

Intertidal Transects

Rocky Intertidal - Grades 6-8

Learning Objectives

A) Students will use vertical transect surveys to collect population data for key intertidal organisms at sites inside and outside of the South La Jolla State Marine Reserve (Part 1).

B) Students will use descriptive statistics to analyze the abundance of species found inside and outside of the MPA
(Part 2).

C) Students will compare abundance inside and outside of the MPA to draw conclusions about MPA impact on abundance
(Part 3).

NGSS: DCI (Disciplinary Core Ideas):
LS2.A
LS4.D

Time: Four to nine 50-minute class periods plus one and a half to two hour field trip

Materials for the Teacher
-Living on the Edge: Field Guide to the Intertidal Teacher Edition
-Quadrat photos if not doing field trip

Materials for the Students
-Living on the Edge: Field Guide to the Intertidal Student Edition
-Clipboard
-Vertical Transect Datasheet (from appendix) and pencil
-0.5m x 0.5m quadrat
-Transect tape or string

Part 1: Data Collection

Background information:
(recommended one to six 50-minute class periods)
See *Living on the Edge: Field Guide to the Intertidal Zone* for more background information and classroom activities that may accompany this lesson. It is recommended you take one 50-minute class period to cover each of the six topics covered in the field guide: The Intertidal Zone, Adaptations, Tidepools, Tides, Marine Protected Areas, and Taxonomy/ID.

Marine Protected Areas (MPAs)

We can think of marine protected areas, or MPAs, as underwater parks. Just like we have national, state, and regional parks on land, there are many different types of MPAs. Different parks allow different activities - same with MPAs! In some of them you can fish, while in others you can't. Some MPAs allow all kinds of activities (fishing, swimming, boating, etc.) while others are much stricter. By restricting what people can do and take in these underwater parks, we can protect California's natural resources.

California has 124 MPAs all along the coast. These MPAs protect many different habitats where many different animals live. MPAs give marine species a safe place to breed and grow. Animals inside of MPAs may be larger than those found outside of MPAs, allowing them to have more offspring than smaller animals. Offspring born within MPAs may also have access to more food, space, and other resources, allowing offspring to be healthier.

MPAs also provide opportunities for people to see beautiful, protected ocean spaces through snorkeling, scuba diving, swimming, kayaking etc. Sometimes, people don't know that they are in an MPA and accidentally do something they aren't supposed to do. That's why it is important to understand what MPAs are, why we have them, and where they are - so you know if you are in one!

Also, have students start to think about the following now. We will discuss it more in-depth at the end off the lesson: Evidence suggests that MPAs may increase biodiversity and abundance by giving species a safe place to live, grow, and reproduce; however, this success is threatened by other activities such as marine debris/pollution. What are some complementary solutions that may be enacted to help reduce or eliminate the threat of marine debris to MPAs?

Intertidal Zone

MPAs protect a wide range of ecosystems in Southern California, including kelp forests, rocky reefs, sandy shores, and the intertidal zone. This lesson will focus on the unique and fun intertidal zone.

The **intertidal zone**, the area between the high and low tide lines, is a harsh and unforgiving habitat. The highly adapted species that live there are subject to the rigors of both the land and the sea, going from completely submerged to only occasionally wet within just a few feet of space. Organisms that inhabit the intertidal zone must endure extreme fluctuations in moisture level, temperature, salinity, and sunlight. Those that are able to do so make up a robust assortment of biologically diverse organisms with specialized adaptations. Visiting these creatures in the space between land and sea is truly an adventure!

MPAs limit or prohibit which intertidal organisms humans may take. This reduces stress on intertidal organisms and safeguards marine resources within this dynamic environment.

Vocabulary

-*Marine Protected Area (MPA)*: MPAs are areas in or near the ocean made to protect or conserve marine life and habitat, safeguard cultural sites, and provide enhanced recreational opportunities.

-*Take*: To hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill any natural resources.

-*Natural Resource*: Materials or substances such as minerals, forests, water, or animals that are found in nature and are valuable to humans.

-*Intertidal Zone*: The area of land in between the high and low tidelines.

-*Abundance*: A measure of the number of individuals of a particular species in a sample.

-*Random sample*: Data collected from a random subset of a population, meant to represent the entire population.

Measuring Abundance

Abundance is a measure of the number of individuals of a particular species in a given area. In its most basic form, abundance equates to population size. For example, if you found 500 limpets at Site A and only 57 limpets at Site B in the same amount of space, then Site A would be said to have a greater abundance of limpets. However, as is often the case in science, things are not always so straightforward and measuring abundance usually involves quite a bit of math!

There are many ways to calculate abundance, including frequency, density, or simple presence/absence. In this lesson we will use descriptive statistics to compare the abundance of target species at two sites using frequency (the percentage of subsamples, in this case quadrats, that contained our target species), density (in this case calculated by average number of individuals found per square meter), and range.

So why do all of this math when we are studying conservation? One of the primary goals of MPAs is to protect, or even increase, species abundance. By limiting or restricting take, we will hopefully increase the number of breeding females as well as allow those females to have more offspring, thereby increasing population size at a rate higher than non-protected areas. See the Big Old Fertile Female Fish (BOFFF) activity for a great representation of this concept. Quantifying the increase in species abundance inside of MPAs helps to guide informed MPA management.

It is important to note that it is nearly impossible to count every single individual of a species at any given site. As is typical in science, instead of observing an impossibly large scale, we will look at a representative subset and build our hypothesis based on inference. We will do this using a method called random sampling. In random sampling, we collect data for a randomly chosen subset of the population. It is crucial that the subset be chosen randomly so as to not introduce human bias (i.e. sampling the individuals that are biggest, easiest to find, or prettiest, as would be tempting to do!).

One of the methods of random sampling that we often use in the intertidal zone is something called a vertical transect. A vertical transect is a line, often marked off by meter tape, that runs perpendicular to the water along which we collect samples. We place squares, called quadrats, at regular intervals along the transect and count only what is within the quadrat. By repeating this several times, we are able to get a subset of data, which is (usually) representative of the entire population. We can then run statistics on this data to draw conclusions about the whole population.

Suggested procedure:

Teacher Prep

1) Divide your class into research groups of about four students each.
2) Create a field kit for each group consisting of:
   - -One clipboard
   - -One datasheet and pencil (see Appendix)
   - -One quadrat (see Appendix; students may assemble)
   - -One meter tape (or string with meters marked on it)

Student Prep

1) In class, study MPAs, the intertidal zone, abundance estimates, and vertical transect surveys. Use the information and activities in Living on the Edge: Field Guide to the Intertidal Zone (recommended activity: Tidepool in a Pan).
2) Have students form a hypothesis for the following research question: Is there a difference in species abundance inside an MPA compared to outside an MPA?
3) Let students explore field kits. First, assemble the quadrats by attaching each of the 0.5m pieces of PVC pipe together using the 90-degree elbows to form a square. Go over the rest of the kit in class with students.
4) Take quadrats and meter tape outside to the schoolyard or a local park. Practice proper placement of meter tape and quadrats until students are comfortable with methodology and instruments (see Conducting Vertical Transects in the Field Trip section below).

Field Trip *(recommended 1.5-2 hours in the field)*

Getting Started

1) Check the tide ahead of time to determine which day and time will have an acceptable low tide for this project. Negative, outgoing tides are recommended. The best tides are in the spring. Tides for La Jolla may be found here: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=9410230

-*Vertical Transect:* A fixed path (with a start and end point) along which one counts and records scientific data. In this case, one that runs perpendicular to the water.
-*Quadrat*: A frame, traditionally square, used in ecology and geography to isolate a standard unit of area for study
-*Experimental site*: The site receiving the experimental treatment (in our case the protection afforded by MPAs)
-*Control site*: The site not receiving experimental treatment.
-*Holdfast*: a root-like structure that anchors aquatic organisms to the substrate. Holdfasts vary in shape and form depending on the species and the type of substrate.Substrate: The surface or material on or from which an organism lives.
-*Frequency*: The number of times something occurs, often represented as a percentage.

2) **Meet at the following location:**
Windandsea Beach in La Jolla
Parking lot at the corner of Nautilus Street and Neptune Place
Street parking is also available for free.
Note, this location does not have public restrooms.

3) Make sure to cover good tidepooling practices with the students:
-Watch where you step, that might not be a rock!
-Leave things how you found them. If you turn over a rock, put it back exactly how you found it.
-Take only pictures. Leave all rocks, plants, animals, and other tidepool creatures exactly how you found them.
-Leave animals be. Tidepool organisms have a hard enough life as it is without being touched by a bunch of sticky fingers.
-Be careful where you put your fingers. Many animals like sea urchins and crabs have defenses against predators.
-Never turn your back on the ocean.... it needs you too much! But seriously, watch out for waves and the incoming tide.
4) Designate a meeting location and end time for the activity. Depending on the group, tides, and weather conditions, often about 45 minutes to an hour is appropriate for data collection.
5) Split the class into two groups, making sure the student research groups of 2-4 students are kept together. One group will descend the stairs below the parking lot and collect data on the rocks just to the north. This group is the Windandsea Beach control group.
6) The other group will head about 10 minutes south and take the stairs down to the beach by Palomar Ave. This group will be the South La Jolla State Marine Reserve experimental group.
7) Make sure to assign at least one chaperone with each group to ensure best practices are met.

Conducting Vertical Transects
*These data collection methods are adapted from NOAA's LiMPETS Monitoring Program.
1) Help students set up one transect per group parallel to each other and perpendicular to the water by laying meter tape or a string with meters marked on it from the highest accessible point in the tidepools to as close to the water as is safe. Please be mindful of the tide. This activity is best done on a negative, outgoing tide.
2) Center a quadrat directly over the meter tape at even intervals (i.e. every three meters) depending on the length of the transect.
3) Record species abundance within the quadrat by counting how many individuals of each species on the datasheet are present.
4) Count only live invertebrates and algae that are attached to the substrate as well as those attached to sessile organisms within the quadrat (e.g., algae

-Descriptive statistics: Mathematical means of describing a particular set of data.
-Central Tendency: Estimate of the "center" of a distribution of data. This includes mean, median, and mode.
-Dispersion: Spread of data around the central tendency.

California Department of Fish and Wildlife Key Messages:
-MPAs protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
-MPAs help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
-MPAs improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and manage

growing on mussels). For algae, only count it if the holdfast is contained inside the quadrat.
5) When the count for one quadrat is completed, proceed to the next location along the transect. Continue until the entire length of the transect has been counted .
6) Students will typically be excited about what they saw and will want time to share with others. Once the class regroups, give them time to
share their observations as well as any surprises they experienced, challenges they faced, or favorite things they saw.

these uses in a manner consistent with protecting biodiversity.
-MPAs protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic values.

Connections:
Art, science, engineering

Ocean Literacy Connection:
-The ocean supports a great diversity of life and ecosystems.
-The ocean and humans are inextricably interconnected.

Suggested extensions:
-For advanced classes, conduct additional data analysis looking at the difference in abundance among the different zones within the intertidal.
-Omit the field trip portion and substitute with quadrat photos in the classroom. Create a table with your findings and complete Parts 2 and 3 of this lesson plan.

PART 2: Data Analysis

(recommended one 50-minute class period)

Background information:

We will be using descriptive statistics to determine whether our data support our hypothesis. **Descriptive statistics** are mathematical means of describing a particular set of data (such as we just collected), as opposed to inferential statistics, which are used to reach conclusions that extend beyond the immediate data set.

There are three major characteristics that descriptive statistics aim to describe:

-Distribution, or frequency of individual values, often represented as a percentage
-Central tendency, or estimate of the “center” of a distribution of data (mean, median, and mode are all measures of central tendency)
-Dispersion, or spread of data around the central tendency, often represented as the range or standard deviation

For this lesson, we will be measuring the distribution of a certain species within our transects using a percentage, central tendency using mean (which will then be used to calculate density), and the dispersion using the range to compare our control and experimental sites. Additionally, we will use the mean to determine the density of a certain species within the sample.

Suggested procedure:

Compile data from all of the transects done at each site on the board. For example, if you did four transects at Windandsea Beach, the students will combine the data from all four of those transects when they do their analysis. Each transect is a replicate, or close copy, of the other transects.

Control (Windandsea Beach)	Green sea anemone	Purple sea urchin	Chiton	Shore crab	California mussel
Transect 1 Quadrat 1 (T1Q1)	# individuals found				
T1Q2					
T1Q3					
T1Q4					
T2Q1					
T2Q2					
T2Q3					
T2Q4					
T3Q1					
T3Q2					
T3Q3					
T3Q4					
T4Q1					
T4Q2					
T4Q3					
T4Q4					

-Instead of calculating abundance by hand, have students complete calculations in Excel.
-Mix and match the six lessons and various activities in Living on the Edge: Field Guide to the Intertidal to meet classroom needs.
-Allow students to conduct a separate inquiry project using the datasets they produce.

Assign each group one species (or more, depending on your time!) on which to conduct their analysis. Make sure that whatever species you choose is represented and analyzed for both the experimental site (South La Jolla SMR) and the control site (Windandsea Beach). For example, if you choose to have students from South La Jolla SMR run the calculations for green sea anemones, make sure one of the groups from Windandsea Beach also runs calculations for green sea anemones so we may compare findings in Part 3.

Have each group conduct the following analysis using data on only one species from one site (experimental OR control) at a time. So, when we are talking about combining quadrats, we mean we are combining quadrats from either the experimental site or the control site, not both.

Calculating Frequency

When calculating frequency, we want to know how often a certain species was found along our transects. This is fairly easy and involves the use of presence/absence data and some simple math.

1) Divide the number of quadrats at one site in which your species was present by the total number of quadrats. For example, if green sea anemones were found in 12 of the 16 quadrats you sampled at Windandsea Beach the frequency would be 12/16 = 0.75 = 75%. So the frequency of green sea anemones at Windandsea Beach would be 75%!

$$\textbf{Frequency (\%)} = \frac{\textbf{\# quadrats in which your species was present}}{\textbf{Total number of quadrats}} \times 100$$

Calculating Central Tendency

There are three ways to calculate central tendency: mean, median, and mode. For this activity, we will be using the mean to calculate the density. You may choose to have students calculate median and mode as well, then hold a discussion about which is most appropriate for this study.

To calculate the mean, we will use the total number of individuals found in each quadrat at a particular site and divide by the total number of quadrats. For the purposes of this study, we may combine the data from all quadrats sampled at one site regardless of which zone in the intertidal they came from, since we are looking at abundance for the entire sampled area. It is important to explain to the students that sometimes vertical transects are used to compare data between the zones within the intertidal (i.e. the abundance of green sea anemones in the spray zone versus the high tide zone) - in that case we would only combine quadrats from the same zones. Since we are not distinguishing between zones in this study, we do not need to worry about this.

1) To calculate the mean, make a list of how many individuals of a certain species were found in each quadrat.

Control (Windandsea Beach)	Green sea anemone
Transect 1 Quadrat 1 (T1Q1)	# individuals found
T1Q2	
T1Q3	
T1Q4	
T2Q1	
T2Q2	
T2Q3	
T2Q4	
T3Q1	
T3Q2	
T3Q3	
T3Q4	
T4Q1	
T4Q2	
T4Q3	
T4Q4	

Control (Windandsea Beach)	Green sea anemone
Transect 1 Quadrat 1 (T1Q1)	4
T1Q2	6
T1Q3	4
T1Q4	7
T2Q1	9
T2Q2	2
T2Q3	1
T2Q4	2
T3Q1	5
T3Q2	6
T3Q3	7
T3Q4	3
T4Q1	1
T4Q2	8
T4Q3	4
T4Q4	2

2) Add up the numbers: Example

4 + 6 + 4 + 7 + 9 + 2 + 1 + 2 + 5 + 6 + 7 + 3 + 1 + 8 + 4 + 2 = 71

3) Divide by the number of quadrats:

71/16 = 4.4

4) So, in this example, we found an average of 4.4 green sea anemones per quadrat!

$$\textbf{Mean} = \frac{\textbf{Total number of individuals of a species found in all quadrats}}{\textbf{Total number of quadrats}}$$

Calculating Density

Now that we have found the mean of our data, it is very easy to calculate the density. In fact, you pretty much already have! Density is a measure of the average number of individuals of a species per a certain unit area. Our quadrats measured 0.5m x 0.5m, or a quarter square meter, which is already a unit of area. However, it is simpler and more common to communicate our data in terms of square meters. So, let's do that calculation.

1) From our calculations above, we concluded that there was an average of 4.4 green sea anemones per quadrat. Since our quadrats represented 0.25m2, how do we calculate how many green sea anemones we found per square meter? Multiple our answer by 4!

4.4 x 4 = 17.6 green sea anemones per square meter!

Density (per m2) = Mean x 4

Calculating Dispersion

To calculate the dispersion of a species, we will use the range. The range is the difference between the highest and the lowest value in a dataset. So, for our data, it is the highest number of individuals of a species found within one quadrat minus the lowest number of individuals of a species.

For our example of green sea anemones, the highest amount of green sea anemones found in any one quadrat was 9. The lowest found in any one quadrat was 1. So our range is 9 – 1 = 8.

Range = Highest number of individuals found in one quadrat – lowest number of individuals found in one quadrat

PART 3: Drawing Conclusions

(recommended one 50 minute class period)

Class Discussion

1) Discuss what the frequency, mean, density, and range each tell us for each site. All of these are technically measures of abundance. What are the pros and cons of using each one for this particular example?
2) Most likely, if we were presenting this data to others, we would draw conclusions based on the density. It is the easiest to compare and probably the easiest for the public to understand. Compare the density for each species between the experimental and control sites. Did any species have a higher abundance inside the MPA? Did any have a lower abundance inside the MPA? [MR1] Did your data support or refute your hypothesis? What conclusions can you draw from this data?
3) Do you think your results are accurate? What are some sources of error? What would you do differently if you did this project again? What would you suggest for future studies?
4) What natural resources did you observe that may be important to humans? How might MPAs protect them? What would happen to the ecosystem if that resource no longer existed? What would happen to humans if that resource no longer existed?

Activity

Have each student write a short op-ed article reflecting what he or she did and learned in the lesson. Articles should be written for a general audience, i.e. the public, who likely does not know much about the intertidal zone, MPAs, or data collection.

A good article about writing tips for aspiring op-ed writers may be found here: https://www.nytimes.com/2017/08/25/opinion/tips-for-aspiring-op-ed-writers.html

Articles should include the following in 3-5 paragraphs:

1) At least one picture or drawing related to the activity
2) A catchy title
3) A hook or first sentence that draws the reader in
4) What is an MPA?
5) What is the intertidal zone?
6) What did you study?
7) How did you study it?
8) What were your results?

9) What were your conclusions?
10) Why is your data important? Why should your readers care?
11) What can your readers do to help save the coast and ocean?

Consider publishing any great articles in the school newspaper, on the school's social media, even in a local newspaper or magazine!

Engage: Play one of the games or complete one of the activities from Living on the Edge: Field Guide to the Intertidal. After reviewing background information, have students practice collecting data with the transects in the schoolyard or park.
Explore: Conduct vertical transect surveys at local tidepools.
Explain: Explain abundance and how we measure it.
Elaborate: Have students calculate abundance using frequency, mean, density, and range.
Evaluate: Ask the students questions relating to what they have learned (more questions may be found in Part 3 of this lesson plan).
Q1: What are the differences between the different measures of abundance?
Q2: Which site had higher abundance? Inside the MPA or out?
Q3: What natural resources are present in the intertidal zone?
Q4: How do MPAs protect those natural resources?

NGSS Alignment

LS2.A Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.
LS4.D Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

Science and Engineering Practices

Asking Questions: Ask questions that arise from examining models or a theory to clarify and/or seek additional information to determine relationships, including quantitative relationships between independent and dependent variables, and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the sustainability of a design.
Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution, apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data, and evaluate the impact of new data on a working explanation and/or model.
Using Mathematics and Computational Thinking: Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
Constructing Explanations and Designing Solutions: Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Engaging in Argument from Evidence: Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence and make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge.

Crosscutting Concepts

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

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Online Resources

La Jolla Tide Charts: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=9410230
NOAA LiMPETS Program: http://limpets.org/rocky-intertidal-monitoring/ri-methods/vertical-transect/
New York Times “Tips for Aspiring Op-Ed Writers”: https://www.nytimes.com/2017/08/25/opinion/tips-for-aspiring-op-ed-writers.html
South Coast Baseline Program Final Report: Rocky Intertidal Ecosystems: https://caseagrant.ucsd.edu/sites/default/files/SCMPA-22-Final-Report_wAppendices.pdf

Appendices

Datasheet on next page

Intertidal Transects Data Sheet

Site: Control or Experimental

Date:

Site Name:

Time:

Group Members:

Transect (T) Quadrat (Q)	Species:	Species:	Species:	Species:	Species:
T1Q1					