MARINE PROTECTED AREA (MPA) LESSON PLANS

GRADES 9-12

SAN DIEGO MPA COLLABORATIVE

WILDCOAST
COSTASALVAJE

Intertidal Bioblitz

Rocky Intertidal - Grades 9-12

Learning Objectives

A) Students will use the iNaturalist app to observe and record intertidal species at sites inside and outside of the South La Jolla State Marine Reserve [MR1] (Part 1.)
B) Students will use species richness and Simpson's Index to calculate the diversity present at the two study sites (Part 2.)
C) Students will compare diversity inside and outside of the MPA to draw conclusions about MPA impact on biodiversity (Part 3.)
[MR1]Why just at La Jolla? Can you make it more general to MPAs across the state so students in other areas can use the curriculum too?

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

Materials for the Students
-Cell phone with iNaturalist app (per 2-4 students)
-Computer with Excel (per 2-4 students)

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 ecological resources.

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 across California, including kelp forests, sandy shores, rocky reefs, 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 being completely submerged to only occasionally wet within just a few feet. 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.

iNaturalist Bioblitz

A "bioblitz" is a **community science** effort to record as many species within a designated location and time period as possible. Public participation is what separates bioblitzes from traditional biological inventories.

Bioblitzes are a way for us to measure biodiversity. The Greek root "bio" means life. That means that "**biodiversity**" is the diversity of life.
We live on a planet full of many different kinds of life - animals, plants, fungi, bacteria, and some things that are so weird that we hardly know what to call them. Scientists classify living things into different groups, with the smallest unit of classification being the species. Nobody really knows how many species exist on Earth because we haven't found them all - not even close! Some scientists think there could be a million species living just in the ocean.

Living organisms (**biotic factors**) interact with the non-living things (**abiotic factors**) around them - examples would be water, sunlight, wind, etc. We call a community of living organisms and their nonliving physical environment an ecosystem. Examples of ocean ecosystems here in California are kelp forests, sandy beaches, rocky shores (and tidepools), and the open ocean.

When scientists talk about biodiversity, they usually are referring to the diversity of both species and ecosystems.

For this activity, we will compare biodiversity between a **control site** (Windandsea Beach) and an **experimental site** (South La Jolla State Marine Reserve) to explore whether there is a difference in biodiversity inside versus outside of an MPA.

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.
-*Community (or citizen) Science*: The collection and/or analysis of scientific data by everyday people.
-*iNaturalist*: A community science project and online social network of naturalists, citizen scientists, and biologists built on the

Suggested procedure:

Teacher Prep

Create an Account on iNaturalist

Log on to www.inaturalist.org and click on "Sign Up" in the upper right-hand corner. Follow website prompts.

Create a Project

*Note: In order to do comparative data analysis between the experimental site (South La Jolla State Marine Reserve) and control site (Windandsea Beach) you will need to create two projects: one for each site.

For Experimental Site (South La Jolla State Marine Reserve)

1) Log in to your account. From your dashboard select "Projects" in the upper right-hand corner.
2) Select "Start a Project"
3) Select "Collection Projects"
4) Fill in Project Name and Summary using class information.
5) Upload whatever pictures you want the students to see under Project Icon and Project Banner.
6) Project Type = Collection
7) Places = South La Jolla State Marine Reserve
8) Date Observed = Range (enter date, start time and end time of your project)
9) Admin(s) = You are automatically an admin. You can add the usernames of any other teachers who need access.

For Control Site (Windandsea Beach)

Follow steps above, except give it a different name and for step 7 enter "Windandsea Beach"

Student Prep

1) In class, cover MPAs, the intertidal zone, bioblitzes, and biodiversity. Use the information and activities in Living on the Edge: Field Guide to the Intertidal Zone. Have students form a hypothesis in response to the following research question: Is there a difference in biodiversity inside an MPA compared to outside an MPA?
2) Break students into research groups of 2-4. Each group will need at least one cell phone.
3) Pass out the iNaturalist guide (available in Living on the Edge: Field Guide to the Intertidal).
4) Have students download the iNaturalist app onto their cell phones.
5) Have students create personal iNaturalist accounts (students must be at least 13 years old to complete this step.)

concept of mapping and sharing observations of biodiversity across the globe. iNaturalist may be accessed via its website or from its mobile applications.
-*Bioblitz*: A community science effort to record as many species within a designated location and time period as possible.
-*Biodiversity*: The variety of life on Earth.
-*Biotic Factor*: The living things in an ecosystem.
-*Abiotic Factor*: The non-living things in an ecosystem.
-*Experimental site*: The site receiving the experimental treatment (in our case the protection afforded by MPAs)
-*Control site*: The site not receiving experimental treatment

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.

i. Open the iNaturalist app.
ii. Click on Log in with Facebook or Google (preferred) or "Sign up now!" if student does not have a Facebook or Google account.
iii. Make sure to click "Yes, license my content so scientists can use my data."
iv. Follow prompts to sign up and log in.

6) Go over how to make useful observations:
i. Take identifiable photos: fill the frame with your subject and make sure the picture is in focus
ii. Take multiple photos
iii. Focus on wild organisms

7) Have students join your project by clicking More > Projects and searching for your project name.

Tip: Have students practice taking good photos using iNaturalist's Seek app. This is a separate app students may download that will allow them to take photos and identify organisms without actually submitting photos to iNaturalist. watershed models call them all

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

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

2) Before you go, distribute copies of the bioblitz pages from Living on the Edge: Field Guide to the Intertidal to each student. These pages include a two-sided guide and worksheet with the research question, project name, and a map of where to meet in case they drive separately.

3) 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.

4) 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.

-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 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.

5) 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.
6) 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 tidepool on the rocks just to the north. This group is the Windandsea Beach control group.
7) 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.
8) Make sure to assign at least one chaperone with each group to ensure best practices are met. Once at the site, give students boundaries and remind them to stay
9) Once at the site, give students boundaries and remind them to stay together. Let student groups explore and make and record as many observations as possible within the iNaturalist app during the designated time period. Observations will be automatically added to the appropriate project.
10) 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.

Suggested extensions:
-Omit the field trip portion and substitute with a mock bioblitz in the classroom. Team up with another teacher and designate one classroom as the MPA and one classroom as the control. Hide organism cards throughout the classrooms and allow students to search and record what they find. Create an Excel file with your findings or use included datasets and complete Parts 2 and 3 of this lesson plan.
-Omit field trip and do a bioblitz in the schoolyard. Use included datasets to complete Parts 2 and 3.
-For students with higher math levels: have them calculate biodiversity using the Shannon Index.
-Instead of calculating biodiversity in Excel students may do the math by hand.
- Mix and match the six lessons and various activities in Living on the Edge: Field Guide to the Intertidal to meet classroom needs.

PART 2: Data Analysis

(recommended two 50 minute class periods: one to cover background and species richness, one to cover Simpson's index)

Background information:

Measuring Biodiversity

A **biodiversity index** is a way of measuring biodiversity. Scientists use different biodiversity indices to measure diversity, and no single one will always be appropriate for the question being posed. In fact, for some conservation questions, more than one measure may have to be used.

There are two basic indices commonly used to measure biodiversity:

Species Richness

-The total number of species in an area

Species Evenness

-How evenly the species are represented in the area.

Species richness is the most commonly used type of biodiversity index because it is easy to calculate (the number of species reported in iNaturalist is the species richness for the site!), most people tend to understand what a species is, and it can be used to directly compare two sites (whichever site has the highest number is more diverse).

Many diversity indices have been developed that combine different measures of biodiversity. One is called the **Simpson's Index**. The **Simpson's Index** includes both species richness and species evenness in a single number.

$$D = \frac{\sum n(n - 1)}{N(N-1)}$$

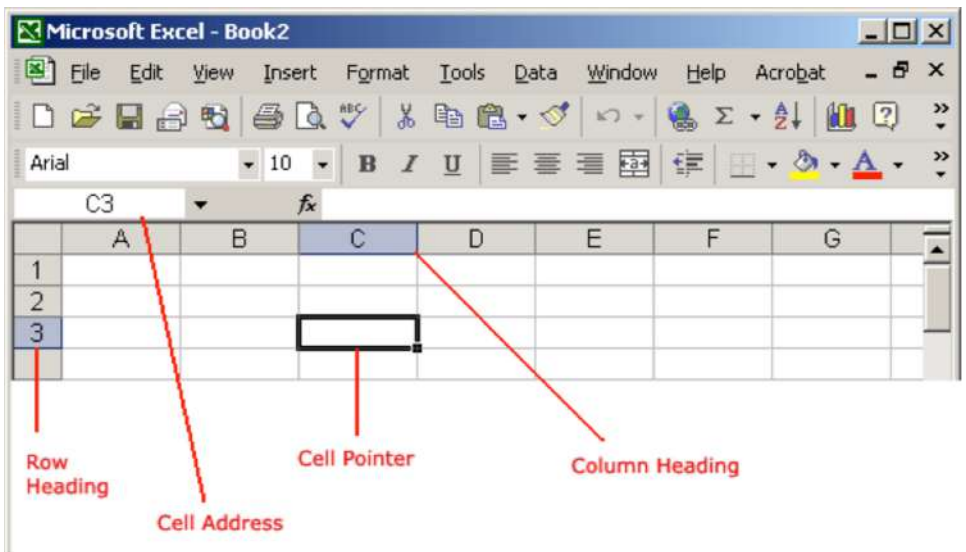
D = Simpson's Index
n = the total number of individuals of a particular species
N = the total number of individuals of all species

D values range between 0-1 with 0 the most diverse and 1 the least diverse.

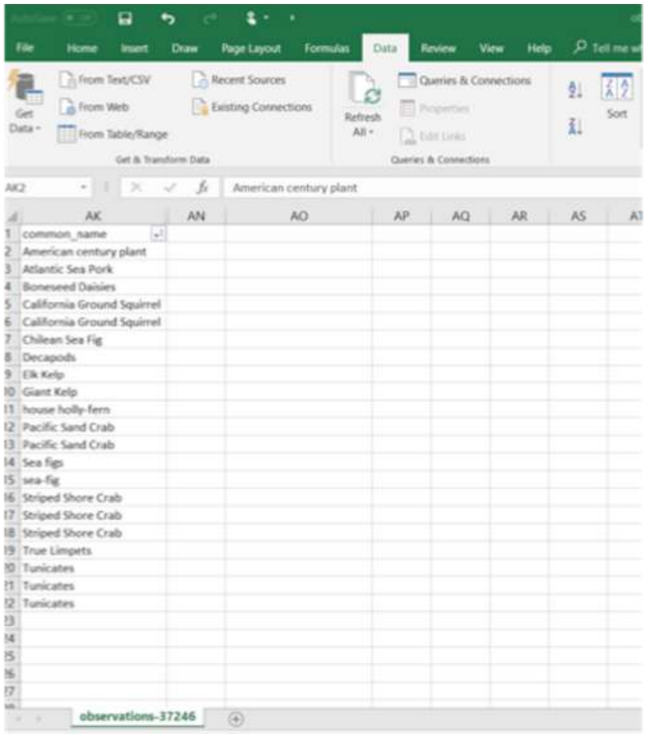
Teacher Prep
On the iNaturalist website, return to your project page. It will show pictures of some of the observations made, as well as stats for most observations, most species, etc. Click on Observations (either at the top, or "View All" next to recent observations.
Once on the observation page click on "Export observations" in the upper right-hand corner. You should not need to change anything in the query. Scroll to the bottom and select "Create Export." This process will take a minute or two and then a green dialogue box should appear at the top of the page with a download button. Click "Download" to download a copy of your class' data in Excel. You will need to repeat this process for each of your two projects.

-Allow students to conduct a separate inquiry project using the datasets they produce.

Suggested procedure:

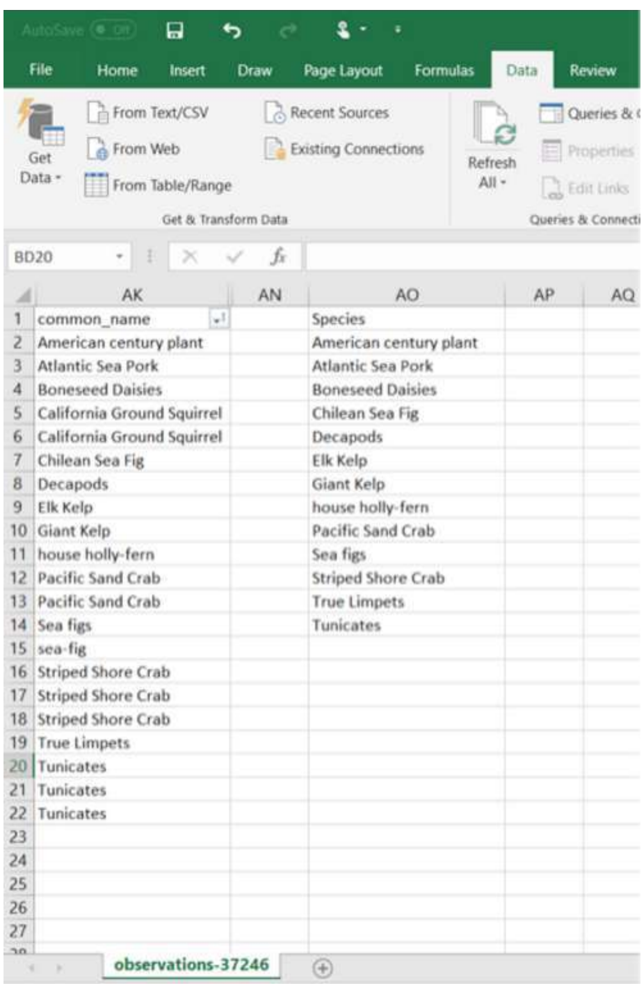


Set up Excel Worksheet
1) Each student research group will need a computer and a copy of the Excel file from their study site.
2) Open the Excel file.
3) Hide columns A-AI by clicking and dragging between column headings. Once desired columns are selected release the mouse, right click within the selected area, and click "Hide."
4) Repeat step 3 to hide columns AL-AM. The remaining columns should be AJ/Scientific Name and AK/Common Name.
5) Decide whether you want your class to use scientific name or common name. They may hide the other column.
6) Select Data>Sort>Sort by and then either common_name or scientific_name depending on which you are using. This will put the species in alphabetical order for easier counting.



Calculate Species Richness

1) Off to side of the species list, have students create a list of species (label this "Species")
2) To calculate the species richness, simply count the number of species (not individuals) found. In this example, species richness is 13.
3) Write this number on the board for each site.



Calculate Simpson's Index

1) First we will calculate the top part of the equation: $\sum n(n-1)$. Next to your species list create the following columns:

- n
- n-1
- n(n-1)

2) To calculate n (the number of individuals of that particular species) have students count and manually fill in the data.

3) To calculate n-1, click on the first empty cell under n-1. Type in the following equation =(number1-1) and push Enter. In this case number1 is the n value of the first species, AP2 in our example. You may type in the cell number or click on the cell. So the keystrokes for this example would be =(click on AP2 cell-1) push Enter

AQ2 | =(AP2-1)

	AO	AP	AQ	AR
1	Species	n	n-1	n(n-1)
2	American century plant	1	=(AP2-1)	
3	Atlantic Sea Pork	1		
4	Boneseed Daisies	2		
5	Chilean Sea Fig	1		
6	Decapods	1		
7	Elk Kelp	1		
8	Giant Kelp	1		
9	house holly-fern	1		
10	Pacific Sand Crab	2		
11	Sea figs	2		
12	Striped Shore Crab	3		
13	True Limpets	1		
14	Tunicates	3		
15				
16				

4) To copy the formula to the rest of the cells click on the cell you just calculated, click on the little green box in the bottom right hand corner of the cell, drag to the last row with species data, and release.

AQ2 | =(AP2-1)

	AO	AP	AQ	AR
1	Species	n	n-1	n(n-1)
2	American century plant	1	0	
3	Atlantic Sea Pork	1	0	
4	Boneseed Daisies	2	1	
5	Chilean Sea Fig	1	0	
6	Decapods	1	0	
7	Elk Kelp	1	0	
8	Giant Kelp	1	0	
9	house holly-fern	1	0	
10	Pacific Sand Crab	2	1	
11	Sea figs	2	1	
12	Striped Shore Crab	3	2	
13	True Limpets	1	0	
14	Tunicates	3	2	
15				
16				
17				

5) To calculate n(n-1) click on the first empty cell under n(n-1). Type in the following equation =number1*number2 and push Enter. In this case number1 is the n value and number2 is the n-1 value.

AQ2 | =AP2*AQ2

	AO	AP	AQ	AR
1	Species	n	n-1	n(n-1)
2	American century plant	1	0	=AP2*AQ2
3	Atlantic Sea Pork	1	0	
4	Boneseed Daisies	2	1	
5	Chilean Sea Fig	1	0	
6	Decapods	1	0	
7	Elk Kelp	1	0	
8	Giant Kelp	1	0	
9	house holly-fern	1	0	
10	Pacific Sand Crab	2	1	
11	Sea figs	2	1	
12	Striped Shore Crab	3	2	
13	True Limpets	1	0	
14	Tunicates	3	2	
15				
16				
17				

6) To copy the formula to the rest of the cells click on the cell you just calculated, click on the little green box in the bottom right hand corner of the cell, drag to the last row with species data, and release.

7) To calculate ∑ (the sum), click on the cell below the last value in n(n-1) and type in the following formula: =sum(number1:number2) and push Enter. Here number1 refers to the first value in the n(n-1) column and number 2 refers to the last value in the n(n-1) column.

AR15 | =sum(AR2:AR14)

	AO	AP	AQ	AR	AS
1	Species	n	n-1	n(n-1)	
2	American century plant	1	0	0	
3	Atlantic Sea Pork	1	0	0	
4	Boneseed Daisies	2	1	2	
5	Chilean Sea Fig	1	0	0	
6	Decapods	1	0	0	
7	Elk Kelp	1	0	0	
8	Giant Kelp	1	0	0	
9	house holly-fern	1	0	0	
10	Pacific Sand Crab	2	1	2	
11	Sea figs	2	1	2	
12	Striped Shore Crab	3	2	6	
13	True Limpets	1	0	0	
14	Tunicates	3	2	6	
15				=sum(AR2:AR14)	
16					
17					

8) Record ∑ n(n - 1) on the board for each site.

9) Now we will calculate the bottom portion of the equation: N(N-1), where N is the total organis of all species.

10) Next to the calculations you just did for ∑ n(n - 1) create the following column labels: Site, N, N(N-1), ∑ n(n - 1), D.

BI11 | fx

	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Species	n	n-1	n(n-1)		Site	N	N(N-1)	∑ n(n - 1)	D
2	American century plant	1	0	0		South La Jolla SMR				
3	Atlantic Sea Pork	1	0	0		Windandsea Beach				
4	Boneseed Daisies	2	1	2						
5	Chilean Sea Fig	1	0	0						
6	Decapods	1	0	0						
7	Elk Kelp	1	0	0						
8	Giant Kelp	1	0	0						
9	house holly-fern	1	0	0						
10	Pacific Sand Crab	2	1	2						
11	Sea figs	2	1	2						
12	Striped Shore Crab	3	2	6						
13	True Limpets	1	0	0						
14	Tunicates	3	2	6						
15				18						
16										

11) Under sites type in the name of your experimental site (South La Jolla SMR) and the control site (Windandsea Beach).

12) To calculate N, you will need to find the sum of all values in the n column. To do this, select the cell below the last value in the n column and type in the following equation: sum(number1:number2) and press enter. In this case number1 is the first n value and number2 is the last n value in the column

AP15 | fx | =sum(AP2:AP14)

	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Species	n	n-1	n(n-1)		Site	N	N(N-1)	∑ n(n - 1)	D
2	American century plant	1	0	0		South La Jolla SMR				
3	Atlantic Sea Pork	1	0	0		Windandsea Beach				
4	Boneseed Daisies	2	1	2						
5	Chilean Sea Fig	1	0	0						
6	Decapods	1	0	0						
7	Elk Kelp	1	0	0						
8	Giant Kelp	1	0	0						
9	house holly-fern	1	0	0						
10	Pacific Sand Crab	2	1	2						
11	Sea figs	2	1	2						
12	Striped Shore Crab	3	2	6						
13	True Limpets	1	0	0						
14	Tunicates	3	2	6						
15		=sum(AP2:AP14)		18						
16										

13) Enter this number into the appropriate cell under N.

AU3 | fx | 20

	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Species	n	n-1	n(n-1)		Site	N	N(N-1)	∑ n(n - 1)	D
2	American century plant	1	0	0		South La Jolla SMR				
3	Atlantic Sea Pork	1	0	0		Windandsea Beach	20			
4	Boneseed Daisies	2	1	2						
5	Chilean Sea Fig	1	0	0						
6	Decapods	1	0	0						
7	Elk Kelp	1	0	0						
8	Giant Kelp	1	0	0						
9	house holly-fern	1	0	0						
10	Pacific Sand Crab	2	1	2						
11	Sea figs	2	1	2						
12	Striped Shore Crab	3	2	6						
13	True Limpets	1	0	0						
14	Tunicates	3	2	6						
15		20		18						
16										
17										

14) To calculate N(N-1) select the appropriate cell in the N(N-1) column and type in the following equation: =number1*(number1-1) and push Enter. Here number1 refers to the N value you calculated in step 13.

AV3 | =AU3*(AU3-1)

	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Species	n	n-1	n(n-1)		Site	N	N(N-1)	∑ n(n - 1)	D
2	American century plant	1	0	0		South La Jolla SMR				
3	Atlantic Sea Pork	1	0	0		Windandsea Beach	20	=AU3*(AU3-1)		
4	Boneseed Daisies	2	1	2						
5	Chilean Sea Fig	1	0	0						
6	Decapods	1	0	0						
7	Elk Kelp	1	0	0						
8	Giant Kelp	1	0	0						
9	house holly-fern	1	0	0						
10	Pacific Sand Crab	2	1	2						
11	Sea figs	2	1	2						
12	Striped Shore Crab	3	2	6						
13	True Limpets	1	0	0						
14	Tunicates	3	2	6						
15		20		18						
16										
17										

15) Transfer the value of ∑ n(n - 1) from step 7 (should also be written on the board) to the appropriate cell under column ∑ n(n - 1).

BH10

	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1	Species	n	n-1	n(n-1)		Site	N	N(N-1)	∑ n(n - 1)	D
2	American century plant	1	0	0		South La Jolla SMR				
3	Atlantic Sea Pork	1	0	0		Windandsea Beach	20	380	18	
4	Boneseed Daisies	2	1	2						
5	Chilean Sea Fig	1	0	0						
6	Decapods	1	0	0						
7	Elk Kelp	1	0	0						
8	Giant Kelp	1	0	0						
9	house holly-fern	1	0	0						
10	Pacific Sand Crab	2	1	2						
11	Sea figs	2	1	2						
12	Striped Shore Crab	3	2	6						
13	True Limpets	1	0	0						
14	Tunicates	3	2	6						
15		20		18						
16										
17										

16) To calculate the D value, select the appropriate cell under the D column and enter the following equation: =number1/number2 and press enter. Here number1 refers to the ∑ n(n - 1) value and number2 refers to the N(N-1) value.

AV3 | =AW3/AV3

	AT	AU	AV	AW	AX
1	Site	N	N(N-1)	∑ n(n - 1)	D
2	South La Jolla SMR				
3	Windandsea Beach	20	380	18	=AW3/AV3
4					

PART 3: Drawing Conclusions

(recommended one 50-minute class period)

Class Discussion

1) Compare the species richness for both sites. Which site seems more diverse?
2) Now compare the Simpson's Index (D value) for each site. Keep in mind the D value for the Simpson's Index should be between 0-1 and is inverse, so 0 is the most diverse and 1 is the least diverse. According to the Simpson's Index which site was more diverse?
3) How do the two measures of biodiversity compare (species richness and Simpson's Index)? Did you get the same or different conclusions from both? Which measure of biodiversity do you think is the most accurate? Which measure of biodiversity would you recommend if speaking to the public? (Optional extension: How does the Shannon Index compare to these two indices?)
4) 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?
5) 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

Assign each student research group a stakeholder group (i.e. local residents, surfers, recreational anglers, commercial anglers, members of a Native American Nation, decision/policy makers, enforcement officials, academics, etc.) and have them create an "elevator pitch" for MPAs to give to a representative of that stakeholder group based on their findings.

A good article about creating elevator pitches can be found here: https://slidebean.com/blog/startups/elevator-pitch-examples

Remind the students that the "product" they are pitching is MPAs.

Present elevator pitches to the class.

Engage: Play one of the games or complete one of the activities from Living on the Edge: Field Guide to the Intertidal. After going over background information have students practice data collection using iNaturalist's Seek app.
Explore: Perform a bioblitz using the iNaturalist app.
Explain: Explain biodiversity and how we measure it.
Elaborate: Have students calculate biodiversity using species richness and Simpson's Index.
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 various indices of biodiversity?
Q2: Which site had higher biodiversity? Inside the MPA or out? Does this result corroborate or refute the hypothesis? Explain.
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.

Online Resources

iNaturalist: www.inaturalist.org
La Jolla Tide Charts: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=9410230

Measuring Biodiversity from the Government of Canada: https://nature.ca/en/teacher-zone/teacher-resources/lessons/student-worksheet-measuring-biodiversity
How to Construct a Good Elevator Pitch: https://slidebean.com/blog/startups/elevator-pitch-examples
South Coast Baseline Program Final Report: Rocky Intertidal Ecosystems: https://caseagrant.ucsd.edu/sites/default/files/SCMPA-22-Final-Report_wAppendices.pdf

Appendices

See next page


Red Algae


Sea Lettuce


Wavy Turban Snail


Black Turban Snail


Keyhole Limpet


Limpet

Two Spot Octopus

California Spiny Lobster

Purple Sea Star

Purple Sea Urchin

California Mussel

Giant Sea Cucumber

Shore Crab

Hermit Crab

Barnacle

Chiton

Giant Green Anemone

California Sea Hare

Bioblitz Datasheet

Experimental Site

Species recorded:

Sea Lettuce

Red Algae

Hermit Crab

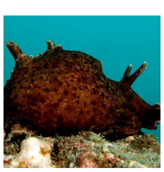
Barnacles

Purple Sea Urchin

Giant Green Anemone

Wavy Turbin Snail

Shore Crab



California Sea Hare

Two Spot Octopus

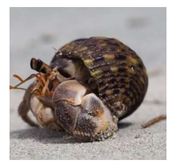
Bioblitz Datasheet

Control Site

Species recorded:

Barnacles

Shore Crab



Hermit Crab

Giant Green Anemone

MPA Watch

Sandy Shore - Grades 9-12

Learning Objectives

A) Students will collect data on human use of coastal marine resources through the MPA Watch community science program and data on terns and plovers for San Diego Zoo Global (Part 1).
B) Students will use Excel to create pie charts illustrating the numerical proportion of activities observed as well as calculating average people observed in terms of survey effort (Part 2).
C) Students will use their results to create a scientific display and complete an oral presentation with study and management recommendations (Part 3).

NGSS: DCI (Disciplinary Core Ideas):
HS-LS2-2
HS-LS2-7
HS-ESS3-1

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

Materials for the Teacher
-Life in the Sand: Field Guide to Sandy Shores

Materials for the Students
-MPA Watch data sheet
-MPA Watch data sets provided in teacher toolkit or by e-mailing
-MPA outreach materials (included in teacher toolkit or can be downloaded here: http://californiampas.org/south-coast-brochures)
~Southern California MPA Guide
~Marine Recreational Brochure San Diego

Part 1: Data Collection

Background information:
(recommended one to six 50-minute class periods)
See Life in the Sand: Field Guide to Sandy Shores 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 topics covered in the field guide

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!

Sandy Shore

Sandy shores are areas where deposits of sand or other sediments cover the shoreline. To beachgoers, sandy shores often appear to be devoid of life, made up only of sand, shells, and the occasional piece of driftwood. But in reality, this dynamic habitat is home to a diversity of species, each specially adapted for life above or below the sand. These organisms must contend with pounding waves, changing tides, and constantly shifting sand particles - not to mention people who love to visit and develop beaches!

Community Science

Community science (also known as citizen science) involves members of the general public (that's you and me!) collecting data that can then be used in scientific research. Anyone can participate in community science.It's a great way for people to help out professional scientists!

There are many different types of community science. Some involve using an app on your phone to take pictures or measurements that are then sent to professional scientists. Today, we are going to do a type of community science that involves taking notes about what you see.

MPA Watch

We already talked about why we create MPAs and how they can help protect ocean animals. Now that California has created these underwater parks, it's important for us to see how people are using them. Are people visiting MPAs? If they are, what kind of activities are they doing there? The answers to these questions will help us to figure out if the MPAs are working and help in the creation of future MPAs. We are all going to be community scientists and help collect some information about what people are doing in this MPA for a statewide program called MPA Watch.

MPA Watch uses a method of scientific sampling referred to as a transect. A transect is a fixed path (with a start and end point) along which an observer counts and records scientific data. In the case of MPA Watch, observers record all the people they pass while walking along the transect. This allows us to create **replicable, unbiased data**.

The observed activity that each person is performing is recorded using an **ethogram**, a list of possible behaviors that may be observed. For example, MPA Watch worked with scientists to create an ethogram of the human behaviors that may be observed at the beach including beach recreation, wildlife watching, fishing, surfing, or snorkeling.

Suggested procedure:

Pre-Trip Discussion

Have the class discuss the following:

1) What would happen to a natural area (i.e. a forest or a beach) if humans were allowed to do whatever they wanted?
2) Are the things that we use from the ocean unlimited? Can we run out?
3) Have students brainstorm examples of activities that could deplete coastal

~Fishing Guide San Diego
~MPA Watch South Coast Snapshot Report
-Computers: one per every two to four students
-Access to the internet
-Graphic design software (Canva is a great free online program – canva.com)
-Poster board, butcher paper, or project board
-Glue
-Tape
-Scissors
-Colored paper
-Any other presentation supplies available

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.

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and/or marine resources (i.e. fishing, collecting, etc.)
4) Have students brainstorm examples of activities that would not deplete coastal and/or marine resources (i.e. swimming, snorkeling, surfing, recreational SCUBA diving, playing at the beach, etc).
5) Would you rather swim/snorkel/kayak/etc. somewhere with lots of species or few species?
6) Key Question: How are humans using coastal and marine resources in marine protected areas?

-*Community (or citizen) Science*: The collection and/or analysis of scientific data by everyday people.
-*MPA Watch*: A community science project that collects data on how humans are using the coast and ocean.
-*Replicable data*: Data that is collected following strict methods so that studies may be repeated independently and achieve the same result.
-*Unbiased data*: Data that represents the true condition of the population without being subject to human error.
-*Ethogram*: A list of the possible kinds of behavior or activity that may be observed in an animal.
-*Experimental site*: The site receiving experimental treatment (in our case the protection afforded by MPAs).
Control site: The site not receiving experimental treatment.
Consumptive: An activity that involves the removal or use of a resource.

Field Trip *(recommended 1.5-2 hours in the field)*
MPA Watch
1) **Meet at the cul-de-sac at the southernmost end of Seacoast Drive in Imperial Beach. Approximate address:**
1698 Seacoast Drive,
Imperial Beach, CA 91932
2) Break students into research groups of approximately four people. Assign half the research groups to the **control site** (OUT 2) and half the research groups to the **experimental site** (TRM 1). Make sure a chaperone accompanies each group.
3) Both groups will begin their surveys on the beach directly adjacent to the parking lot. Walk onto the beach and look for the rock wall at the end of the houses. This demarcates the boundary between the control survey (OUT 2) and the experimental survey (TRM 1). *Note: while both groups start in the same place, they will be collecting data in different orders along different transects.

a. **Instructions for Control Site Groups**:
Control survey begins on the beach at the rock wall along the houses at the end of Seacoast Drive and runs north until the Imperial Beach Pier (approximately 1.8 miles round trip). From south to north collect San Diego Zoo bird data. On return trip from north to south collect MPA Watch human use data for site OUT 2. Note, during medium to high tide the southern end of the beach (where you begin and end) may be inaccessible. Groups may walk north along Seacoast Drive and use the next access point instead.

b. **Instructions for Experimental Site Groups**:
Experimental survey begins on the beach at the rock wall along the houses at the end of Seacoast Drive and runs south until the Tijuana River Mouth (the river mouth is obvious; approximately 2.0 miles round trip). From north to south collect MPA Watch human use data for TRM 1. On return trip from south to north collect San Diego Zoo bird data. Note: This survey is within the Tijuana River Mouth State Marine Conservation Area.

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MPA Watch Data Collection Instructions for All Groups

1) Each research group should get a clipboard, pencil, and MPA Watch data collection sheet (see appendix).

2) Within each group designate the following roles (or similar based on your beach conditions):

Researcher #1: Surfers/Boogie Boarders

Researcher #2: Beach Recreation

Researcher #3: All Other Activity

Researcher #4: Note Taker

3) Fill out the metadata section of the datasheet (Names, Date, Transect ID (see transect information), Start Time, Clouds, Precipitation, Air Temperature, Wind, Tide Level, Visibility, Beach Status, Sea State.

4) From the start point, walk south toward the end point.

5) As you walk Researchers #1-3 will count how many people they see doing their assigned activity and tell Researcher #4.

6) Researcher #4 will record the data on the datasheet in the appropriate row.

*Note: tally marks or numbers may be used as long as the method is consistent.

7) Collect data on what a person is doing only as you pass them or they pass you. Do not look ahead or behind.

8) Count each person only once, even if they pass you multiple times.

9)Data is collected for anyone on the sand and in the water, not in parking lots or on cliffs.

10) Each kayak/boat counts as one, even if there is more than one person in it.

11) Domestic animals (i.e. dogs) are counted separately from their human. So if you see a person walking their dog on-leash, the dog would count as one tally for "Domestic Animal On-Leash" and the human would count as "Beach Recreation."

12) "Hand Collection of Biota" means the collection of anything that is alive.

13) The back of the page may be used if additional space is needed, just make sure to label the activities.

14) Stop at the stop point, fill in the end time at the top of the datasheet, and total all activities.

San Diego Zoo Bird Data Collection

1) As you walk south to north along your assigned transect fill out the SDZG Terns and Plovers Datasheet. Record how many of each species are seen, their activity, if any birds seemed in distress, and nearby human activity.

PART 2: Data Analysis

(recommended two 50-minute class periods)

Entering Data

MPA Watch

1) Make a master data sheet by averaging the number of observations made for each category across groups.
2) E-mail the master data sheet to angela@wildcoast.org

San Diego Zoo Birds

1) Follow the same steps as for MPA Watch.

-*Non-Consumptive*: An activity that does not involve the removal or use of a resource.

-*Effort*: A way to calculate data that eliminates discrepancies based on the effort put into collecting the data (in our case the differing length of the transects). Expressed in terms of "per unit of effort;" i.e. people per mile.

California Department of Fish and Wildlife Key Messages:

-To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.

-To ensure that California's MPAs have clearly defined objectives, effective management measures, adequate enforcement, and are based on sound scientific guidelines.

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:
-Instead of a field trip, create an ethogram of the possible behaviors that may be observed in your schoolyard or down a popular walkway. Complete a transect using the same data collection methods as MPA Watch (outlined in Part 1) recording data on your ethogram instead of the MPA Watch datasheet. Use the included MPA Watch datasets to complete Parts 2 and 3.
-Mix and match the six lessons and various activities in Life in the Sand: Field Guide to Sandy Shores to meet classroom needs.

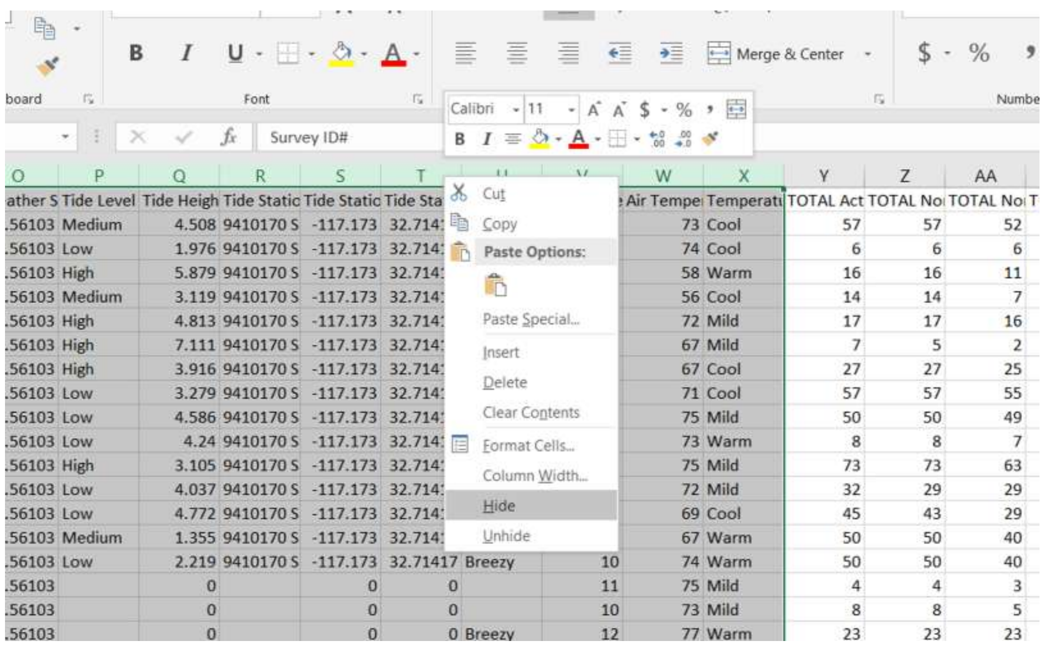
Downloading Data for Analysis

MPA Watch

1) A copy of the MPA Watch data for San Diego County is included with the digital version of this toolkit. To receive more current data please email angela@wildcoast.org. *Note: If you submitted a master data sheet from your groups' field trip you will automatically receive an email with the most current data.

Analyzing the Data

1) Provide a computer to each research group.
2) Give each group a copy of the data file for their site (either OUT 2 for the control site or TRM 1 for the experimental site).
3) Have students open the data file in Excel.
Have students identify the following groups of
4) Have students identify the following groups of columns in the data file: Metadata (columns A-X), activity counts (columns Y-DG), general activities (columns DH-DL), and violation reports (columns DM-DW).
5) For this activity we will only be looking at the activity count data. Have students select columns A-X. Right click and select "Hide." Do the same for columns DH-DW. *Note: If you left click on a column heading you can then hold and drag across multiple column headings to select multiple columns at once.



HINT: To "freeze" the top row (keep it visible while the other rows scroll) click on View > Freeze Panes > Freeze Top Row

6) Have students work in their groups to explore the activity data. Have them identify what each column represents. Clarify any activities if necessary. Point out that columns Y-AG are totals of various other columns rather than activity counts themselves.
7) In their groups have students brainstorm different ways to categorize the data.

-Allow students to conduct a separate inquiry project using the datasets.
-If you have enough time visit the Tijuana Estuary Visitor Center located a few blocks away at 301 Caspian Way, Imperial Beach, CA 91932. Entrance is free. The visitor center is closed Monday and Tuesday. There are also hiking trails near the visitor center that explore the endangered wetland.

8) For this analysis we will divide the data between **consumptive activities** (those that use resources) and **non-consumptive activities** (those that do not use resources) as well as land-based activities and water-based activities. Therefore, the four types of data categories are: land-based consumptive, water-based consumptive, land-based non-consumptive and water-based non-consumptive. Have students assign each category a color and highlight each column according to the category in which it belongs.

Consumptive vs. Non-Consumptive

1) The first analysis we will conduct is the proportion of consumptive activities to non-consumptive activities. This will be represented with a pie chart. We will use the data from column Z "TOTAL Nonconsumptive Activities" and column AD "TOTAL Consumptive Activities."

2) To do this we must find the totals for each column. To do this for non-consumptive activities have students select a cell in column Z below the data then enter the formula =SUM(Z2:Z#). Replace the # sign with the number of the last row in that column. Push Enter. Repeat for column AD =SUM(AD2:AD#)

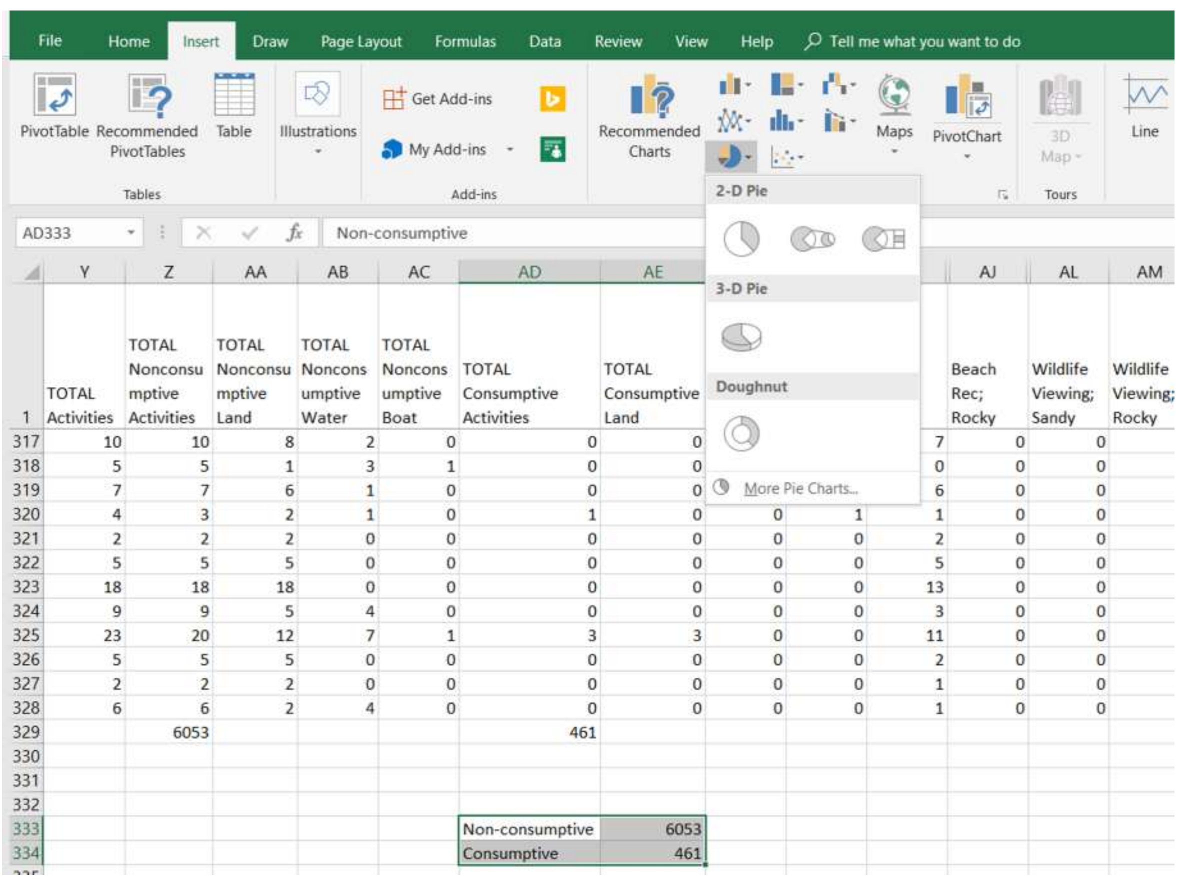
SUM | =SUM(Z2:Z328)

	Y	Z	AA	AB	AC	AD	AE	AF	AG	
1	TOTAL Activities	TOTAL Nonconsumptive Activities	TOTAL Nonconsumptive Land	TOTAL Nonconsumptive Water	TOTAL Nonconsumptive Boat	TOTAL Consumptive Activities	TOTAL Consumptive Land	TOTAL Consumptive Water	TOTAL Consumptive Boat	Bea Rec, San
317	10	10	8	2	0	0	0	0	0	
318	5	5	1	3	1	0	0	0	0	
319	7	7	6	1	0	0	0	0	0	
320	4	3	2	1	0	1	0	0	1	
321	2	2	2	0	0	0	0	0	0	
322	5	5	5	0	0	0	0	0	0	
323	18	18	18	0	0	0	0	0	0	
324	9	9	5	4	0	0	0	0	0	
325	23	20	12	7	1	3	3	0	0	
326	5	5	5	0	0	0	0	0	0	
327	2	2	2	0	0	0	0	0	0	
328	6	6	2	4	0	0	0	0	0	
329		=SUM(Z2:Z328)								
330										

3) To make the pie chart of this data, make a small table below your data with the data labels (Consumptive and Non-consumptive) and the totals you just calculated in step 2.

1	TOTAL Activities	TOTAL Nonconsumptive Activities	TOTAL Nonconsumptive Land	TOTAL Nonconsumptive Water	TOTAL Nonconsumptive Boat	TOTAL Consumptive Activities	TOTAL Consumptive Land	TOTAL Consumptive Water	TOTAL Consumptive Boat	Beach Rec; Sandy	Beach Rec; Rocky
317	10	10	8	2	0	0	0	0	0	7	
318	5	5	1	3	1	0	0	0	0	0	
319	7	7	6	1	0	0	0	0	0	6	
320	4	3	2	1	0	1	0	0	1	1	
321	2	2	2	0	0	0	0	0	0	2	
322	5	5	5	0	0	0	0	0	0	5	
323	18	18	18	0	0	0	0	0	0	13	
324	9	9	5	4	0	0	0	0	0	3	
325	23	20	12	7	1	3	3	0	0	11	
326	5	5	5	0	0	0	0	0	0	2	
327	2	2	2	0	0	0	0	0	0	1	
328	6	6	2	4	0	0	0	0	0	1	
329		6053				461					
330											
331											
332											
333						Non-consumptive	6053				
334						Consumptive	461				
335											
336											

4) Select Insert from the top menu, click on the pie chart icon, then select the type of pie chart you would like to make. Change the title of the pie chart to "Consumptive vs Non-Consumptive Resource Use in San Diego County MPAs" and the data labels to Consumptive and Non-consumptive appropriately.



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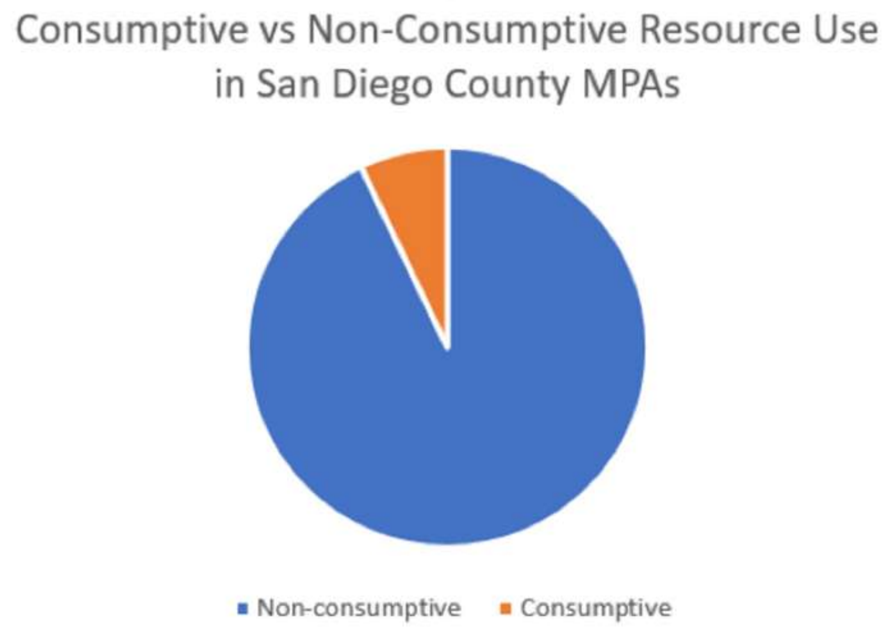


5) Compare results between the control site (not in the MPA) and the experimental site (in the MPA). Are there any differences?

Most Common Activities

In addition to determining if most of the activity is consumptive or non-consumptive, we also want to know which activities are most common at each site so that we may better focus our outreach efforts. In this activity we will create a snapshot of the types of activities people are doing at our survey sites.

1) Tell students to find the totals for each of the activity columns (AH-DG) using the method described in step 2 above. Hint: students do not have to enter the formula for each activity. Rather, enter the formula for the first activity, AH Beach Rec; Sandy, and then click and drag the little green box in the bottom right hand corner of the cell across the other columns you wish to calculate. Excel will automatically copy the formula to each of those cells and change the formula to calculate each specific column.

2) Have students look at the totals for each of the columns. Identify the five most common activities and create a table with the name of the activity and the number of people observed doing that activity.

3) Use the table to create a pie chart for the five most common activities observed following the instructions from steps 3 and 4 above.

4) Compare results between the control site (not in the MPA) and the experimental site (in the MPA). Are there any differences?

Calculating Effort

The above calculations are a simple way to provide a snapshot of activity along our coast. They are easy to calculate and read. This type of analysis (pie charts!) is what is preferred by our data partners at the California Department of Fish and Wildlife.

This type of data analysis is limited in that it does not offer an idea of how many people were observed participating in a certain activity, just whether it was seen more frequently than other activities. However, we cannot simply compare the number of people from the control site to the number of people from the experimental site, since their distances are not equal. Think about this: is seeing 500 people on a beach a mile long the same thing as seeing 500 people on a beach that is a quarter mile long?

For this next analysis we will re-calculate what we did above to incorporate effort. Fortunately, effort is actually relatively easy to calculate.

The formula for effort is:

$$\frac{\text{Average \# People Observed Per Survey}}{\text{Survey Distance}}$$

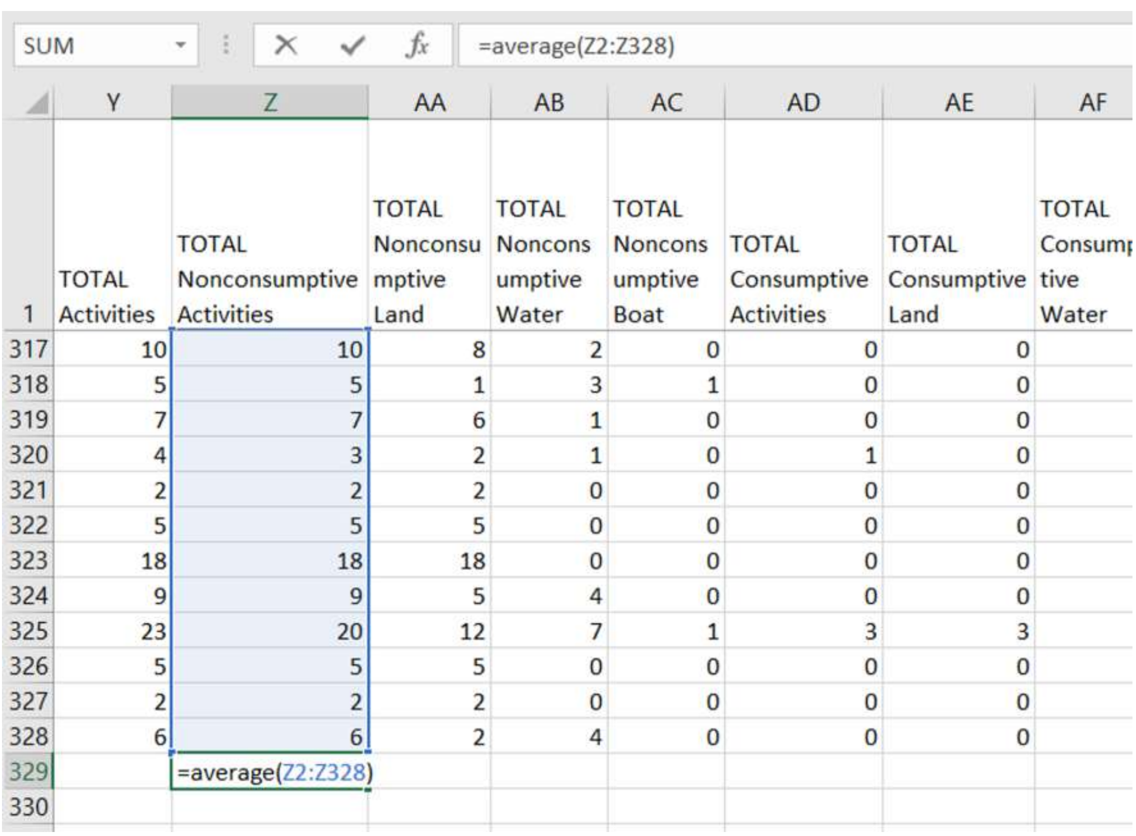
Note that the total number of people could actually refer to the total number of people observed or it could refer to the total number of people observed doing one type of activity (i.e. the total number of people you saw on the entire survey or the number of people you saw doing beach recreation on the survey). The unit for effort is average # people per survey mile and can be used to make bar charts comparing surveys of different distances since it eliminates distance as a variable.

Consumptive vs. Non-Consumptive - Effort

1) The first step in determining effort is to find the average number of people for each activity, in this case the average number of people observed participating in some kind of consumptive activity and the average number of people observed participating in some kind of non-consumptive activity. Note, in this context average will be calculated using the mean.

2) To calculate the average we will use the same columns we did for the calculations above, Z "TOTAL Nonconsumptive Activities" and column AD "TOTAL Consumptive Activities."

3) Select a cell below Z "TOTAL Nonconsumptive Activities" and enter the following formula - =average(Z2:Z#). Replace the # sign with the number of the last row in that column. Push Enter.



SUM | =average(Z2:Z328)

	Y	Z	AA	AB	AC	AD	AE	AF
1	TOTAL Activities	TOTAL Nonconsumptive Activities	TOTAL Nonconsu mptive Land	TOTAL Noncons umptive Water	TOTAL Noncons umptive Boat	TOTAL Consumptive Activities	TOTAL Consumptive Land	TOTAL Consump tive Water
317	10	10	8	2	0	0	0	
318	5	5	1	3	1	0	0	
319	7	7	6	1	0	0	0	
320	4	3	2	1	0	1	0	
321	2	2	2	0	0	0	0	
322	5	5	5	0	0	0	0	
323	18	18	18	0	0	0	0	
324	9	9	5	4	0	0	0	
325	23	20	12	7	1	3	3	
326	5	5	5	0	0	0	0	
327	2	2	2	0	0	0	0	
328	6	6	2	4	0	0	0	
329		=average(Z2:Z328)						
330								

4) Repeat for column AD “TOTAL Consumptive Activities” =average(AD2:AD#)

5) Now that we have calculated the top half of the equation, Average # People Observed Per Survey, we need to calculate the survey distance. This is actually easy! It is simply the distance of the transect you walked in one direction.

a. OUT 2 = 0.92 miles

b. TRM 1 = 0.84 miles

6)Alternatively, you could have students get on Google Earth and calculate the distance themselves.

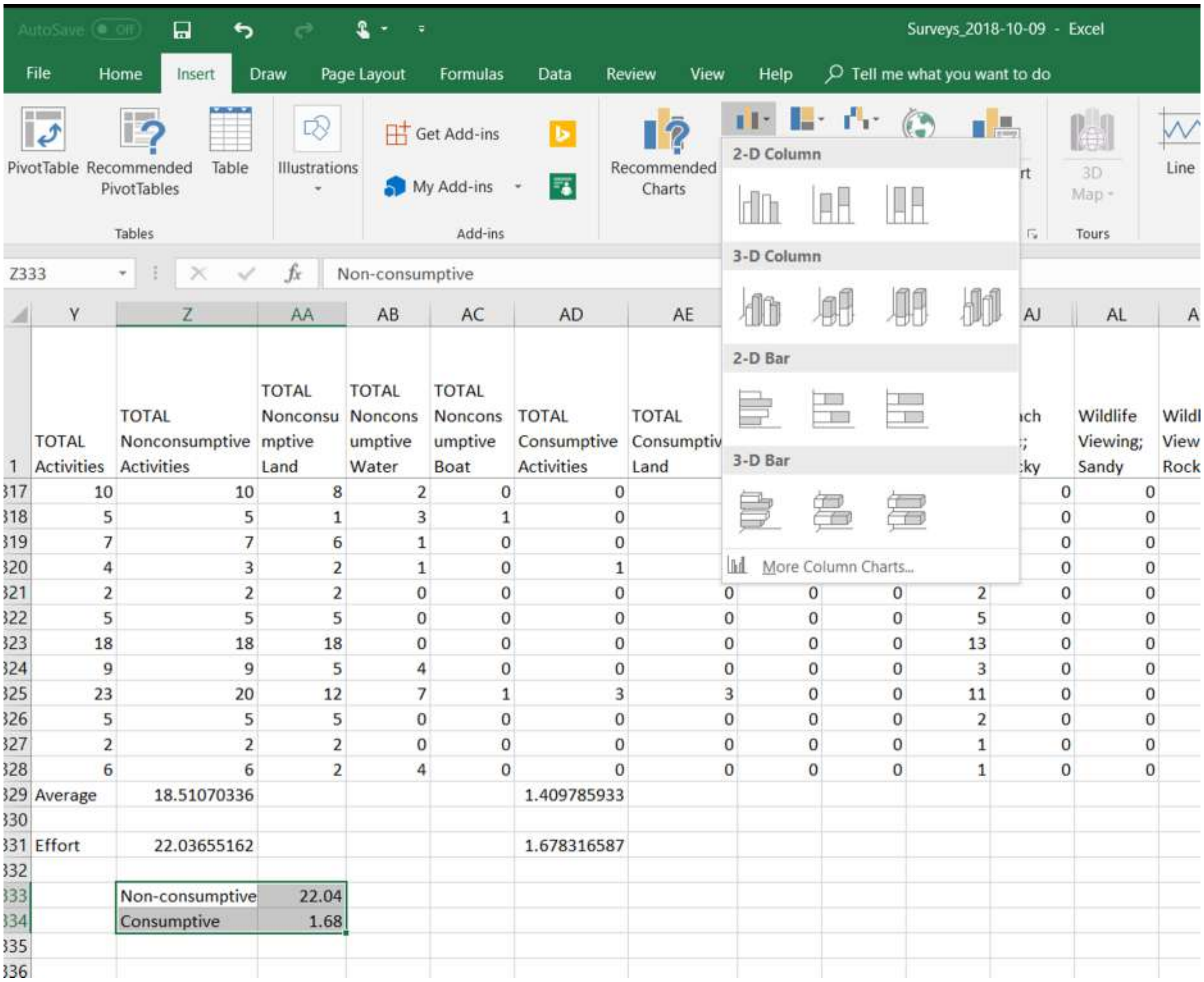
7) Finally, to calculate effort divide the totals from steps 3 and 4 by the distance of the appropriate survey.

Z331 =Z329/0.84

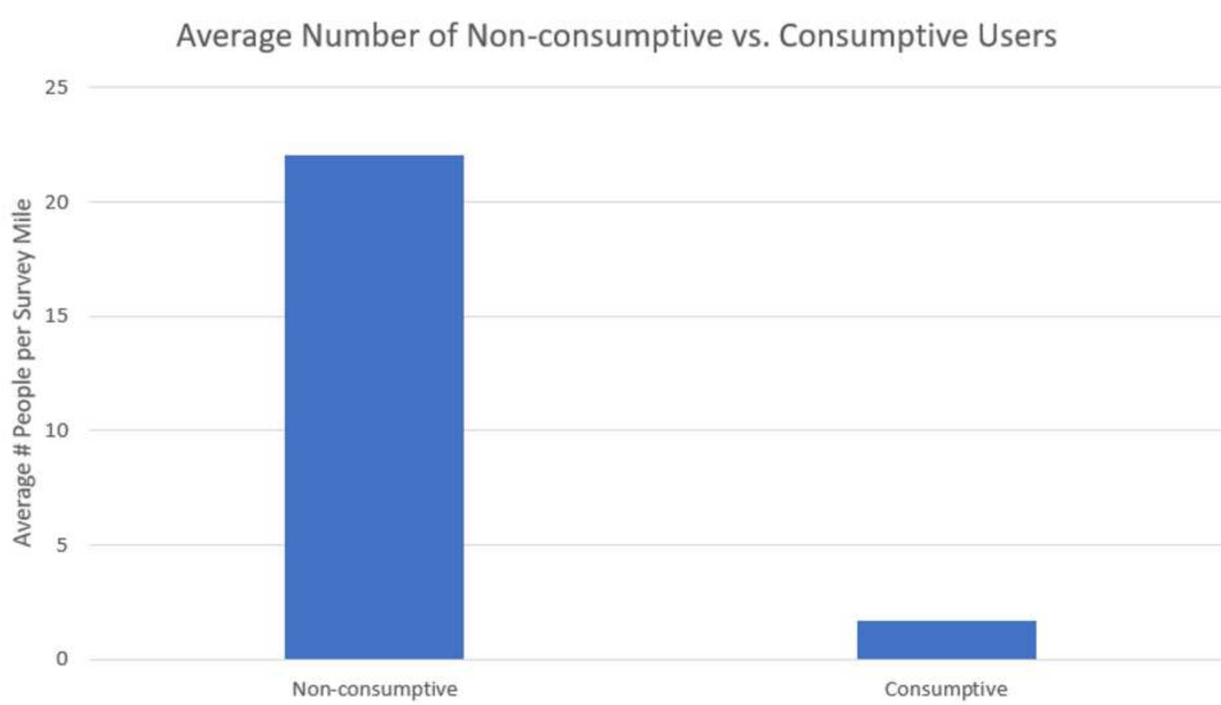
	Y	Z	AA	AB	AC	AD	AE	AF
1	TOTAL Activities	TOTAL Nonconsumptive Activities	TOTAL Nonconsumptive Land	TOTAL Nonconsumptive Water	TOTAL Nonconsumptive Boat	TOTAL Consumptive Activities	TOTAL Consumptive Land	TOTAL Consumptive Water
317	10	10	8	2	0	0	0	[illegible]
318	5	5	1	3	1	0	0	[illegible]
319	7	7	6	1	0	0	0	[illegible]
320	4	3	2	1	0	1	0	[illegible]
321	2	2	2	0	0	0	0	[illegible]
322	5	5	5	0	0	0	0	[illegible]
323	18	18	18	0	0	0	0	[illegible]
324	9	9	5	4	0	0	0	[illegible]
325	23	20	12	7	1	3	3	[illegible]
326	5	5	5	0	0	0	0	[illegible]
327	2	2	2	0	0	0	0	[illegible]
328	6	6	2	4	0	0	0	[illegible]
329	Average	18.51070336						
330								
331	Effort	=Z329/0.84						
332								

8) Now that we have calculated effort we will create a bar chart comparing the average number of non-consumptive activities vs the average number of consumptive activities observed at our site.

9) To create the bar chart make a table with your data labels and effort totals and then click on Insert > Bar Chart icon > then select which type of bar chart you would like.



10) If the bar chart does have a title or axis labels click on the plus sign next to the chart and select them. The x-axis should already be labeled with Non-consumptive and consumptive. Label the Y-axis "Average # People per Survey Mile."



Most Common Activities – Effort
1) Complete the steps above for the five most common activities you identified during the first part of data analysis.

San Diego Zoo Terns and Plovers
1) Ask students if it would make more sense to analyze the amount of terns and plovers seen as a pie chart or as a bar chart (per unit of effort). Should terns and plovers be grouped or separated? Create the appropriate chart.

Student Choice
1) Have students identify a question they would like to answer from the data. Students should write out the question, a hypothesis, run the proper analysis, and create the correct type of chart.
2) Have each group discuss their charts. Which activities were seen most frequently? Which were seen least frequently?
3) What impact might these activities have on the environment? What further questions do you have? What further analysis needs to be done to answer this question?

PART 3: Drawing Conclusions

(*recommended two to three 50-minute class period)*

Activity

- Have students create a poster (or other display) outlining their research using the format of a peer-reviewed journal article:
    - o Introduction (Background on the topic, why it is important to study, what we already know)
    - o Methods (How the data was collected)
    - o Results (Include pie charts here)
    - o Conclusions (What does your data tell us? Why is it important?
- What future studies should be done? What were some possible sources of error?)
- Posters should also include a map of the MPA and a picture of their beach as well as any other relevant items.
-Students will provide an oral presentation of their group project.

Class Discussion

- How do the two types of data analysis compare? When would be an appropriate time to use each method?
- How do MPAs protect ocean ecosystems?
- What type of human activities interfere with the protection of MPAs?
- How do these activities interfere?
- How did human activity compare between the control site (outside of the MPA) and the experimental site (inside the MPA)?

- Did the amount of birds seen inside vs outside the MPA differ? Did you notice any corresponding trends with human use?
- How might different types of human use affect biodiversity? Did you see any evidence for this?
- Is there value in allowing recreation within MPAs?
- What steps can we take to balance protection of natural resources with the importance of allowing recreation in MPAs?
- What are some possible sources of error in your study?
- What do you recommend for future studies?

Did some of your students come up with awesome questions and displays? MPA Watch would love to see them! Please send pictures to angela@wildcoast.org !

Engage: Play one of the games or complete one of the activities from Life in the Sand: Field Guide to Sandy Shores.
Explore: Collect MPA Watch data.
Explain: Explain how different types of human use can impact the environment. Which types of human use are harmful? Which are beneficial?
Elaborate: Have students compare the amount of human use and types of human use inside vs. outside the MPA.
Evaluate: Ask the students questions relating to what they have learned (more questions may be found in Part 3 of this lesson plan).
Q1: How do MPAs protect ocean ecosystems?
Q2: What type of human activities interfere with the protection of MPAs?
Q3: How did human activity compare between the control site (outside the MPA) and the experimental site (inside the MPA)?
Q4: What steps can we take to balance protection of natural resources with the importance of allowing recreation?

NGSS Alignment

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-ESS3-1. Earth and Human Activity Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

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

Patterns. Observed patterns of forms and events guide organization and classification and prompt questions about relationships and the factors that influence them.

Online Resources

MPA Watch: www.mpawatch.org ; www.wildcoast.org/mpawatch

Terns and Plovers Datasheet

Site: Control or Experimental

Site Name:

Group:

Date:

Start Time:

End Time:

Snowy Plover

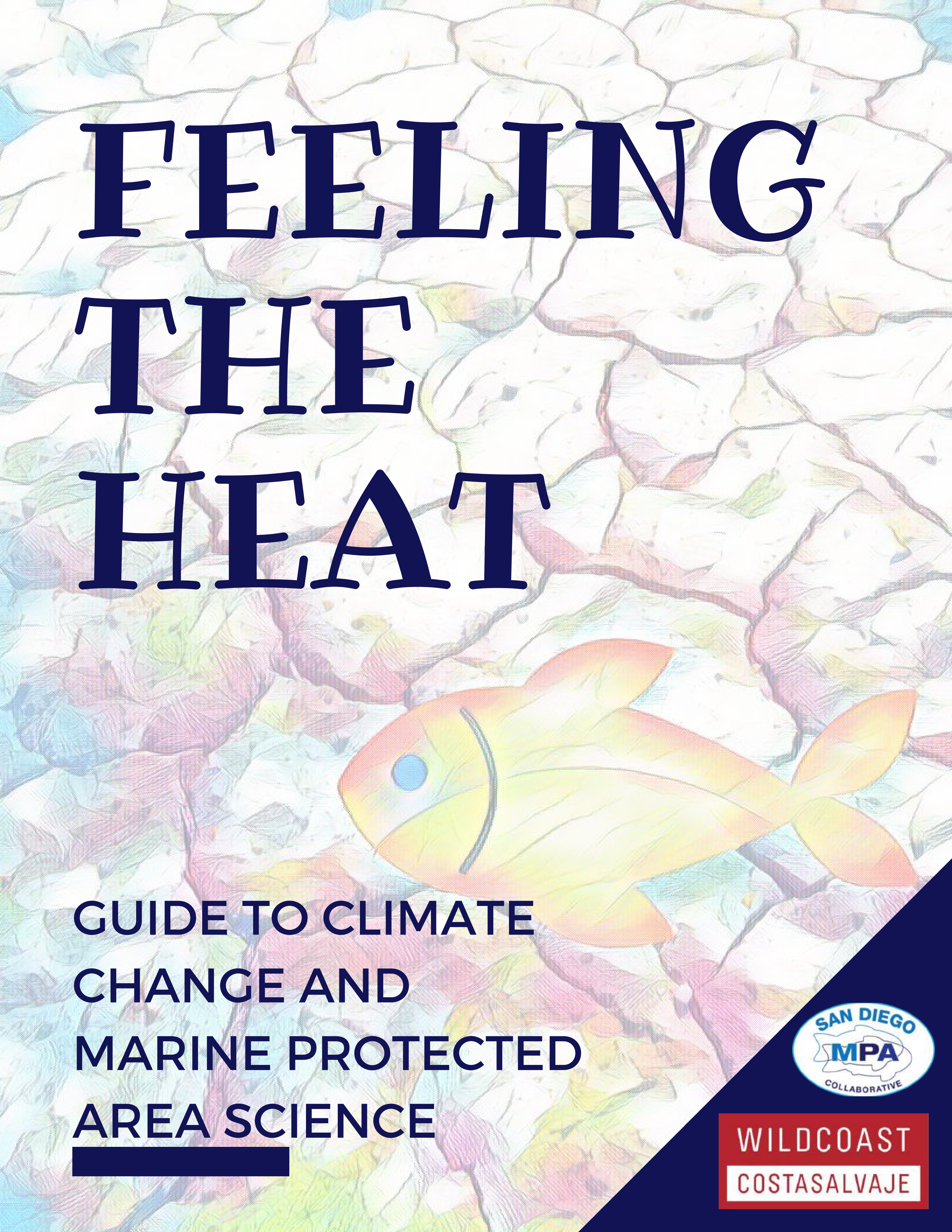
The western snowy plover is a small shorebird, about 6 inches long, with a thin dark bill, pale brown to gray upper parts, white or buff colored belly, and darker patches on its shoulders and head, white forehead and supercilium (eyebrow line).
U.S. Fish and Wildlife Service

# Birds in Group	Bird Activity	Human Activity

California Least Tern

The CA Least Tern has a distinctive black cap. It has black stripes running from the cap across the eyes to the beak. These contrast with a white forehead. 8¼ to 9 inches long. Its wingspan is 19 to 21 inches. Has a forked tail.
U.S. Fish and Wildlife Service

# Birds in Group	Bird Activity	Human Activity



FEELING THE HEAT

GUIDE TO CLIMATE CHANGE AND MARINE PROTECTED AREA SCIENCE

SAN DIEGO MPA COLLABORATIVE

WILDCOAST COSTASALVAJE

Table of Contents

Climate Change and MPAs

ACTIVITIES

APPENDICIES

WILDCOAST
COSTASALVAJE

SAN DIEGO MPA COLLABORATIVE

Climate Change and Marine Protected Area Science

Climate Change - Grades 9-12

Learning Objectives

Part 1:

1A) Students will be able to distinguish the features of weather and climate and express how an anomalous weather event does not provide empirical evidence for or against climate change.

1B) Students will be able to explain the elements of climate and analyze the earth's energy balance that affects climate change. (What is climate change?)

1C) Students will be able to identify the causes of climate change as well as the evidence for these causes. (What is responsible for climate change and how do we know?)

Part 2:

2A) Students will be able to analyze the impact of climate change on physical and biological systems, recognizing those that will most affect coastal communities, like San Diego. This will include climate change impacts on biodiversity.

2B) Students will recognize the connectivity within a watershed. Students will learn that even inland communities are connected to and influence coastal and marine ecosystems.

2C) Students will be able to explain what a Marine Protected Area is and locate MPAs in their community

Part 3:

3A) Students will be able to recognize the risks and problems society faces as climate change impacts are anticipated and realized and, be able to offer solutions to address these impacts

3B) Students will be able to compare and contrast climate change adaptation strategies in light of environmental, financial, and social impact.

3C) Students will recognize the importance and benefit of employing natural climate solutions as climate adaptation strategies

NGSS: DCI (Disciplinary Core Ideas):
HS-LS2
HS-LS4
HS-ESS2
HS-ESS3

Time: Three lessons, 90-120 min each

Materials for the Teacher
-Answer key

Materials for the Students
-San Diego MPA Wildlife and Recreation guide
~Southern California MPA Guide
~Marine Recreational Brochure San Diego

PART 1: The Science of Climate Change

Background Information: Climate Change

Climate change is a change in the statistical distribution of weather patterns over a given period of time (can be decades, thousands, or even millions of years). In short, the term climate change refers to a change in the average weather conditions. While climate change is a naturally occurring process being shaped by factors such as biotic activity, variations in solar radiation, and volcanic eruptions, the rate at which current climate change is occurring today is unnatural. Anthropogenic activities, including the increased output of greenhouse gases, have increased the rate at which our climate is changing.

Prior Student Knowledge:
~Students will have been introduced to the science of climate change in a previous lesson in this unit.
~Students should have already learned about habitats and ecosystems.
~Students will have their own personal experiences that inform and enhance their understanding of ecoregions in their community.
Possible Preconceptions/Misconceptions:
~Students may confuse weather and climate.
~Students may misconceive that climate change is the result of the hole in the ozone layer.
~There may be climate change denial or the denial of science by some students or their friends and families.

Vocabulary
Part 1
Anthropogenic- Caused by humans or human interaction.
Biotic- A living part of an ecosystem.
Climate - the composite or generally prevailing weather conditions of a place averaged over a period of time, often 30 years.
Greenhouse effect - the warming of the earth's atmosphere that occurs when the sun's radiation passes through the atmosphere, is absorbed by the earth, and is given off as radiation of longer wavelength which can be absorbed by atmospheric gases (as carbon dioxide and water vapor).
Weather- the day-to-day state of the atmosphere, and its short-term variation in minutes to weeks.
Radiation- the process in which energy is emitted by one body, transmitted through an intervening space or medium, and absorbed by another body.

Suggested Procedure:
Pre-Lab Discussion
~The teacher will administer a pre-lesson assessment to gauge student knowledge on topics to be covered in this unit: The mechanisms of climate change, the effects of climate change, coastal ecosystems, marine protected areas, and mitigation/adaptation/resiliency.
-This pre-lesson assessment can be administered again at the end of the unit as a summative assessment.
~Ask students what they **know**, **think**, and **feel** about climate change -
-Where do they hear about climate change?
-By raising their hands and displaying their fingers, how worried are they about climate change?
(1 meaning I'm not worried at all, 5 meaning I'm extremely worried)

Greenhouse in a Jar Lab (Appendix A)
~This lab is designed to get students thinking about the heat-trapping effect of atmospheric carbon dioxide (the greenhouse effect).
~By designing this activity as an inquiry-based lab, students are called upon to use the NGSS Science Practice of **Planning and Carrying Out Investigations** by constructing their own experiment to **develop and use a model** demonstrating the heat-trapping effect of greenhouse gases.
~Students should begin considering in what ways this model represents a system similar to the Earth and its atmospheric processes.

~Questions to encourage and focus student exploration:
-What variable is responsible for producing the difference in temperature between the two bottles?
-What would happen if we added more of that variable? (Alka-seltzer which produces CO2)
-How is CO2 being produced every day outside of this experiment?
-What effect does that have on the temperature of the air within Earth's atmosphere?

Explain Concepts and Vocabulary
Description:
~A PowerPoint presentation takes students through the mechanisms driving climate change.
~Throughout the presentation, the teacher will encourage student participation by asking higher-order thinking questions. Students should be prepared to explain their answers and justify these explanations.

Questions May Include:
~What relates weather and climate?
~Why is the climate system important?
~Do the graphs in this accurately represent the data and show a full picture?

~Students are asked to interpret data from graphs.
~A video helps explain how scientists measure atmospheric CO2, how we know CO2 concentrations are rising, and why it matters.
~It should be pointed out that the video is shot at Scripps Institution of Oceanography, a local and familiar institution for students in San Diego, but a world-leader in oceanic and atmospheric science.
~The greenhouse effect is compared to a heat-trapping blanket to help students understand the way greenhouse gases retain radiated energy and warm the atmosphere. The heat-trapping blanket analogy is consistent with climate change messaging from NNOCCI and Climate Science Alliance, reinforcing these concepts across different platforms.

Vocabulary:
Student explanations should precede introduction of terms or explanations by the teacher. Students may be asked to provide examples they recognize in their personal lives.

Student Journaling
Description:
Ask students to reflect on how we as a society and how we as individuals contribute to global climate change.

Instruct students to take a moment to write about these questions:
~Do you think we, as individuals, have a responsibility to change our behavior?
~As a state? A nation? A planet?
~Do you think that you personally can make a difference? Why or why not?

Discussion
Formative Monitoring (Questioning / Discussion):
~Ask students to think about these questions, discuss their ideas with a partner, then ask them to share with the class for group discussion.
~How did our lab show how greenhouse gases work?
~What was accurate about this model?
~What did this model leave out?
~Are there ways we can change it to be more representative of Earth's atmospheric system?

Part 1 continued
Greenhouse gas – a gas that can absorb infrared radiation in the atmosphere. Examples include carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, water vapor, and ozone.

Part 2
Ecoregion – areas of similarity in the mosaic of biotic, abiotic, terrestrial, and aquatic ecosystem components with humans being considered as part of the biota.
Ecosystem – a biological community of interacting organisms and their physical environment.
Marine Protected Area (MPA) - areas of seas, oceans, estuaries, or large lakes which restrict some human activities for a conservation purpose, typically to protect natural or cultural resources. Levels of protection vary between MPAs.
Watershed - the area of land where all of the water drains into the same place. Watersheds can be composed of creeks, streams, rivers, ponds, lakes, wetlands, groundwater, and oceans.

Further Elaboration on Part 1:
As an extension of this lesson, students can calculate their own carbon footprint.
http://web.stanford.edu/group/inquiry2insight/cgi-bin/i2sea-r3b/i2s.php?page=calculate

PART 2: The Consequences of Climate Change

Brief Lesson Description:
Following a lesson on the science of climate change, this lesson will demonstrate how climate change is impacting society not only at global, but also at local scales. This lesson focuses on climate change impacts on coastal and marine ecosystems in San Diego County. Students will be introduced to Marine Protected Areas (MPAs) as a spatial management tool.

Description of ENGAGE Opening Activity:
~As a class, we locate ourselves on a map. Starting globally, and continuing on increasingly smaller scales, students will mark with a pushpin the community in which they live.

~Students may also be shown two short videos. Both are produced by WILDCOAST. 1) The first offers an introductory primer on Marine Protected Areas. https://www.youtube.com/watch?v=gSE9SdtW-po

2) The second video gives a little "sneak peek" of the Floating Lab project students will participate in as an extension of this lesson.
https://www.youtube.com/watch?v=bL1jtoIpHaU

This video may also, or alternatively, be shown, which is a combination of the first two highlighting both the importance of MPAs and the Floating Lab project.
https://www.youtube.com/watch?v=zjcLTL_cNB0

EXPLORE:
Lesson Description – Materials Needed / Probing or Clarifying Questions:
~Following the mapping activity, the teacher will offer a quick review of climate change and the greenhouse (heat-trapping blanket) effect.
~Students will work in groups to brainstorm climate change impacts. Each group will be given a broad impact of climate change and be asked to think of as many consequences as they can that will result from, or relate to, that impact. Each group will be asked to list impacts related to one of these broad categories: rising atmospheric temperatures, changes in precipitation, and changing ocean conditions.

~Following the mapping exercise and brainstorming activity, students will be primed to think about how the impacts they listed will be realized both globally and locally.
~Ask students to think about what makes their nation, state, region, county, and town special and different from others.
~What impacts from climate change will affect them most based on where they live?

Part 2 continued
Zonation – the distribution of plants or animals into specific zones according to such parameters as altitude or depth, each characterized by its dominant species.

Part 3
Adaptation - Reacting or changing to fit the new circumstance; coping with impacts that cannot be avoided.
Carbon sequestration - Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide or other forms of carbon to mitigate or defer global warming.
Infrastructure - the fundamental facilities and systems serving a country, city, or area, as transportation.

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Explanation of Concepts and Vocabulary
Description:
Using PowerPoint, the teacher will discuss what a watershed is and how it functions. Teacher will orient students within their local watershed, emphasizing their connection to the watershed and establishing a sense of place.

~In groups, students will research different ecoregions within their coastal community. Ecoregions to be studied include inland coastal watershed, intertidal/littoral zone, subtidal nearshore, and offshore.
~To guide student exploration and research, we will draw a "map" of the coast from inland to offshore. Students will be given a list of habitats labeled with pictures and be asked to place them in the ecoregion they think it belongs (e.g. kelp forest – offshore, rocky reef - subtidal nearshore, beach – intertidal/littoral).

Student research should focus on defining:
-Features/conditions of the ecoregion.
-Different kinds of habitats that can be found there.
-Limiting factors affecting wildlife. (How are animals adapted to live there?)
-Ecosystem services provided by the ecoregion. (How does the ecosystem provide benefits for humans?)
-The realized and predicted impacts from climate change.

Students will design a poster representing their group's ecoregion and present the information they have gathered before their classmates.

Following the coastal watershed ecoregion research activity, we will discuss Marine Protected Areas (MPAs) as a spatial management tool – a way to manage and protect these ecosystems.

Together, we will answer the following questions:
-What is an MPA?
-How do MPAs work?
-Where are our local MPAs? (In our watershed? In our region?)
    -We can demarcate the MPAs on the map from the first activity.

Beyond the classroom
Description: Floating Lab
Floating labs are a part of WILDCOAST's Explore My MPA program and available free to students from underserved communities. Contact WILDCOAST's conservation team for more details.
Students will join WILDCOAST staff on a field trip to the South La Jolla State Marine Reserve (Marine Protected Area) via boat.
Students will form 3 small groups to perform different tasks. One group will conduct a plankton tow, one will collect water samples at different depths, and one will complete an MPA Watch boat-based survey.
Each group is responsible for collecting data and recognizing why data collection of this kind is important.

Formative Monitoring (Questioning / Discussion):
Following the Floating Lab, each group will explain to the rest of the class what they did during the Floating Lab and what data they collected. Each group should express why these data are important and how these data can inform us about climate change.

Summative Assessment (Quiz / Project / Report):
Group presentations on ecoregions will serve as a summative assessment. Does the group demonstrate and articulate understanding of:
-Habitats and wildlife found in the ecoregion.
-Ecosystem services provided.
-Climate change impacts that especially affect the ecoregion.

PART 3: Climate Change Resilience

Brief Lesson Description:
In this lesson, students will learn how the impacts of climate change discussed in the previous lesson can be addressed through mitigation and adaptation strategies. We will focus on employing natural climate solutions in climate change adaptation.

Engage students
Students will be shown a video addressing what it means to be resilient and the steps necessary to achieve resilience.
https://toolkit.climate.gov/#steps

~Ask students how this can apply to addressing climate change. What can we do to become resilient in facing the impacts of climate change?

Students will explore different case studies of climate change mitigation and adaptation strategies that have been employed across the state of California. Full case study report can be found here:
http://coastalresilience.org/wp-content/uploads/2017/11/tnc_Natural-Shoreline-Case-Study_hi.pdf

~Students will be divided into groups of four. Each group member will read a different article or case study taking notes on why this strategy was employed and what problem it addressed.

~The case studies chosen offer natural *climate* solutions, which is important to recognize within this unit that focuses on *coastal* ecosystems in San Diego County. One of the readings is an adapted newspaper article that discusses the pros and cons of using seawalls as a climate change adaptation strategy.

~Guide student reading by asking students to look for the financial, social, and environmental costs incurred in their case study.

Note: These case studies may need to be adapted depending on the grade and/or reading level of students. If the material is challenging for students, instruct the class to read through the material and focus on the big ideas mentioned rather than getting too caught up in the details. The important part is that they understand which adaptation strategy was used in their case study, but not every specific detail about its implementation.

Students will share with the class the main points from their reading – explaining how and why the climate adaptation strategy in their case study was used.

Climate adaptation strategies featured in the case studies include:
-Managed retreat
-Dune restoration
-Establishment of oyster reefs
-Eelgrass restoration
-Developing living shorelines

~The newspaper article discusses the possibility of seawalls and beach nourishment as adaptation strategies.
~The examples provided by students should be written down on the board because they will serve as adaptation strategies that may be used in the activity that follows.
~The teacher will use examples provided by students to show the difference between adaptation and mitigation of climate change. Most of the examples in the case studies are adaptation strategies and the teacher should be prepared to give examples of mitigation - such as using renewable energy, increased use of public transportation, carbon sequestration, and other activities that reduce the amount of greenhouse gas emissions to the atmosphere.

Applications and Extensions
Description: Students will participate in a mock City Council meeting (Appendix B)
Students will be presented with a scenario in which sea level rise and coastal erosion threatens existing infrastructure, necessitating the development of a management strategy or adaptation plan. In this lesson, students look at Cardiff State Beach as an example where coastal erosion is washing away the beach and flooding occurs on Highway 101 during high tide and storm events.
~Students will continue working in the same group in which they read the case studies. Each group will be given a different stakeholder position to represent. Stakeholder positions include: homeowners, business owners (Chart House restaurant), recreators (Swami's Surfing Assoc.), conservation interests (WILDCOAST), and Caltrans which manages the Highway 101.
Students will be presented with 3 management plans to address the threats impacting Cardiff State Beach and surrounding infrastructure: 1. Full managed retreat. 2. A seawall that extends across the entire beach 3. Do nothing to address the problem.
~Students will need to argue their stakeholder position, providing reasons and their rationale for choosing their position. Students may include evidence from their case study to support their argument.
~Students will be asked to provide counterarguments to the points made by their classmates and offer reasons for their rebuttal.

~In this exercise, compromise will be necessary. Using the list of adaptation strategies developed following the reading exercise, students may offer these strategies as alternatives to the management plans proposed.

Formative Monitoring (Questioning / Discussion):
The teacher should try to elicit participation from different members from each stakeholder group to make sure that each student has an understanding of the process and the reasons for which their stakeholder group holds a particular position.

Summative Assessment:
This lesson is the last in a three-lesson unit. A post-unit assessment will be administered to gauge student learning and overall comprehension. This assessment is the same as the assessment given at the beginning of the unit. This will inform whether or not student comprehension and understanding increased.

Advanced Student Learning Objectives

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 and 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 trade off 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, Systems and System Models, Energy and Matter: Flows, Cycles, and Conservation, Stability and Change, Scale, Proportion, and Quantity

Appendix A

Names: Date:

QUESTION: How does the presence of increased levels of CO_2 affect the temperature inside a bottle when exposed to heat?

You will have access to other materials you may want to use in your experiment set up, like tools for measuring (beakers, ruler, stopwatch, etc.) and tools for securing materials in place (string, tape, tin foil, etc.)

Draw a diagram of experimental set up in the box below

Student response:
What data will you need to collect? How will you collect this data?

Appendix A

Written procedure (the steps you will take to perform this experiment)

Hypothesis: What do you think will happen?

Appendix B

City of Encinitas:
Draft Management Plan Cardiff State Beach

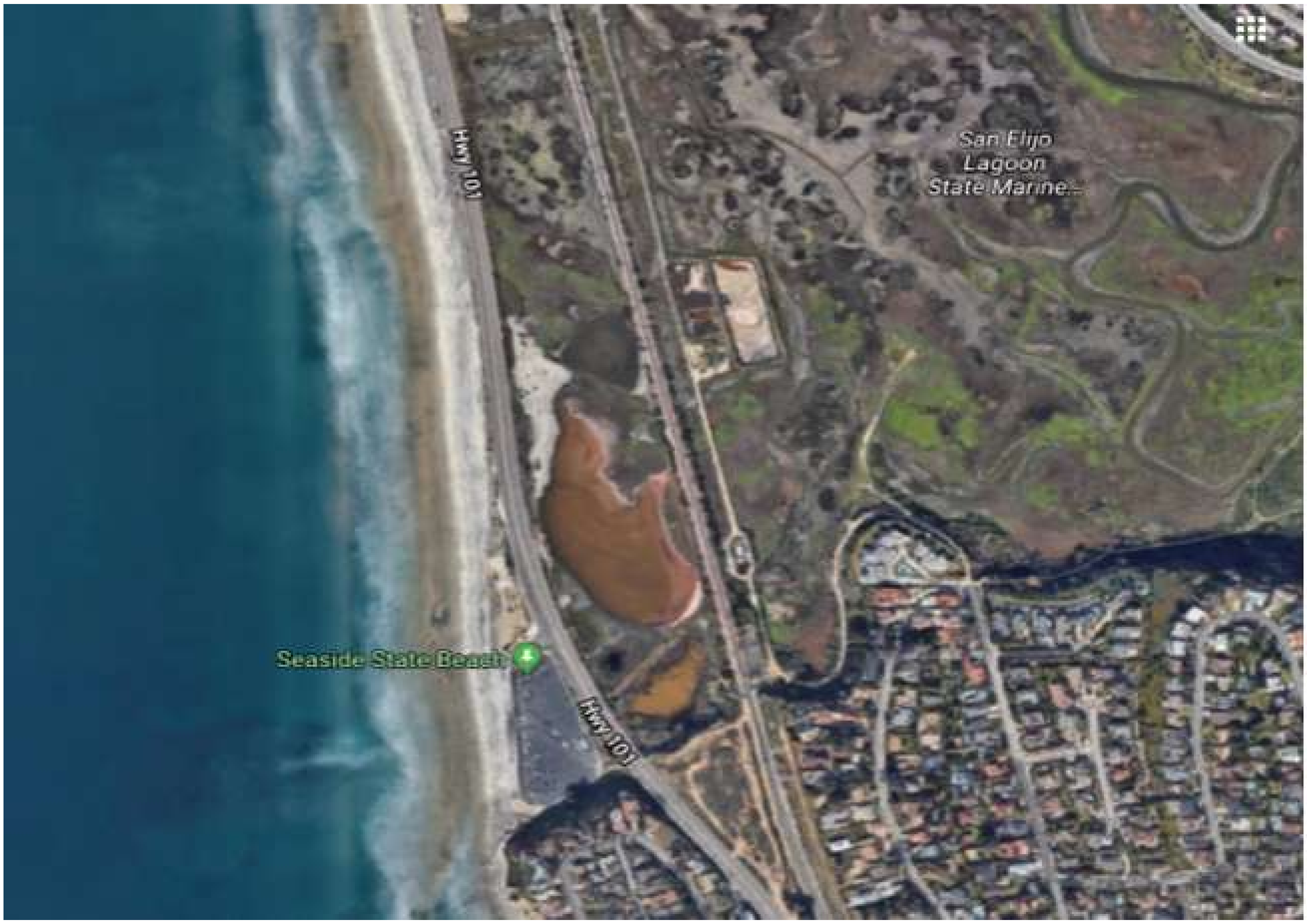
The City of Encinitas is developing a draft management plan to address the problems of sea level rise and coastal erosion that impact Cardiff State Beach and the surrounding areas. As someone who lives or works in the area, you have an interest in how the problem is managed, which makes you a stakeholder. You want your ideas and opinions heard by the city council as they decide how to proceed.

Stakeholder interests that will be represented at city council meetings include homeowners, local businesses (The Chart House restaurant), conservation interests (WILDCOAST), recreators (Swami's Surfing Association), and CalTrans which maintains Highway 101.

The best management plan is one that will have the most long-term benefits for both the people and the environment. It is impossible to please everyone, so compromise between stakeholders is important.

Use what you have learned in class, and the resources provided, to argue your stakeholder group's position concerning the development of a management plan that aims to address the problems of sea level rise and coastal erosion. You must provide reasons and rationale when arguing your position.

Appendix B



Background information on the area:

Cardiff State Beach (just north of the point labeled Seaside State Beach) is threatened by coastal erosion due to sea level rise.

Highway 101 handles 20,000 vehicle trips per day.

Highway 101 has been flooded and damaged in high tide and extreme weather events. Flooding is expected to increase, and damage to the highway is likely to worsen due to impacts of climate change.

Highway 101 was constructed where sand dunes historically existed.

The parking lot just south of the Seaside State Beach marker is important for coastal access (people can park there to get to the beach), but it is also subject to sea level rise and often floods and fills with sand and sediment.

Two Marine Protected Areas surround Cardiff State Beach; The San Elijo Lagoon State Marine Conservation Area is to the east of Cardiff State Beach and the Swami's State Marine Conservation area is to the west, offshore. MPAs prioritize conservation and one of the goals in establishing MPAs is to enhance the recreation value of coastal areas.

Appendix B (Teacher guide)

For teacher:

The options the City Council has offered are:
1. Full managed retreat
2. A seawall extending the entire length of Cardiff State Beach
3. Do nothing to address the issue.

Students must take into consideration the financial cost of the adaptation strategy they recommend.

Option #1 – Full managed retreat: over $1 billion to relocate all homes, business and infrastructure

Option #2 – Seawall: $10 million up front cost to build seawall across the entire beach. Costs an additional $500,000 every 10 years for restoration and maintenance

Option #3 – Do nothing: $0 up-front cost - Cost of restorative action/ rebuilding after storms - 5 years = $100 million 10 years = $500 million 20 years = $900 million

Other potential solutions that can address the problems may be proposed by students as alternatives to the above options. These alternative options should come from the case studies they read earlier in class.

Beach nourishment (sand replenishment) – $1 million every 5 years
Dune restoration - $2 million
Eelgrass bed restoration - $3 million
Oyster reef - $3 million
Relocating the parking lot at Cardiff State Beach - $5 million
Raising the Highway 101 or relocating - $11 million

Values/interests of different stakeholder groups:
- beach access
- recreation (trails, surfing, bird watching, sunbathing, water sports)
- open space
- transportation infrastructure
- property value
- tourism opportunity
- business revenue
-public safety
-wildlife

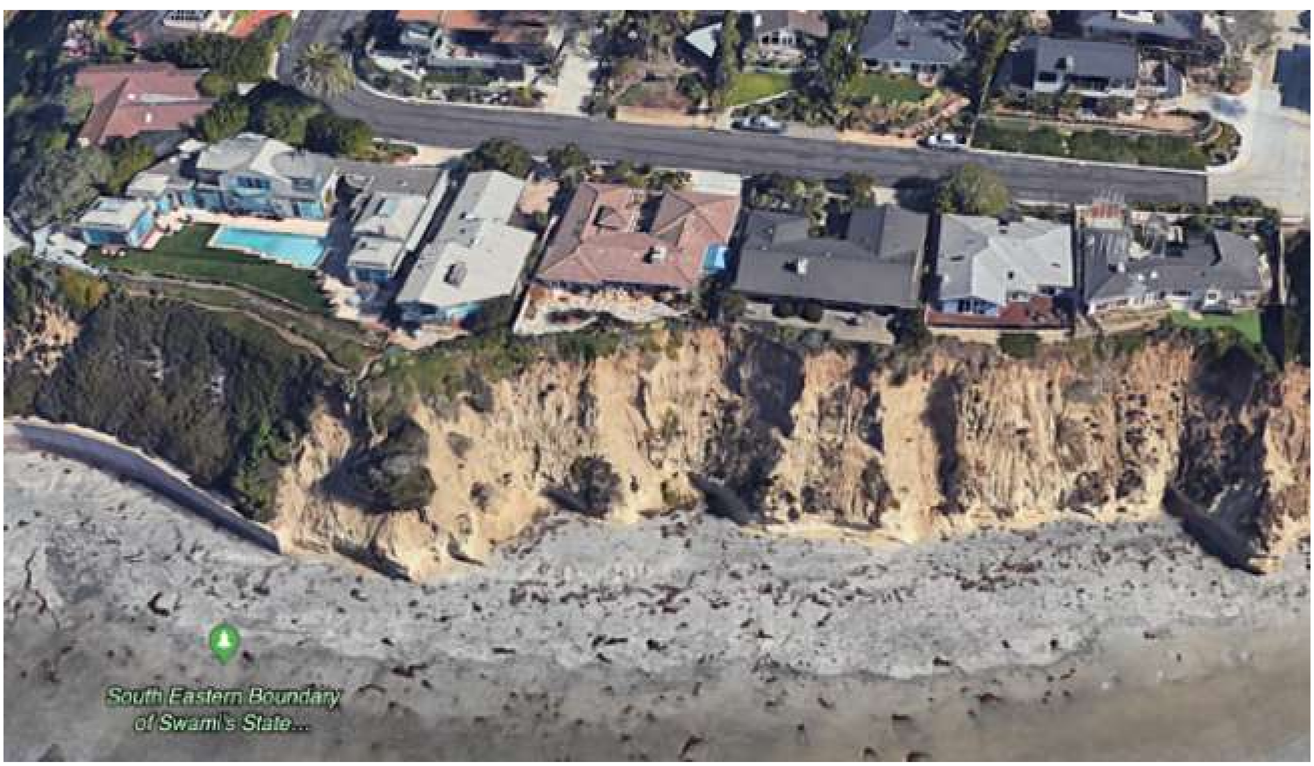
Appendix B

Home owners

After years of working 18-hour days on Wall Street you now own a beautiful house on West Circle Drive in Solana Beach. Your property value is $6.2 million, but in your opinion, is it essentially priceless because the view is breathtaking. You have spent a lot of time and money on home improvement projects and this is where you raised your children, after all!

Sadly, coastal erosion threatens your precious home as the cliffs it is built upon start to crumble. You will do anything to protect it, and don't want to move. You like being able to walk down to the beach, but you would rather build a seawall that stabilizes the cliff and allows the sand in front of your home to be washed away than have to move.

Because your property tax is so high, you feel like you should have a say in what the city chooses because a lot of your money is going to whatever project they choose! You don't mind putting a long seawall across the border of Cardiff State Beach – you think it's too crowded by tourists anyway.



Appendix B

Chart House

You are the owner of an upscale restaurant. It is a popular dining location for locals and vacationing visitors alike! The beach front view is the reason many people go to the restaurant, and without it, your restaurant would not be as successful. Sure, your food is delicious, but it is the view that allows you to charge $47 for a dinner entrée.

You recognize that sea level rise is affecting your business because in high tide events the waves crash into the windows of the dining room. But, if you were to move you would lose a lot of business, and you pay a lot of money in property and sales tax to the city. Your ideal option would be beach replenishment (putting more sand onto the beach periodically because it is washing away) and putting in eelgrass beds nearshore to lessen the impact of waves during storm events.

Appendix B

WILDCOAST

You are a team of passionate ocean-lovers committed to conserving and sustaining coastal and marine ecosystems and wildlife. This means that you prioritize protecting the ecological habitats like those found in the San Elijo Lagoon State Marine Conservation Area and Swami's SMCA. You work with the California Department of Fish and Wildlife and other conservation groups to manage Marine Protected Areas in San Diego County. In fact, you care about MPAs so much that you are the co-chair of the San Diego Marine Protected Area Cooperative!

You are against putting in seawalls because there are natural alternatives that do less harm to the environment! In fact, you argue that managed retreat and ecosystem restoration is a much better option because it enhances coastal access and recreation opportunity, which is a goal of MPAs.

Appendix B

CalTrans

You may not have the most exciting job, but it is your responsibility to keep California moving! The mission of CalTrans is to provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability. That means you take keeping the Highway 101 that runs along the entire coast of California up and running very seriously. The 101 handles 20,000 vehicle trips per day which is hugely important to San Diego's vitality and function.

You don't have a strong position on whether seawalls are built or if a natural shoreline is built instead, all you know is that you have a very tight budget and do not have a lot of money to spend on whatever project moves forward. You also cannot keep shutting down the highway because it floods during high tides and storms.

Appendix B

Swami's surfing association

Swami's Surfing Association Inc. was established in 1964, as a non-profit organization by local surfers for the purpose of support and improving the beach community, and supporting environmental issues. You are a founding member of the SSA and are known as the "Big Kahuna". Now, your grandkids are learning how to surf at Swami's. Your number one priority is making sure you and they have access to the beach and that the waves stay natural and gnarly.

Putting in seawalls is a huge problem for you because it limits access to the beach and makes the waves suck. The awesome waves at Swami's rely on the natural sand flow of the San Elijo Lagoon and its surrounding watershed. You believe a natural shoreline solution would enhance the wave, but you'd hate to see the Chart House move since you love their Sunday brunch after a killer surf sesh.

Appendix C

Name: ____ Date:_______________

1. What was your favorite part of this unit? Why?

2. What was your least favorite part? Why?

3. What was your biggest "take-away"? What was the most important thing you learned?

4. What do you still have questions about? Is there anything we discussed that you still do not feel you understand completely?

5. What do you suggest I change to improve this lesson in the future?

Appendix D

Name: ____ Date:________________

This is a questionnaire designed only to help me understand what you learned from our lessons on climate change and coastal ecosystems. This will not be graded, but will help me structure my lessons to help other students in the future! Please, answer these questions as best you can.

1. The difference between weather and climate is:
a. Weather is what we expect based on years of data while climate is what is happening right now.
b. Weather includes more variables like moisture and wind, while climate just focuses on temperature.
c. Weather is predictable, but climate is not.
d. Weather is a day-to-day event while climate is a consistent pattern over many years.

2. Which of these is a greenhouse gas? Circle all that apply.
a. Carbon dioxide
b. Oxygen
c. Nitrogen
d. Methane
e. Nitrous oxide
f. Helium

3. Atmospheric greenhouse gases make the earth's average temperature:
a. Warmer
b. Cooler
c. Do not affect Earth's temperature

4. To stabilize carbon dioxide concentrations (keep them from growing) in the atmosphere, carbon dioxide emissions from human activities must:
a. Be kept at current levels
b. Be increased
c. Be reduced
d. Be measured

5. When coal or oil is burned for electricity, it makes:
a. Radiation
b. Ozone
c. Carbon dioxide
d. Methane

Appendix D

6. The leading cause of global climate change is the presence of a hole in the ozone layer.
True
False

7. Which of the following threats will likely result from climate change? Circle all that apply.
a. Sea level rise will affect coastal communities.
b. More frequent and intense storms.
c. More frequent and intense droughts.
d. Air temperature and ocean temperature will rise.
e. Increased number of heat-wave (extreme high temperature) days.
f. Increased frequency of wildfires.

8. Which of the following choices represents a way to mitigate (to lessen, to diminish) carbon dioxide emissions? Circle all that apply.
a. Drive more cars.
b. Use solar electricity.
c. Restore (plant) coastal vegetation.
d. Burn more coal.
e. Ride your bike or walk to nearby places.

9. Which of the following is a way to adapt (adjust) to climate change? Circle all that apply.
a. Reduce use of fossil fuels.
b. Preserve the habitat of plant and animal species that are especially vulnerable to climate change.
c. Teach about climate change in schools.
d. Plant different crops that can better stand a changing climate.
e. Move roads, railways, and buildings away from low coastal areas vulnerable to sea level rise.

10. As climate change alters environmental conditions, species will have to adapt to the new conditions or move to find more suitable (better) conditions elsewhere to survive.
True
False

11. Name one thing you did today (besides breathing) that produced carbon dioxide.

12. Name one thing you or your community can do to reduce carbon dioxide emissions to the atmosphere.

13a. What is one thing you or your community could do to prepare for, or adapt to, future changes in climate.

Appendix D

13b. Explain how or why your suggestion would work.

14. Which of these is a coastal or marine ecosystem that can be found in San Diego County. Circle all that apply.
a. Kelp forest
b. Rocky reef
c. Coral reef
d. Sandy beach
e. Mangrove swamp
f. Seagrass meadow
g. Salt marsh

15. Have you ever been to a Marine Protected Area?
Yes
No
I don't know

16. Have you ever done one of the following activities in San Diego County? Circle all that apply.
a. Kayaked in the ocean.
b. Been on a boat in the ocean.
c. Collected scientific data on the beach or in the ocean.
d. Learned about the ocean or coastal ecosystems while on the beach or on a boat.
e. None of the above.

17. In your own words, explain what a Marine Protected Area is, or what you think a Marine Protected Area is.

18. How might a Marine Protected Area help address climate change impacts

Appendix D ***ANSWER KEY***

Answers are ***BOLDED***:

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*** All above are correct

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True
False

11 - 13 b. Answers will vary

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15 - 18 Answers will vary