FEELING THE HEAT

GUIDE TO CLIMATE CHANGE AND MARINE PROTECTED AREA SCIENCE

SAN DIEGO MPA COLLABORATIVE

WILDCOAST
COSTASALVAJE

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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?

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.

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 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.

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?

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 CO2 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

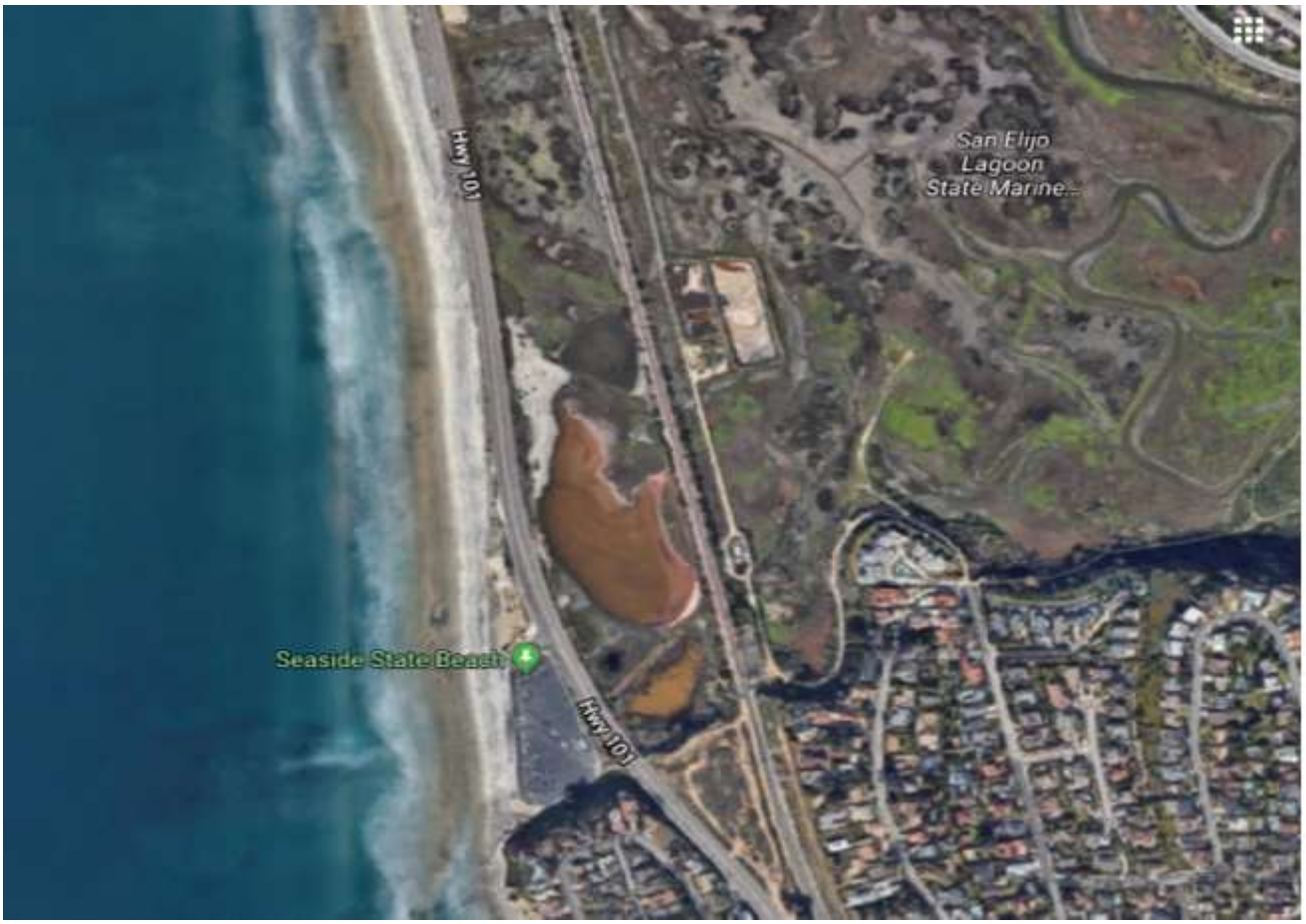
The City of Encinitas is developing a draft management plan to address the problems of sea level rise and coastal erosion that impact Cardiff State Beach and the surrounding areas. As someone who lives or works in the area, you have an interest in how the problem is managed, which makes you a stakeholder. 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

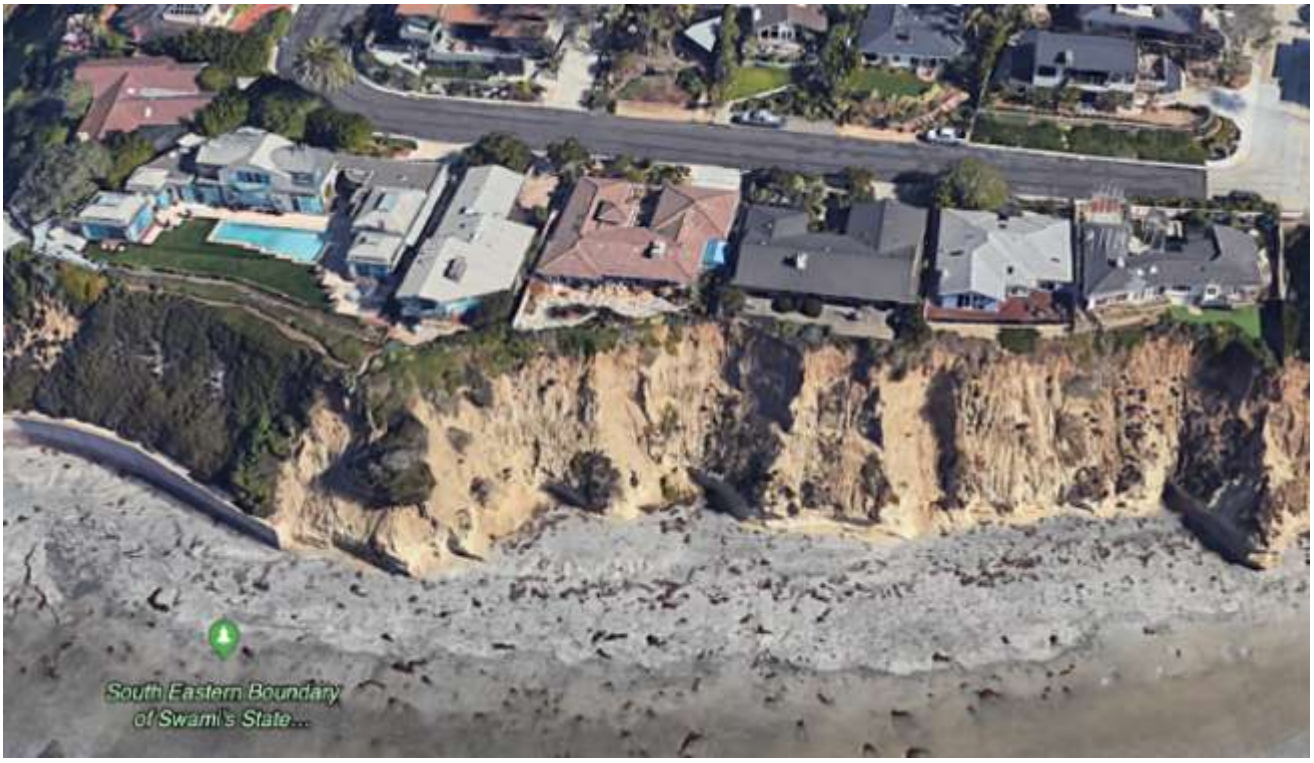
Appendix B

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***:

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 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

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

Appendix D ***ANSWER KEY***

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.
*** All above are correct

8. Which of the following choices best represents a way to mitigate (to lesson, to diminish) carbon dioxide emissions?
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?
a. Reduce use of fossil fuels.
b. Preserve the habitat of plant and animal species 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 - 13 b. Answers will vary

14. Which of these is a coastal or marine ecosystem that can be found in San Diego. 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 - 18 Answers will vary