A Sense of the Coast: Getting to Know the Golden Shore

A California Coastal Voices Teacher-Guided Project

Big Sur. Photo: Mark Ray

Challenging Question:

How can we make sense of interacting Earth systems on California's coast?

For this Project:

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A Sense of the Coast: Getting to Know the Golden Shore contains material adapted with permission from NASA Earth Observatory.

Challenging Question

How can we make sense of interacting Earth systems on California's coast?

This unit supports learning in the following Next Generation Science Standards Performance Expectations:

HS-ESS2-1: Develop a model to illustrate how Earth's surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS3-1: 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.

A Sense of the Coast: Getting to Know the Golden Shore

Overview

The California coast is a complex, ever-changing landscape that varies dramatically from north to south, offering students many opportunities to examine patterns of visual evidence, infer and explain causal mechanisms, and analyze models of Earth systems. The following activities guide students through these tasks as they focus on the physical, cultural, and ecological landscape.

Making sense of our world requires a perspective that is both directly experiential and broadly remote, and human experiences are but one point of reference. Remote sensing, the science of obtaining information about objects or areas from a distance (typically from aircraft or satellites), provides the expanded perspective needed to make sense of our direct experience. Students will use remote sensing images from the California Coastal Records Project, NASA, and the National Oceanographic and Atmospheric Administration to develop accurate information about coastal places. Students will ask geospatial questions, define geographic problems, and construct evidence-based explanations.

Throughout *A Sense of the Coast: Getting to Know the Golden Shore,* students will work in groups to create a "virtual tour" of a coastal place. Using digital tools and other research, students will develop an in-depth understanding of a coastal park and convey that understanding through a multimedia presentation. California coastal park brochures, which can be downloaded from the *Coastal Voices Website*, will be helpful as a starting place.

Students will provide evidence of learning by:

- Conducting a classroom presentation of how their chosen coastal park looks, sounds, and feels, accurately conveying its physical, cultural, geologic, and ecological features, including multimedia aids, to lead their audience on a virtual field trip. The presentation will include how the place has changed over time and may change in the future, with reference as appropriate to human settlement and resource use, and plant and animal communities.

HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

At the end of this unit you will find further standards connections, including the three dimensions of *NGSS* and California's *Environmental Principles and Concepts*.

Find images for download, links to videos, and other resources referred to within this project on the *Coastal Voices Website*:

www.coastal.ca.gov/coastalvoices

- Maintaining a science notebook that will be reviewed by the teacher for evidence of changes in student thinking.

Prior to Beginning the Activities

Students should read *Making Sense of Images* and familiarize themselves with the *Guiding Questions for Image Analysis* worksheet, both found in the Readings and Resources section.

Activities

These classroom-based activities are structured to provide core content learning through model-driven inquiry into patterns in coastal systems, observable cause and effect mechanisms, and understanding how change occurs in coastal environments. The goal is to employ systems thinking at a variety of scales to construct explanations and engage in evidence-based argumentation.

1. Invitation to Engage: The Global Perspective
2. Exploration: A Place-Based Perspective on the California Coast
3. Explanation: From Rainforest to Desert (Part 1)
4. Elaboration: From Rainforest to Desert (Part 2)
5. Extend and Evaluate: Sense of Place, Sense of Truth
6. Evaluation: Communicating Science Concepts

Humpback off of Moss Landing. Photo: Shane Keena

Activity

A Sense of the Coast Invitation to Engage: The Global Perspective

Guiding Questions:

- What is an Earth system?
- How can science explicitly bound, model, and investigate Earth systems that influence California?
- How do global Earth systems translate into landforms?

Materials Required:

- Individual student notebooks
- Note cards
- Hair dryers (optional) and trays (one each per group), safety goggles for each student, and sand. Ask students to bring hair dryers from home, if using.

Download from or access on the *Coastal Voices Website*:

- Daily Phenomenon #1
- Global Atmospheric Circulation Model
- Wind Speed and Direction Spreadsheet

During this session, students examine the nature and practices of Earth science as they construct a sense of scale through image analysis and hands-on investigation.

Daily Phenomenon

Ask students to look at the Blue Marble image (Daily Phenomenon #1) and in their notebook make a list of things that move and change on and around the Earth (e.g. cloud formations, tides, and currents). Have students think about how those things interact and propose a preliminary definition of an Earth system that encompasses those interactions.

Explore

1. Instruct students to respond on note cards to the following question: How do we gain understanding of Earth's systems? Cards are turned in to the teacher for review and organized by commonalities on the board.
2. Students form groups of three as directed by teacher. These are groups for cooperative learning and the group project throughout the unit. Once in groups, students talk about their ideas.
3. Groups examine the Global Atmospheric Circulation Model and discuss any patterns they notice.
4. Based on what they've seen and discussed, students individually draw a preliminary model of how wind circulates over the Pacific in their notebook. Explicitly note that the prevailing wind direction for most of the year in California is from the north, northwest. This will become a key fact as they interpret images.
5. Teacher places sand-filled trays and hair dryers, if using, in front of each group. STUDENTS MUST WEAR SAFETY GOGGLES AT ALL TIMES DURING THIS ACTIVITY.
6. Working within their groups, students hold the hair dryer back about 20 centimeters and slowly direct air onto the sand at about a 45 degree angle from the long axis of the tray for one minute. Keep dryers on low heat and low volume settings. In their journals, students draw a diagram of the results and repeat the procedure several times adding one minute each time. Alternately, students can blow onto the sand. Students

The Earth from space, NASA

diagram and compare one student blowing versus multiple students blowing at the same time, as well as blowing gently for a minute versus blowing hard and short.

Working with the Numbers

Working individually or in groups, during class or as homework (depending on resources and teacher preference), download a spreadsheet from the *Coastal Voices Website* showing wind speed and direction for Oxnard, California. Have students graph the wind speed over time and make claims about any patterns they see. Ask students to revise their graphical depiction to include the third data point (wind direction) and have them speculate on reasons for variations in windspeed and direction throughout the day.

Reflect on Thinking

In their notebooks, students individually write a Reflective Summary that responds to the guiding questions of the day. Teacher guides, prompts, and evaluates student thinking.

Initiating the Project

Transition back to groups. The groups will work together throughout the unit to develop a sense of a coastal place by creating a virtual field trip of a California coastal park, conveying its physical, cultural, geologic, and ecological features, and how it has changed over time. Groups should begin by sharing any experiences or curiosity they have about particular parks on the California coast. They should narrow down their interest to the northern, central, or southern region of the coast and discuss briefly how they might learn about and convey how a place looks, sounds, and feels without being able to visit in person, including how they will find out how a place has changed over time, what influenced those changes, and what changes may be coming in the future.

Activity

A Sense of the Coast Exploration: A Place-Based Perspective on the California Coast

Guiding Questions:

- How do I analyze and interpret visual data?
- How do I infer from observed effects what Earth system may have caused a change?
- What is it like at the coast?

Materials Required:

- Individual student notebooks
- *Making Sense of Images* and *Guiding Questions for Image Analysis*, found in the Readings and Resources section
- One or more maps of California for student reference
- *It's More Than a Place* reading

Download from or access on the *Coastal Voices Website*:

- Daily Phenomenon #2
- Getting to Know the Golden Shore image sets
- California coastal park brochures
- California Coastal Trail video segments

In this station-based image analysis activity, groups rotate from one station to another making sense of the images presented. At each station they will look for patterns, shapes, and textures. This exercise is useful in interpreting imagery because distinctive patterns can be matched to external models (maps) to identify key features.

Bodies of water—rivers, lakes, and the ocean—are often the simplest features to identify because they tend to have unique shapes and they show up on maps. Other obvious patterns come from the way people use the land. Farms usually have geometric shapes—circles or rectangles—that stand out against the seemingly more random patterns seen in nature. When people cut down a forest, the clearing is often square or has a series of herring-bone lines that form along roads. A straight line anywhere in an image is almost certainly human-made, and may be a road, a canal, or some kind of boundary made visible by land use.

Daily Phenomenon

Students individually examine the photos of Tolowa Dunes (Daily Phenomenon #2) following the *Guiding Questions for Image Analysis* worksheet, taking notes in their notebook.

Explore

Teacher sets up classroom stations equal to the number of groups in the class with images selected from the Getting to Know the Golden Shore image sets. Teacher displays the images however best fits their classroom and available resources (e.g. on laptops or tablets, or printed out). At each station groups will look for patterns, shapes, and textures within the image.

1. Each student organizes a data sheet in their notebook. Headings should include **patterns**, **shapes**, and **textures**, and columns should be numbered with the number of stations in the classroom. It is also helpful to speculate on the exact origin of the California image. The teacher should make a California map available to help orient the students. Remind students that the satellite images from Google are all oriented with north up, while the other photos may not be.

Ventura Pier. Photo: Dennis Kneff

2. Begin rotating through stations. Continue until each group has analyzed at least three images.
3. Direct students to circle their chairs and conduct a reflective conversation on the process. Each group must share their ideas for performing the analysis process as well as preliminary conclusions about the patterns revealed in the images.
4. Each group uses the *Guiding Questions for Image Analysis* worksheet to revise their conclusions about one of the images and answer the questions for that place.
5. If applicable, provide California coastal park brochures to groups for further background. These should also be available to the groups as they continue their project work.
6. Groups present their conclusions to the class.

Evaluate Explanations

Students transition to individual journaling and complete a Reflective Summary responding to the guiding question of the day.

Managing the Project

Students work in groups to complete their selection of a California coastal park. Their choice may be an entire park, or a place within a park such as a particular beach, lagoon, river, or forest. They may select from one of the places explored during this class session, or they may choose another location after browsing California coastal park brochures, after viewing video segments on the California Coastal Trail, or after doing their own exploration.

Groups should begin to research the look, sound, and feel of their location; its physical, cultural, geologic, and ecological features, climate, visitorship, etc.; and how it has changed over time with respect to human settlement, resource use, and plant and animal communities. A virtual field trip means providing an experience for the audience that conveys an in-depth understanding of that place, what it would be like to visit, and how it has changed over time and may change in the future. For example, how might climate change affect this place? The presentation can make use of a variety of media. This work may continue to out-of-class time.

GO DEEP...

The California State Parks PORTS program facilitates interactive video conferencing between classrooms and parks staff. Teachers can choose from more than a dozen topics and locations. Students might have a conversation with a ranger on a kayak in the waters off Point Lobos, explore the salmon in Mill Creek in Del Norte Redwoods State Park, or learn about habitat restoration at Crystal Cove. Visit *ports.parks.ca.gov* to schedule your conference.

Student Preparation for Next Session

Read *It's More Than A Place*.

Additional Resource

California Geomorphic Provinces (download from the *Coastal Voices Website*)

It's More Than A Place

A person's notion of a place may be cultural, physical, ecological, and sometimes even legal, so communicating about place might include art, science, or anything in between. A Yurok tribal member paddling along the North Coast's wooded shores may have one approach to thinking about place even as the GPS on her phone provides her with additional information. A vacationing hiker making her way down the nearby California Coastal Trail may have her own perspective based on her first-hand experience of ecological relationships. Let's start with how a scientist identifies a place, even as we acknowledge other ways of knowing.

A place can be identified by its latitude and longitude, and perhaps with a street address. For example, the Ford House Museum is at latitude/longitude 39.304685, -123.799587, and at 45035 Main Street in Mendocino, California. These are two examples of an absolute location for the Ford House. The Ford House could also be described as being across the street from the water tower, or next to the bluffs in Mendocino Headlands State Park, or 0.4 miles west of the Shoreline Highway. When a location is described in relation to something else it is called a relative location.

Places exist on a vertical plane as well as a horizontal plane. The town of Mendocino can be described as being at an elevation of 154 feet (or 47 meters), or 54 feet higher than the town of Fort Bragg, which is 10.3 miles to the north.

When describing places in California, you can choose to frame them in relation to major geologic features. The state is divided up into 11 geomorphic provinces as described by the California Department of Conservation, each with unique, defining features. Mendocino is part of the Coast Range geomorphic province, having a coastline that is uplifted, terraced, and wave-cut. You might also describe a place in terms of its vegetation type, annual rainfall, soil type, watershed, or animal migration routes.

You might wish to describe a place in terms of the people that live there; for example, in 2010, the population of Mendocino was counted at 894 residents, which is 201 more than Shelter Cove, in adjacent Humboldt County. You might include in your description statistics on languages spoken, household income, or median age. You might include details on historic and current American Indian tribes, and patterns of human migration into and out of the place. You might include major industries or crops, transit access, or percentage of the land that is covered by roads and buildings.

There are almost as many ways to describe a place as there are places. And even more ways to combine and layer different data on a map to tell a story and answer your questions. Traditional knowledge, first-hand experience, and remote sensing technology all offer valuable information. The key is to make conscious choices and to frame your investigation of place in a manner relevant to your purpose. How will you describe your place?

Mendocino Coast. Photo: Karen Ganschow

Activity

A Sense of the Coast Explanation: From Rainforest to Desert (Part 1)

Guiding Questions:

- How do I analyze and interpret visual data?
- How do I infer from observed effects what Earth system may have caused a change?

Materials Required:

- Individual student notebooks
- Exit tickets (Teacher-preferred format)
- *Making Sense of Images*; *Guiding Questions for Image Analysis*; and the *Creativity*, *Presentation*, and *Collaboration Rubrics*; all found in the Readings and Resources section

Download from or access on the *Coastal Voices Website*:

- Daily Phenomenon #3
- Getting to Know the Golden Shore image sets
- Sea Surface Temperature Image
- Geography/Vegetation Map
- Climate/Topography Map
- Average Global Sea Surface Temperature Spreadsheet

In this Earth systems lab, students use geospatial procedures used by coastal zone analysts, scientists, and engineers to analyze and interpret images from California coastal places. Students work on images provided by the California Coastal Records Project, incorporate a sea surface temperature image into their analysis, compare conclusions and supporting evidence, and communicate their reasoning.

Daily Phenomenon

Using their notebooks, students examine the images of Carmel Beach and Carmel River Beach (Daily Phenomenon #3) to construct an explanation for why the two beaches vary in color.

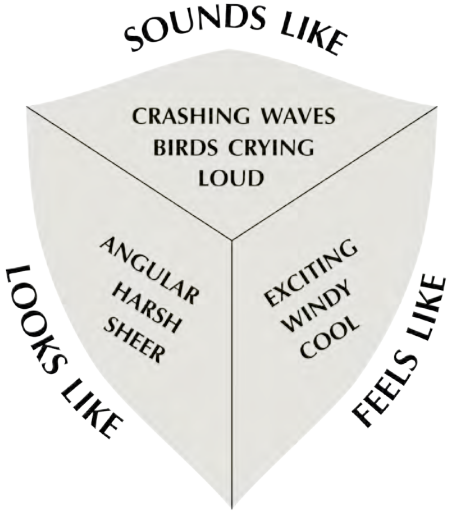
Explore

Tech tip: The colors in an image will depend on what kind of light the instrument measured. True-color images, like photographs, use visible light—red, green and blue wavelengths—so the colors are similar to what a person would see from space. False-color images incorporate infrared light and may take on unexpected colors. Be sure to examine any keys or labels explaining the classification scheme.

1. Students refer to the *Guiding Questions for Image Analysis* worksheet, while teachers provide their choice of images from the Getting to Know the Golden Shore image sets and invite clarifying questions.
2. Teacher initiates a verbal think-pair-share on the analysis of the images. Have students think silently to themselves about the images and create a Y chart (looks like, sounds like, feels like) that describes one of the places shown. (See graphic on page 28.) Have students share and discuss their thoughts with their partner, and finally "pair-share" their conclusions and insight with the class.
3. Teacher provides sea surface temperature image and models interpretation of the image. Ask students to make a claim for how the local sea surface temperature impacts land conditions.

Working with the Numbers

Working individually or in groups, during class or as homework (depending on resources and teacher preference), download a spreadsheet from the *Coastal Voices Website* showing average global



sea surface temperature change from 1880 to 2015. Students can graph the annual anomaly (the change in reference to a long-term average) as well as the upper and lower confidence intervals. What trends do they identify? The data use the 1970-2000 average as a baseline for depicting change. What is the significance of the baseline? Why is temperature presented as a departure from the baseline reference? Why would choosing a different baseline not change the shape of the graph? What arguments can students make as to how the changing global average sea surface temperature impacts coastal places?

Reflect on Thinking

Students revise explanations of the images and write an exit ticket that must be handed to teacher before exiting class. Students should include the process for image analysis as they understand it and add one constructive suggestion for improving the process.

GO DEEP...

One way to present text, photos, and maps together is with a Story Map. This free application from Esri has a goal of making it easy to use geography to tell a story on a web-based platform.

storymaps.arcgis.com

Managing the Project

Students continue work in groups to complete their California coastal virtual field trip. This work may continue into out-of-class time.

Student Preparation for Next Session

- Review *Creativity*, *Presentation*, and *Collaboration Rubrics*, found in the Readings and Resources section.
- Review Geography/Vegetation map and Climate/Topography map and bring to school for the next session.

Zuma Beach. Photo: Nick Steers

Activity

A Sense of the Coast Elaboration: From Rainforest to Desert (Part 2)

Guiding Questions:

- How do I analyze and interpret visual data?
- How do I infer from observed effects what Earth system may have caused a change?

Materials Required:

- Individual student notebooks
- *Making Sense of Images*; *Guiding Questions for Image Analysis*; and the *Creativity*, *Presentation*, and *Collaboration Rubrics*; all found in the Readings and Resources section

Download from or access on the *Coastal Voices Website*:

- Daily Phenomenon #4
- A Sense of the Coast from Space image set
- Geography/Vegetation Map
- Climate/Topography Map

In this Earth systems lab, students will use geospatial procedures used by coastal analysts, scientists, and engineers to analyze and interpret images from coastal places. Students examine satellite images, incorporate data from California Fish and Game's *Atlas of Biodiversity* Geography/Vegetation and Climate/Topography maps into their analysis, and subsequently compare conclusions and communicate reasoning.

Daily Phenomenon

Using their notebooks, students examine the Dark Marble image (Daily Phenomenon #4) following the *Guiding Questions for Image Analysis* worksheet.

Explore

Tech Tip: Get Geographically Oriented—Find North. When you get lost, the simplest way to figure out where you are is to find a familiar landmark and orient yourself with respect to it. The same technique applies to analysis of images. If you know where north is, you can figure out if that mountain range is running north to south or east to west, or if a city is on the east side of the river or the west. These details can help you match the features to a map or other information.

1. Students refer to *Guiding Questions for Image Analysis*, while the teacher provides images from A Sense of the Coast from Space and invite clarifying questions.
2. Teacher initiates a verbal think-pair-share on the analysis of the images.
3. Students now examine both maps from the *Atlas of Biodiversity*. Students write peer quiz questions and query new partners about the data presented on each map. If time allows, consider making these questions the base of a more formal evaluation.
4. Ask students to share what they think is meant by the word "biodiversity," and how it is depicted by these maps. If needed, explain that biodiversity describes the variability among living organisms in a location.
5. Students revise their explanations of A Sense of the Coast from Space images using insights from their examination of the *Atlas of Biodiversity* maps.

GO DEEP...

NASA has produced a guide for teachers titled, *Remote Sensing Math*. For grades 9 through 12, it contains space science problems designed as "one-pagers," each with a teacher guide and answer key. Visit the *Coastal Voices Website* to download this book.

Working with the Numbers

Working individually or in groups, during class or as homework (depending on resources and teacher preference), download a spreadsheet from the *Coastal Voices Website* showing annual surface temperature change in the contiguous 48 U.S. states over time. Students should create a graph of the data, which uses the 1901-2000 average temperature as a baseline. Have students demonstrate that using a different baseline would not change the shape of the graph. Ask students to compare this graph with the sea surface temperature graph from the last activity. What changes in the *Atlas of Biodiversity* maps might be predicted from the surface temperature data?

Reflect on Thinking

Working individually, students write a Reflective Summary in their notebooks that responds to the guiding questions of the day. Teacher guides, prompts, and evaluates student thinking.

Managing the Project

Groups continue work on their virtual field trip presentations.

Student Preparation for Next Session

Students use the rubrics for self and peer evaluation and write a plan of improvement, as directed by the teacher.

Additional Resource

NOAA Ocean Explorer explains the ocean's effect on climate. (Download from the *Coastal Voices Website*.)

Limantour Beach. Photo: Sandra Bradman

Activity

A Sense of the Coast Extend and Evaluate: Sense of Place, Sense of Truth

Guiding Questions:

- How can we increase our confidence in the accuracy of our visual data conclusions?

Materials Required:

- Individual student notebooks
- Computers with ability to access Google Maps or other online mapping program, or printed images of the school site
- Graph paper, color pencils, small metric ruler
- *Presentation Rubric*, found in the Readings and Resources section

Consider your prior knowledge. Perhaps the most powerful tool for interpreting an image is some kind of prior knowledge of the place being studied, or of a place with similar characteristics. If you know that a severe storm moved across the coast last year, it's easy to figure out that the dark brown patch carved out of a coastal road might be erosion from the storm. In this Earth systems lab, students use their existing knowledge of school sites to identify objects as seen through remote sensing images.

Daily Phenomenon

Individually in their notebooks, students draw their school site based on their own mental map (a type of conceptual model defined by National Geographic as "an internal representation of a person's personal perceptions, knowledge, and thoughts about a geographic area"). Students should include five basic components: paths, edges, nodes, districts, and landmarks, and depict the relationships between the components. Finally, students should connect their model to big ideas such as cause and effect, structure and function, and patterns. This model will be revised after students examine satellite images of their school site. Teachers circulate, define terms if unknown, and ensure that students add sufficient detail.

Elements of an Urban Image

As described by urban planner Kevin Lynch in his 1960 book *The Image of the City*, the five elements of an urban image may be perceived differently depending on the observer. Briefly they are:

- **Paths** – routes that people travel
- **Edges** – boundaries that separate or join…
- **Districts** – distinct areas within the city
- **Nodes** – a junction or gathering place
- **Landmarks** - physical references

Explore

1. Convene groups and direct students to find commonalities and distinctions in the drawings of their mental maps. Briefly consider the role of perception in interpretation of images and explain that "ground truthing" is a process of comparing remote sensing data to known sites to improve accuracy of interpretation.
2. With students remaining in their groups, direct them to use Google maps or other online mapping program to find their school using the school's exact address. If technical issues preclude this online approach, use pre-printed images of the school grounds.
3. Teacher models using the tool, naming each of the features and briefly demonstrating its use.
4. Provide five minutes of time to explore the application, before directing students to toggle to the "Earth" or satellite view.

San Francisco and the Bay. Photo: Paul Vu

Spend a few moments discussing the term "scale." Explain: Large scale means more detail. A large scale map may show a small area with lots of detail. A small scale map may show a larger area but less detail.

5. Ask students to explore the image of their school at several different scales. Finally, have them focus on the largest scale image in which the entire school site is in view, to compare it to their own mental map.
6. Students individually draw a second map using the image as a reference to improve the depicted accuracy of the built features like buildings, pools, athletic fields, or parking lots. If time allows for a deeper exploration of scale, this step can be performed on graph paper.

Explain and Elaborate

7. Teacher poses a question for an instructional conversation on how personal experience of a place influences perception. Ask students to think of procedures for improving the quality of their image interpretations and have each group write a quality control suggestion on the board.

Reflect on Thinking

Students transition to individual journaling and complete a Reflective Summary that responds to the guiding question of the day.

Managing the Project

Groups complete work on their virtual field trip presentations, which will be presented in the next class session.

Student Preparation for Next Session

Students review *Presentation Rubric*.

GO DEEP...

The Canada Centre for Mapping and Earth Observation has a tutorial on remote sensing technology and its applications, appropriate for high school and early college level students. It goes in-depth into the elements of the remote sensing process with short quizzes interspersed.

Landsat satellites have captured images of Earth from space since 1972, providing a record of natural and human changes over time. USGS has produced an activity guide leading students through a step by step analysis of Landsat images using free MultiSpec software. The activities were written for grades 5 through 8 and include many extensions and a teacher guide.

Visit the *Coastal Voices Website* for links.

Activity

A Sense of the Coast Evaluation: Communicating Science Concepts

Guiding Questions:

- What is the best way to communicate science and social science concepts?

Materials Required:

- Individual student notebooks
- *Creativity*, *Presentation*, and *Collaboration Rubrics*, found in the Readings and Resources section.

In this gallery walk, each group will present the virtual field trip of their chosen California coastal park location.

Evaluate and Defend

Each group will be evaluated by rotating groups of peers. If class size exceeds forty students, consider a more formal theatre-style presentation.

1. Immediately upon entering the room, groups set up multimedia aids in their assigned spot.
2. Each group takes a few minutes to practice responding to questions with evidence.
3. Groups hang a large sheet of butcher paper next to their assigned spot, placing markers nearby so classmates can post comments.
4. If possible, rotate students so that each group's work is presented once by each group member. Audience members complete the *Presentation Rubrics*.

Construct Explanations and Reflect on Thinking

In their notebooks, students write a Reflective Summary that responds to the guiding question of the day.

At-Home

Students use the full rubric set (or as assigned by the teacher) for self and peer evaluation to reflect upon performance.

Monterey Bay, Photo: John Charles Bruckman

Connecting to the Standards

***A Sense of the Coast: Getting to Know the Golden Shore* supports the following *Next Generation Science Standards* Performance Expectations.**

HS-ESS2-1: Develop a model to illustrate how Earth's surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
HS-ESS3-1: 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.
HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

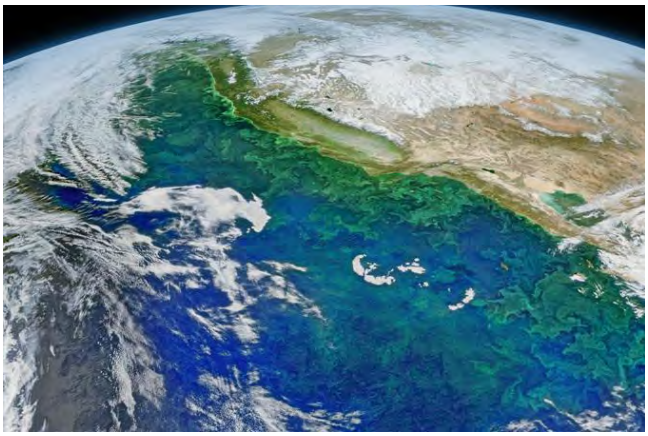
Environmental Principles and Concepts	Specific Connections to Unit / Activity Designation
Principle I—People Depend on Natural Systems	• Analysis of earth images from space followed by climate and biodiversity maps, making connections between populations and ecosystem services. (Elaboration) • Presentation of the virtual tour project. (Evaluation)
Principle II—People Influence Natural Systems	• Presentation of the virtual tour project. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Disciplinary Core Ideas	ESS2.A – Energy flows and matter cycles within and among Earth's systems. (6-8)	• Analyze surface and sea surface temperature tables showing change over time. (Elaboration)
	ESS2.C – Water movement causes weathering and erosion, changing landscape features. (6-8)	• Analysis of coastal image sets. (Exploration)
	ESS2.C – The planet's dynamics are greatly influenced by water's unique chemical and physical properties. (9-12)	• Analysis of coastal image sets and sea surface temperature data. (Explanation) • Analysis of satellite images and climate and biodiversity maps. (Elaboration)
	ESS2.D – Complex interactions determine local weather patterns and influence climate, including the role of the ocean. (6-8)	• Analysis of satellite and aerial images and Global Atmospheric Circulation Model. (Invitation to Engage) • Analysis of coastal image sets and sea surface temperature data. (Explanation)
	ESS3.A – Resource availability has guided the development of human society, and the use of natural resources has associated costs, risks, and benefits. (9-12)	• Analysis of coastal image sets. (Exploration)
	LS2.A – Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors. (6-8)	• Analysis of satellite images and climate and biodiversity maps. (Elaboration)
	LS4.D – Humans depend on biodiversity but also have adverse impacts on it. (9-12)	• Presentation of the virtual tour project. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Crosscutting Concepts	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (9-12)	• Presentation of the virtual tour project. (Evaluation)
	Patterns can be used to identify cause and effect relationships. (6-8)	• Analysis of coastal image sets. (Exploration) • Presentation of the virtual tour project. (Evaluation)
	Cause and effect relationships may be used to predict phenomena in natural systems. (6-8)	• Analysis of satellite images, climate and biodiversity maps, and surface and sea surface temperature data showing change over time. (Elaboration) • Presentation of the virtual tour project. (Evaluation)
	Phenomena that can be observed at one scale may not be observable at another scale. (6-12)	• Exploration of scale in an image of the school. (Extend)
	Models can be used to simulate systems and interactions. (6-8)	• Use a hands-on lab to produce a predictive model. (Invitation to Engage)
	Small changes in one part of a system might cause large changes in another part. (6-8)	• Analysis of coastal image sets and sea surface temperature data. (Explanation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Science and Engineering Practices	Ask questions to determine relationships between independent and dependent variables. (6-12)	• As part of analysis of satellite images, climate and biodiversity maps, and surface and sea surface temperature data showing change over time. (Elaboration)
	Use a model based on evidence to illustrate relationships between systems or between components of a system. (9-12)	• Use a hands-on lab to produce a predictive model. (Invitation to Engage)
	Use a model to predict and/or describe phenomena. (6-8)	• Use a hands-on lab to produce a predictive model. (Invitation to Engage)
	Analyze data in order to make valid and reliable scientific claims. (9-12)	• Analysis of coastal image sets and sea surface temperature data. (Explanation) • Analyze data showing changes in land and sea surface temperature to make claims regarding climate and biodiversity impacts. (Elaboration)
	Analyze and interpret data to provide evidence for phenomena. (6-8)	• Analysis of coastal image sets and sea surface temperature data. (Explanation)
	Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. (9-12)	• After analysis of satellite images, climate and biodiversity maps are added to the analysis. (Elaboration)
	Construct, use, and/present an oral argument based on data and evidence. (6-12)	• Throughout the unit during learning conversations. • Presentation of the virtual tour project. (Evaluation)
	Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. (6-8)	• Throughout the unit during learning conversations. • Presentation of the virtual tour project. (Evaluation)
	Communicate scientific and/or technical information or ideas in multiple formats. (6-12)	• Throughout the unit during learning conversations. • Presentation of the virtual tour project. (Evaluation)

Making Sense of Images



Earth Observatory, NASA

Images can be much more than a snapshot—they are often evidence of choices made, of a culture's impact on the land, and of the natural systems acting upon a place. Images can dramatically document changes over time: coastal weather hazards can be predicted, slow-moving geological processes can become visible, connections between biological communities can be seen. In a fast changing world of many environmental problems, image analysts provide insight into past choices, current conditions, and possible future scenarios that may be used to make sensible choices. Images do more than document problems—they often point the way to solutions.

Thinking Tools for Image Analysis

Coastal image analysts look for evidence relevant to specific questions they are seeking to answer or for a phenomenon they are seeking to explain. Analysts may start by looking for evidence of the following big ideas:

- Patterns
- Cause and effect mechanisms
- Scale
- Natural systems and boundaries/ intersections with other systems
- Structure and function
- Stability and change
- Energy flows and cycles

Observed **patterns** are the foundation of many scientific questions. Consider, for example, the patterns inscribed in beach sand by human activity or on water by wind.

Cause and effect relationships are often the focus of an image analysis. Once a pattern is noticed, the hunt for an explanation can begin. For example, you may have noticed the impact of a holiday on a beach or park. Overflowing garbage cans, plastic bags pinned in the bushes by wind, and footprints covering the beaches are all evidence of heavy human traffic the day before.

Scale and placement within **natural systems** is vital to image analysis. Before interpreting an image, it's helpful to know the general location and a reference for the size of the objects in the image. Considerations of scale, place, and their conceptual boundaries inform how an analyst will model a system. For example, the small beach shown above is on Lake Tahoe, a relatively closed system with an alpine climate. This makes the dynamics different from a beach on the temperate and energetic Pacific shore.

The concept of **structure and function** explores how the form or shape of an object or living thing is related to or depends upon its function, and vice versa. For example, coastal armoring structures (such as seawalls) are sometimes built to function as protection for homes that are too close to eroding bluffs and beaches. Natural rates of erosion within a beach system, angles of surf and currents, and the height of projected sea level rise must be understood to make informed choices as to how and whether to build on the coast or to install coastal armoring to protect existing structures.

Determining the degree of **stability and change** within the beach system is how engineers place parameters around these decisions. When looking at the photo on the right, two questions might be: how is the Pacific Ocean's level changing over time at the location, and what other factors (sand starvation, storms, el Niño) might be destabilizing the beach?

Finally, **energy**, energy flows, and the consequences of moving energy are a frequent focus of image analysis investigations of the natural systems in coastal zones. The moon, the atmosphere, the ocean, and adjacent land areas all impart energy to beaches. Energy is conserved, meaning that energy can't be created or destroyed, so typically the task of the image analysis becomes describing how the energy is flowing within a given place or natural system. Have you ever stood on a beach as a powerful wave breaks upon the shore, sending both vibrations into the sand and sound into the atmosphere?

These seven thinking tools may be used independently or woven together to reflect the complicated nature of natural systems. Your choice of tools will be governed by your purpose. For example, engineers planning to build a power plant will want to know if an area is geologically stable. A policy maker working on enhancing access to a beach would seek images that offer insights into transportation routes. Where to locate bathroom facilities or build low impact trails is another question answered using image analysis. Beach users seek shelter from the wind, so a bathroom could logically be sited near but not in these relatively rare spots. Beach users have historically created damaging informal trails, sometimes visible in aerial photographs. Placing low impact trails and boardwalks along these routes could make access easier and protect vulnerable plant and animal communities. This pathway in Palos Verdes protects sensitive coastal scrub habitat.

Interpretation of Aerial Photographs

The following elaborates on the Guiding Questions for Image Analysis worksheet.

Absolute Location: In what coastal region was this image created?

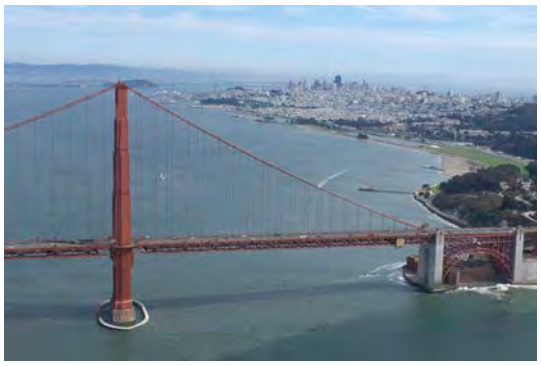
Use clues like plant communities or size of rivers to place the image in either the North, Central, or South Coast regions. Recognizable human-built landmarks can help. Distinctive types of trees (redwoods for example), or distinctively contoured points of land are the most common starting point for an analysis. For example, if the coast has large, impressive trees on both sides of a coastal point, the location is likely in a northern region; by contrast, if only low scrubby plants are visible then a location further south in the coastal scrub biome may be inferred initially. Be careful in your conclusions, as a location completely exposed to the North Coast's incessant winds will also have only low, ground-hugging plants. Piles of large logs on the beach will, however, be a reasonably definitive clue to North Coast beaches.

Place: What would a person in this place see, hear, and feel?

Determine what direction is north. Subsequently, think about the prevailing wind, direction that hills and cliffs face, evidence of precipitation, and plant community.

Normally, you should begin by looking for a reference object to give you a sense of scale. If buildings are present, find a home, school, or road. This will help you develop a good picture of things combined with your prior knowledge.

Human/Environment Interaction: How do humans depend upon and/or influence (positive or negative) the coastal environment in this place? What ecosystem services can you identify? Examples of some of the many ecosystem services include natural shoreline protection, water filtration, food production, carbon sequestration, and recreation.



Movement and Access: How are people accessing this place and how could access be improved? This may be considered from perspectives inside or outside of the study site but keep your purpose in mind. Increasing and enhancing access is one purpose, protecting and enhancing habitat is another. They might or might not be mutually exclusive.

Bio-Region: How and why is one area in this place similar to another? Can you identify any natural geographic boundaries?

Photos courtesy of the California Coastal Records Project.

Guiding Questions for Image Analysis

Place this handout in your project notebook for repeated reference.

Absolute Location: In what coastal region was this image created? What is your evidence?

Place: What would a person in this place see, hear, and/or feel? What is your evidence?

Human/Environment Interaction: How do humans depend upon and/or influence (positive or negative) the coastal environment in this place? What ecosystem services can you identify? What is your evidence?

Movement and Access: How are people accessing this place and how could access be improved? This should be considered from perspectives inside or outside of the study site, but be sure to use remote sensing tools to build your perspective.

Bio-Region: What natural factors influence the biological community found in this place? Be sure to consider climate, geology, geography, and vegetation distribution.

CREATIVITY & INNOVATION RUBRIC

Courtesy of the Buck Institute for Education

PROCESS:

Creativity & Innovation Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Launching the Project: Define the Creative Challenge	• may just "follow directions" without understanding the purpose for innovation or considering the needs and interests of the target audience	• understands the basic purpose for innovation but does not thoroughly consider the needs and interests of the target audience	• understands the purpose driving the process of innovation (Who needs this? Why?) • develops insight about the particular needs and interests of the target audience	
Building Knowledge, Understanding, and Skills: Identify Sources of Information	• uses only typical sources of information (website, book, article) • does not offer new ideas during discussions	• finds one or two sources of information that are not typical • offers new ideas during discussions, but stays within narrow perspectives	• in addition to typical sources, finds unusual ways or places to get information (adult expert, community member, business or organization, literature) • promotes divergent and creative perspectives during discussions (CC 11-12.SL.1c)	
Developing and Revising Ideas and Products: Generate and Select Ideas	• stays within existing frameworks; does not use idea-generating techniques to develop new ideas for product(s) • selects one idea without evaluating the quality of ideas • does not ask new questions or elaborate on the selected idea • reproduces existing ideas; does not imagine new ones • does not consider or use feedback and critique to revise product	• develops some original ideas for product(s), but could develop more with better use of idea-generating techniques • evaluates ideas, but not thoroughly before selecting one • asks a few new questions but may make only minor changes to the selected idea • shows some imagination when shaping ideas into a product, but may stay within conventional boundaries • considers and may use some feedback and critique to revise a product, but does not seek it out	• uses idea-generating techniques to develop several original ideas for product(s) • carefully evaluates the quality of ideas and selects the best one to shape into a product • asks new questions, takes different perspectives to elaborate and improve on the selected idea • uses ingenuity and imagination, going outside conventional boundaries, when shaping ideas into a product • seeks out and uses feedback and critique to revise product to better meet the needs of the intended audience (CC 6-12.W.5)	

CREATIVITY & INNOVATION RUBRIC, PROCESS, continued

Creativity & Innovation Opportunity at Phases of a Project	Below Standard	Approaching Standard	At Standard	Above Standard
Presenting Products and Answers to Driving Question: Present Work to Users/Target Audience	• presents ideas and products in typical ways (text-heavy slides, recitation of notes, no interactive features)	• adds some interesting touches to presentation media • attempts to include elements in presentation that make it more lively and engaging	• creates visually exciting presentation media • includes elements in presentation that are especially fun, lively, engaging, or powerful to the particular audience	

PRODUCT:

	Below Standard	Approaching Standard	At Standard	Above Standard
Originality	• relies on existing models, ideas, or directions; it is not new or unique • follows rules and conventions; uses materials and ideas in typical ways	• has some new ideas or improvements, but some ideas are predictable or conventional • may show a tentative attempt to step outside rules and conventions, or find new uses for common materials or ideas	• is new, unique, surprising; shows a personal touch • may successfully break rules and conventions, or use common materials or ideas in new, clever and surprising ways	
Value	• is not useful or valuable to the intended audience/user • would not work in the real world; impractical or unfeasible	• is useful and valuable to some extent; it may not solve certain aspects of the defined problem or exactly meet the identified need • unclear if product would be practical or feasible	• is seen as useful and valuable; it solves the defined problem or meets the identified need • is practical, feasible	
Style	• is safe, ordinary, made in a conventional style • has several elements that do not fit together; it is a mish-mash	• has some interesting touches, but lacks a distinct style • has some elements that may be excessive or do not fit together well	• is well-crafted, striking, designed with a distinct style but still appropriate for the purpose • combines different elements into a coherent whole	

Note: The term "product" is used in this rubric as an umbrella term for the result of the process of innovation during a project. A product may be a constructed object, proposal, presentation, solution to a problem, service, system, work of art or piece of writing, an invention, event, an improvement to an existing product, etc.

PRESENTATION RUBRIC

Courtesy of the Buck Institute for Education

	Below Standard	Approaching Standard	At Standard	Above Standard
Explanation of Ideas & Information	• does not present information, arguments, ideas, or findings clearly, concisely, and logically; argument lacks supporting evidence; audience cannot follow the line of reasoning • selects information, develops ideas and uses a style inappropriate to the purpose, task, and audience (may be too much or too little information, or the wrong approach) • does not address alternative or opposing perspectives	• presents information, findings, arguments and supporting evidence in a way that is not always clear, concise, and logical; line of reasoning is sometimes hard to follow • attempts to select information, develop ideas and use a style appropriate to the purpose, task, and audience but does not fully succeed • attempts to address alternative or opposing perspectives, but not clearly or completely	• presents information, findings, arguments and supporting evidence clearly, concisely, and logically; audience can easily follow the line of reasoning (CC 9-12.SL.4) • selects information, develops ideas and uses a style appropriate to the purpose, task, and audience (CC 9-12.SL.4) • clearly and completely addresses alternative or opposing perspectives (CC 11-12.SL.4)	
Organization	• does not meet requirements for what should be included in the presentation • does not have an introduction and/or conclusion • uses time poorly; the whole presentation, or a part of it, is too short or too long	• meets most requirements for what should be included in the presentation • has an introduction and conclusion, but they are not clear or interesting • generally times presentation well, but may spend too much or too little time on a topic, a/v aid, or idea	• meets all requirements for what should be included in the presentation • has a clear and interesting introduction and conclusion • organizes time well; no part of the presentation is too short or too long	
Eyes & Body	• does not look at audience; reads notes or slides • does not use gestures or movements • lacks poise and confidence (fidgets, slouches, appears nervous) • wears clothing inappropriate for the occasion	• makes infrequent eye contact; reads notes or slides most of the time • uses a few gestures or movements but they do not look natural • shows some poise and confidence, (only a little fidgeting or nervous movement) • makes some attempt to wear clothing appropriate for the occasion	• keeps eye contact with audience most of the time; only glances at notes or slides • uses natural gestures and movements • looks poised and confident • wears clothing appropriate for the occasion	

PRESENTATION RUBRIC, continued

	Below Standard	Approaching Standard	At Standard	Above Standard
Voice	• mumbles or speaks too quickly or slowly • speaks too softly to be understood • frequently uses "filler" words ("uh, um, so, and, like, etc.") • does not adapt speech for the context and task	• speaks clearly most of the time • speaks loudly enough for the audience to hear most of the time, but may speak in a monotone • occasionally uses filler words • attempts to adapt speech for the context and task but is unsuccessful or inconsistent	• speaks clearly; not too quickly or slowly • speaks loudly enough for everyone to hear; changes tone and pace to maintain interest • rarely uses filler words • adapts speech for the context and task, demonstrating command of formal English when appropriate (CC 9-12.SL.6)	
Presentation Aids	• does not use audio/visual aids or media • attempts to use one or a few audio/visual aids or media, but they do not add to or may distract from the presentation	• uses audio/visual aids or media, but they may sometimes distract from or not add to the presentation • sometimes has trouble bringing audio/visual aids or media smoothly into the presentation	• uses well-produced audio/visual aids or media to enhance understanding of findings, reasoning, and evidence, and to add interest (CC 9-12.SL.5) • smoothly brings audio/visual aids or media into the presentation	
Response to Audience Questions	• does not address audience questions (goes off topic or misunderstands without seeking clarification)	• answers audience questions, but not always clearly or completely	• answers audience questions clearly and completely • seeks clarification, admits "I don't know" or explains how the answer might be found when unable to answer a question	
Participation in Team Presentations	• Not all team members participate; only one or two speak	• All team members participate, but not equally	• All team members participate for about the same length of time • All team members are able to answer questions about the topic as a whole, not just their part of it	

COLLABORATION RUBRIC

Courtesy of the Buck Institute for Education

Individual Performance	Below Standard	Approaching Standard	At Standard	Above Standard
Takes Responsibility for Oneself	• is not prepared, informed, and ready to work with the team • does not use technology tools as agreed upon by the team to communicate and manage project tasks • does not do project tasks • does not complete tasks on time • does not use feedback from others to improve work	• is usually prepared, informed, and ready to work with the team • uses technology tools as agreed upon by the team to communicate and manage project tasks, but not consistently • does some project tasks, but needs to be reminded • completes most tasks on time • sometimes uses feedback from others to improve work	• is prepared and ready to work; is well informed on the project topic and cites evidence to probe and reflect on ideas with the team (CC 6-12.SL.1a) • consistently uses technology tools as agreed upon by the team to communicate and manage project tasks • does tasks without having to be reminded • completes tasks on time • uses feedback from others to improve work	
Helps the Team	• does not help the team solve problems; may cause problems • does not ask probing questions, express ideas, or elaborate in response to questions in discussions • does not give useful feedback to others • does not offer to help others if they need it	• cooperates with the team but may not actively help it solve problems • sometimes expresses ideas clearly, asks probing questions, and elaborates in response to questions in discussions • gives feedback to others, but it may not always be useful • sometimes offers to help others if they need it	• helps the team solve problems and manage conflicts • makes discussions effective by clearly expressing ideas, asking probing questions, making sure everyone is heard, responding thoughtfully to new information and perspectives (CC 6-12.SL.1c) • gives useful feedback (specific, feasible, supportive) to others so they can improve their work • offers to help others do their work if needed	
Respects Others	• is impolite or unkind to teammates (may interrupt, ignore ideas, hurt feelings) • does not acknowledge or respect other perspectives	• is usually polite and kind to teammates • usually acknowledges and respects other perspectives and disagrees diplomatically	• is polite and kind to teammates • acknowledges and respects other perspectives; disagrees diplomatically	

COLLABORATION RUBRIC, continued

Team Performance	**Below Standard**	**Approaching Standard**	**At Standard**	**Above Standard**
Makes and Follows Agreements	• does not discuss how the team will work together • does not follow rules for collegial discussions, decision-making and conflict resolution • does not discuss how well agreements are being followed • allows breakdowns in teamwork to happen; needs teacher to intervene	• discusses how the team will work together, but not in detail; may just "go through the motions" when creating an agreement • usually follows rules for collegial discussions, decision-making, and conflict resolution • discusses how well agreements are being followed, but not in depth; may ignore subtle issues • notices when norms are not being followed but asks the teacher for help to resolve issues	• makes detailed agreements about how the team will work together, including the use of technology tools • follows rules for collegial discussions (CC 6-12.SL.1b), decision-making, and conflict resolution • honestly and accurately discusses how well agreements are being followed • takes appropriate action when norms are not being followed; attempts to resolve issues without asking the teacher for help	
Organizes Work	• does project work without creating a task list • does not set a schedule and track progress toward goals and deadlines • does not assign roles or share leadership; one person may do too much, or all members may do random tasks • wastes time and does not run meetings well; materials, drafts, notes are not organized (may be misplaced or inaccessible)	• creates a task list that divides project work among the team, but it may not be in detail or followed closely • sets a schedule for doing tasks but does not follow it closely • assigns roles but does not follow them, or selects only one "leader" who makes most decisions • usually uses time and runs meetings well, but may occasionally waste time; keeps materials, drafts, notes, but not always organized	• creates a detailed task list that divides project work reasonably among the team (CC 6-12.SL.1b) • sets a schedule and tracks progress toward goals and deadlines (CC 6-12.SL.1b) • assigns roles if and as needed, based on team members' strengths (CC 6-12.SL.1b) • uses time and runs meetings efficiently; keeps materials, drafts, notes organized	
Works as a Whole Team	• does not recognize or use special talents of team members • does project tasks separately and does not put them together; it is a collection of individual work	• makes some attempt to use special talents of team members • does most project tasks separately and puts them together at the end	• recognizes and uses special talents of each team member • develops ideas and creates products with involvement of all team members; tasks done separately are brought to the team for critique and revision	

CRITICAL THINKING RUBRIC

Courtesy of the Buck Institute for Education

Critical Thinking Opportunity at Phases of a Project	**Below Standard**	**Approaching Standard**	**At Standard**	**Above Standard**
Launching the Project: Analyze Challenging Question and Begin Inquiry	• sees only superficial aspects of, or one point of view on, the Challenging Question	• identifies some central aspects of the Challenging Question, but may not see complexities or consider various points of view • asks some follow-up questions about the topic or the wants and needs of the audience or users of a product, but does not dig deep	• shows understanding of central aspects of the Challenging Question by identifying in detail what needs to be known to answer it and considering various possible points of view on it • asks follow-up questions that focus or broaden inquiry, as appropriate (CC 6-12.W.7) • asks follow-up questions to gain understanding of the wants and needs of audience or product users	
Building Knowledge, Understanding, and Skills: Gather and Evaluate Information	• is unable to integrate information to address the Challenging Question; gathers too little, too much, or irrelevant information, or from too few sources • accepts information at face value (does not evaluate its quality)	• attempts to integrate information to address the Challenging Question, but it may be too little, too much, or gathered from too few sources; some of it may not be relevant • understands that the quality of information should be considered, but does not do so thoroughly	• integrates relevant and sufficient information to address the Challenging Question, gathered from multiple and varied sources (CC 6,11-12.RI.7) • thoroughly assesses the quality of information (considers usefulness, accuracy and credibility; distinguishes fact vs. opinion; recognizes bias) (CC 6-12.W.8)	
Developing and Revising Ideas and Products: Use Evidence and Criteria	• accepts arguments for possible answers to the Challenging Question without questioning whether reasoning is valid • uses evidence without considering how strong it is • relies on “gut feeling” to evaluate and revise ideas, product prototypes or problem solutions (does not use criteria)	• recognizes the need for valid reasoning and strong evidence, but does not evaluate it carefully when developing answers to the Challenging Question • evaluates and revises ideas, product prototypes or problem solutions based on incomplete or invalid criteria	• evaluates arguments for possible answers to the Challenging Question by assessing whether reasoning is valid and evidence is relevant and sufficient (CC 6-12.SL.3, RI.8) • justifies choice of criteria used to evaluate ideas, product prototypes or problem solutions • revises inadequate drafts, designs or solutions and explains why they will better meet evaluation criteria (CC 6-12.W.5)	

CRITICAL THINKING RUBRIC, continued

Critical Thinking Opportunity at Phases of a Project	**Below Standard**	**Approaching Standard**	**At Standard**	**Above Standard**
Presenting Products and Answers to Driving Question: Justify Choices, Consider Alternatives & Implications	• chooses one presentation medium without considering advantages and disadvantages of using other mediums to present a particular topic or idea • cannot give valid reasons or supporting evidence to defend choices made when answering the Challenging Question or creating products • does not consider alternative answers to the Challenging Question, designs for products, or points of view • is not able to explain important new understanding gained in the project	• considers the advantages and disadvantages of using different mediums to present a particular topic or idea, but not thoroughly • explains choices made when answering the Challenging Question or creating products, but some reasons are not valid or lack supporting evidence • understands that there may be alternative answers to the Challenging Question or designs for products, but does not consider them carefully • can explain some things learned in the project, but is not entirely clear about new understanding	• evaluates the advantages and disadvantages of using different mediums to present a particular topic or idea (CC 8.RI.7) • justifies choices made when answering the Challenging Question or creating products, by giving valid reasons with supporting evidence (CC 6-12.SL.4) • recognizes the limitations of an answer to the Challenging Question or a product design (how it might not be complete, certain, or perfect) and considers alternative perspectives (CC 11-12.SL.4) • can clearly explain new understanding gained in the project and how it might transfer to other situations or contexts	

APPLICATION OF CONTENT KNOWLEDGE: FORMAL WRITTEN REPORTS AND PUBLIC PRESENTATIONS RUBRIC

Indicators of Achievement Adapted from Costa and Kallick, NCTE, and NGSS

Habit of Mind	Unsatisfactory	Growing to Competency	Competent (State Standard)	Distinguished
Striving for Accurancy	Sloppy or incomplete work with no evidence of revision or editing process. Feedback from peer reviewers and adult colaborators is not incorporated into work.	Student occasionally reviews checklists, rubrics, and peer feedback to enhance wrtten communications. Care is taken to convey significnat science concepts with examples and data.	Student understands and can apply two to three relevant science concepts in a written sequence of claims, evidence, and reasoning. Student works with peers as instructional resources.	Without sacrificing scientific accuracy, student constructs a coherent storyline referencing California places, issues, and connections to his or her own life. Student demonstrates a command of writing mechanics, organization, and ability to revise and edit.
Creative Questioning	Student does not initiate questioning in any written or verbal form. When questions are asked, they focus on meeting minimum requirements as articulated by adults.	Student intiates science-based questioing with support from peers or teachers. The value of questioing is understood, but the habit is still being cultivated.	Student independently produces original questions, considers questions from multiple perspectives, and produces original answers. Student brainstorms with others during the questioning process and listens carefully to arguments made by peers.	Student uses science and engineering practices to develop personalized place-based driving questions with connections to science concepts and to the ideas of classmates. Student considers alternative perspectives and nurtures an inclination to question daily.
Applying Past Knowledge to New Situations	Science notebooks, feedback from peers, and previous experience does not inform actions or writing.	When reminded and supported, prior knowledge is accessed and used to improve speaking and written communications.	Student consistently uses prior knowledge to investigate new phenomena. Reference to previous experience or careful use of analogies may be seen.	Student consistently uses prior knowledge to investigate new phenomena. Reference to previous experience or careful use of analogies may be seen.
Thinking and Communicating with Clarity and Precision	Use of vague and imprecise language leads to confusion about meaning. Science vocabulary is missiing or used incorrectly.	Science concepts and ideas are communicated using analogies from everyday life, but subtle distinctions are lost due to a lack of vocabulary or incomplete grasp of scientific concepts.	Student avoids generalizations and distortions of fact while clearly defining science terms, concepts, and ideas. Student can distinguish between closely related science topics (e.g. weather and climate, or heat and temperature).	Students use exact language to convey science concepts and emerging ideas. Claims are supported with evidence and reasoning that is grounded in place, personal experience, and relevant science concepts. Writing is concise, descriptive, and coherent.

SCIENCE NOTEBOOK AND EXIT TICKET RUBRIC

NGSS Element	**Unsatisfactory**	**Growing to Competency**	**Competent (State Standard)**	**Distinguished**
Crosscutting Concepts	Student does not show connections across content area boundaries. Most learning activity is limited to memorizing facts without context.	Student identifies patterns and classifies relationships as causal or correlational. Student understands that events that occur closely in time may or may not be related.	Student places significant knowledge in context using systems, models, and causal analysis. Student evaluates questions and models for testability, arguments for validity, and solutions for practicality.	Explanatory power of crosscutting concepts is fully utilized to think and write as scientists do while addressing real world environmental problems. Alternative explanations are routinely considered, as is instrument error.
Science and Engineering Practices	Student identifies testable questions and performs simple qualitative investigations, but fails to recognize the many ways that scientists perform their work.	Student specifies relationships, between variables and clarifies arguments, but rarely evaluates or proposes solutions.	Student uses evidence and computational thinking to analyze geoscience data, construct arguments, develop conceptual models, plan investigations, and propose science-based actions.	Science and engineering practices are habitually referenced in writing. System level thinking is demonstrated in reference to boundaries, interactions, and constraints posed by methods, society, or environmental concerns.
Disciplinary Core Ideas	Student does not demonstrate understanding of science content; science vocabulary is wholly absent.	Student can identify components, yet understandings about relationships between components are elusive. Placing knowledge in context, using thinking tools like the crosscutting concepts is rare, but increasing.	Student presents Earth systems that are dynamic, interactive, and composed of both living and non-living features, with feedback effects that may be altered by human activity. Science vocabulary is weilded with precision and clarity.	Writing is precise and clear with no composition or style errors leading to elegant place-based expression of science concepts. Student makes a personal connection to the information and acts upon valid science information.
Conceptual Models	Work is inaccurate, lacking most needed components; messy craftsmanship detracts from overall presentation and obscures meaning.	Poor craftsmanship obscures meaning. Model is missing an element needed to completely understand science concepts or make predictions.	Model is neat; all depictions are accurate, legible, and scientifically defensible. Models have components, relationships, and connections labeled. Predictions about future conditions may be made.	Models can be used to evalute the merits and disadvantages of various actions, generate predictions, and quantify relationships between components or variables.