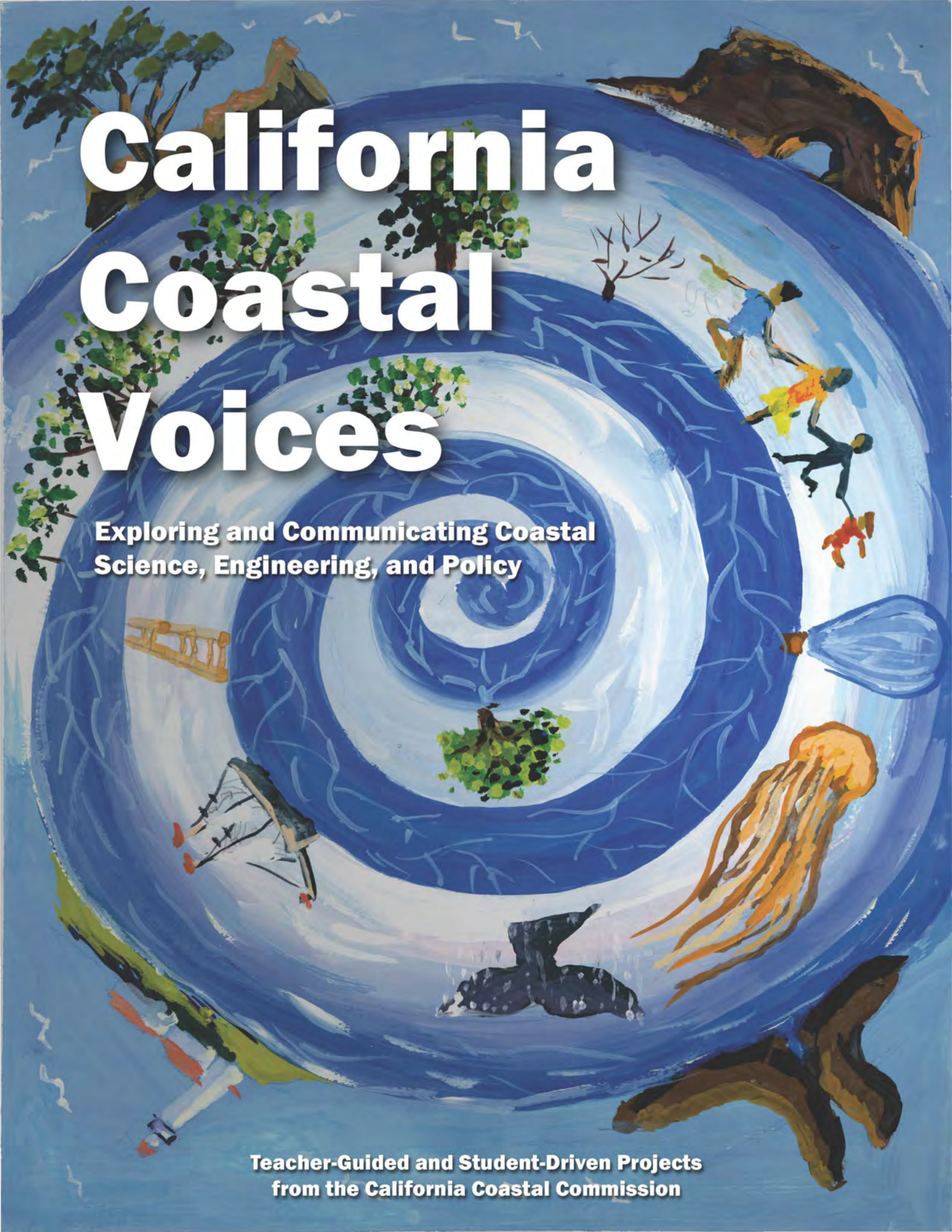


California Coastal Voices

Exploring and Communicating Coastal Science, Engineering, and Policy

Teacher-Guided and Student-Driven Projects
from the California Coastal Commission

California Coastal Voices

Exploring and Communicating Coastal Science, Engineering, and Policy

Teacher-Guided and Student-Driven Projects from the California Coastal Commission

Curriculum Developer
Kurt Holland

Editing and Writing
Annie Kohut Frankel
Christiane M.R. Parry

The projects in this book rely heavily on material available on the Coastal Voices Website:

www.coastal.ca.gov/coastalvoices

The California Coastal Commission was established by voter initiative in 1972 and made permanent by the California Legislature in 1976 with the passage of the California Coastal Act. The Commission is committed to protecting and enhancing California's coast and ocean for present and future generations through careful planning and regulation of environmentally-sustainable development, rigorous use of science, strong public participation, education, and effective intergovernmental coordination. The Commission's Public Education Program, including the Whale Tail® Grants, is funded through purchases of Whale Tail® License Plates and donations to the Protect Our Coast and Oceans Fund on California tax forms.

California Coastal Commission
Public Education Program
45 Fremont Street, Suite 2000
San Francisco, CA 94105
(415) 904-5200
coast4u@coastal.ca.gov
coastforyou.org

California Coastal Voices

Exploring and Communicating Coastal Science, Engineering, and Policy in California

Teacher Support Pieces

Teacher-Guided Inquiry Projects

Student-Driven Community-Based Projects

Readings & Resources

Advisors

Teacher Advisors

Tara Treiber, New Roads High School
Anand Patel, PhD, Crossroads High School & Santa Monica College
Meg Jakuboski, Education Director, NatureBridge
Martha Chacon, Santa Monica High School
Jennifer Swart, Heal the Bay
Brian Brown, Water Education Foundation
Joseph Centoni, Half Moon Bay High School
Jesse Madsen, San Rafael High School

Student Advisors

Sadie Mae Saltzman, Skidmore College
Dylan Archer, UCSC
Allegra Fonda-Bonardi, Harvard and MIT
Mateo VanHolland, UCSC
Hannah Nicholson, Santa Monica High School

Project-Based Learning Advisors

John Larmer, Chief Editor, Buck Institute for Education
Elliot Washor, Founder and Co-Director of Big Picture Learning
Jessica Rishe, Big Picture Learning and Principal, Santa Monica-Malibu USD
Marni Masuda-Cleveland, National Faculty, Buck Institute for Education
Micki Evans, National Faculty, Buck Institute for Education
James Fester, National Faculty, Buck Institute for Education
Kristyn Kamps, National Faculty, Buck Institute for Education
Al Summers, National Faculty, Buck Institute for Education

Acknowledgements

Thank you to the California State Parks Foundation for serving as the fiscal agent for this project. Many educational organizations contributed materials or allowed us to adapt their work including: Buck Institute for Education; Constitutional Rights Foundation; Lawrence Hall of Science; the Science Education Resource Center at Carleton College. We leaned heavily on images, technical expertise, and data from various branches of the National Oceanic and Atmospheric Administration. Several activities and diagrams first appeared in the California Coastal Commission's *Waves, Wetlands, and Watersheds* by Julia Copple Davenport. Many of the activities were piloted at Ocean Literacy workshops hosted by Channel Islands National Marine Sanctuary. NASA science communicators were generous with both time and their materials, particularly Holli Riebeek, now at Goddard Space Flight Center. Sarah Sikich, of Heal the Bay, was both an inspiration and a valued partner. Erin Selleck, Kurt's wife, gave generously of her time and talents toward their shared goals of protecting and enhancing California's coast.

Most of the coastal shoreline photos come from the California Coastal Records Project, the extraordinary collection of pilot Gabrielle Adelman and photographer Kenneth Adelman. Thank you to the Adelmans for making the California coast visible to anyone with an internet connection.

Individuals who gave their time, scientific materials, or technical expertise include: Gary Griggs, UC Santa Cruz; Linda Chilton, USC-Sea Grant; Al Trujillo, Palomar College; Ron Steffens, Green Mountain College; Tom Ford, The Bay Foundation; Lyndell Whitley, Wrigley Institute for the Environment; Mark Abramson, Santa Monica Bay Restoration Commission; Gerald A. Lieberman, State Education and Environment Roundtable; and Greg Benoit, Lesley Ewing, Susan Hansch, Leah L. Henry, Charles Lester, Linda Locklin, Luna Taylor, and Matt Yurko, staff of the California Coastal Commission.

Cover art by Karina He, from the 2015 California Coastal Art & Poetry Contest.

Introduction

The coast is emblematic of California, from sunny, sandy beaches with volleyball courts and lifeguard towers to redwood crested rocky crags. California's climate, ecology, and economy are intertwined with the coast and ocean and these connections offer a perfect learning opportunity for middle and high school students to delve into interesting and complex subjects.

California Coastal Voices is a project-based learning tool designed to address science, social science, and environmental literacy. The projects and activities note specific connections to the Next Generation Science Standards performance expectations and three dimensions, the History-Social Science Standards, and California's Environmental Principles and Concepts. Consisting of six "projects" or stand-alone units that introduce students to coastal conflicts, challenges, and scientific and policy issues, the emphasis is on problem solving and communication. The projects, which can be modified to meet student interests and needs, will be especially useful for teachers of environmental science or those who seek to integrate Earth science into biology, chemistry, or physics classes. Several of the projects work well in government and seminar classes.

California Coastal Voices incorporates strategies that have been teacher-tested and proven in classrooms throughout California and are endorsed by the *California Science Framework*, including:

- Problem-based learning, a form of project-based learning as articulated by the Buck Institute for Education
- The BSCS 5E instructional model (engage, explore, explain, elaborate, evaluate)
- Science notebooks
- Outdoor learning experiences

California Coastal Voices supports student learning of California's *Environmental Principles and Concepts* to nurture and celebrate environmental literacy. Students participating in the *California Coastal Voices* projects explore natural systems, consider how people influence natural systems, and are empowered to directly participate in decision-making about complex natural resource management issues. Students investigate local environments as their context for learning and think about how human society has altered and been influenced by natural functions. Keeping learning relevant to students' own lives supports educational equity by empowering students to be agents of change in their communities.

> "The learning cycle, or 5E sequence of instruction, is one of the science education community's most studied, tried-and-true approaches for helping students learn about science content and practices."
>
> "The CA NGSS emphasize the importance of making sense of phenomena and solving problems by using all three dimensions of learning [i.e. science and engineering practices, disciplinary core ideas, and crosscutting concepts]. Instructional approaches such as problem-based learning and project-based learning provide students with the time and support to successfully engage in three-dimensional learning."
>
> *2016 California Science Framework*

The *California Coastal Voices* projects fall into two types:

- **Teacher-Guided Projects** are designed to be accessible to most secondary school teachers. The three *Teacher-Guided Projects* have more scaffolding, are more tightly-constructed, and are less open-ended than the *Student-Driven Projects*. They include step-by-step instructions for classroom activities, and although these activities work best as part of the entire Project, most can be pulled out for stand-alone use. Key elements of project-based learning are woven into an enhanced 5E learning cycle with an instructional focus on the crosscutting concepts from NGSS and two key science and engineering practices: arguing from evidence and modeling.
- **Student-Driven Projects** have been designed to incorporate the elements of high quality project-based learning as articulated by the Buck Institute for Education. While accessible to any motivated teacher, the three *Student-Driven Projects* are most suitable for teachers with experience managing highly differentiated student-driven classrooms, high levels of student choice, and project-based learning routines.

Art by Alejandra Martinez, 10th grade

Please read *Organizing for Student Success* to orient yourself to the contents of the guide and tips for teaching. *Essential Elements of Project-Based Learning* provides background on this instructional strategy. Following the six projects is a Readings and Resources section that contains tools for group learning, rubrics for self-assessment, and readings on California coastal law and on remote sensing analysis that are required for some projects. Finally, please make use of the *Coastal Voices Website* at **www.coastal.ca.gov/coastalvoices** for slideshows, images, videos, and links needed for the projects as well as for additional teacher background reading.

Thank you for bringing the California coast into your classroom and helping to inspire your students to be engaged, active, educated stewards of our natural world. California, the nation, and the ocean are waiting for them.

Organizing for Student Success

What follows is an overview of the tools and strategies in *California Coastal Voices*. "Part A" is applicable to all six Projects, both *Teacher-Guided* and *Student-Driven*. It includes a description of tools, suggested classroom strategies, two methods of assessment, and a chart showing student and teacher roles over the course of a project. "Part B" provides additional guidance specifically for *Student-Driven Projects*.

Part A: Teacher-Guided and Student-Driven Projects

Tools

- The **Daily Phenomenon** is a warm up for use in the first minutes of class. This tool, which is built into the *Teacher-Guided Projects*, focuses on crosscutting concepts and constructing arguments from evidence. *Student-Driven Projects* also benefit from implementing this routine. The Daily Phenomenon is the "engage" step of the 5E cycle for a single class session and is often an image (downloadable from the *Coastal Voices Website* at **www.coastal.ca.gov/coastalvoices**) for students to analyze independently in their notebooks.
- **Thematic Slideshows** featuring the California coast are available as downloads from the *Coastal Voices Website* and are used in some of the *Teacher-Guided* activities as well as for the Daily Phenomena.
- **Making Sense of Images** and the **Guiding Questions for Image Analysis** support student acquisition of the crosscutting concepts, geographic familiarity with the coast, and ability to construct arguments from evidence. Both are available in the Readings and Resources section of *California Coastal Voices*.
- **Go Deep** sidebars are opportunities to delve further into significant topics via additional labs, diagrams, readings, or complementary curriculum from partners such as NOAA, Lawrence Hall of Science, and NASA.

Key Instructional Strategies

Prep for "Just in Time" Personalized Instruction before the project begins. Teachers should spend time with the technical issues addressed in the project, background readings, and NGSS performance expectations to ensure that content knowledge can be deployed as needed.

Group Management Contracts are a critical component of managing project-based learning. Should time allow, guide students through the process of creating group agreements. There are many examples online, ranging from simple to complex. You will find a sample *Group Management Contract* in the Readings and Resources section.

Group Roles help ensure accountability and smooth work flow within student teams. Additionally, they encourage teenagers to try on various professional roles. The following suggested roles are referenced within *Student-Driven Projects* and may be assigned for *Teacher-Guided Projects* as well:

1. Principal Investigator: The project leader partners with the teacher to advance the project. Specific responsibilities include attending mini-lessons (research strategies, time management, prioritization) given by the teacher, teaching those same concepts/skills to their team, and relaying logistical information to the team.
2. Scientist: In partnership with the teacher, the scientist leads the team in science thinking, attends mini-lessons and labs led by the teacher, and focuses on explaining the natural world using evidence, conceptual models, and reasoning.
3. Engineer: Students in this role define problems and potential engineering solutions. They make choices about solutions based on the best available science, relevant government policies, and availability of resources. They attend engineering briefings as assigned by the teacher and lead designing, building, and testing any material objects the team decides to construct.
4. Policy Analyst: This role requires keeping one foot in environmental science and the other in government policy and benefits from an ability to think and reason following legal frameworks. This person attends policy briefings offered by the teacher and conveys concepts to the team.

Get Outside: Leaving the classroom to interact with the community is even better than bringing professionals into the classroom. The enhanced learning experience is worth the effort of coordinating with other teachers, scheduling transportation, and filling out paperwork. Most of the projects in *California Coastal Voices* can be done without leaving the classroom (or easily altered to that end); however, all are improved by engaging learners with the world beyond the school. Facilitating a field experience may mean partnering with afterschool organizations, local non-profits, and parents.

Student Assessment Routines

Self-Assessment with Rubrics

Assessment is designed to support students as they learn to manage their own learning, thinking processes, and formative interactions with adults. A key goal is helping students visualize and cultivate desirable Habits of Mind as articulated by Costa and Kallick, especially creative questioning, persisting to completion, and listening with empathy and understanding.

How do you make a Habit of Mind visible, learnable, and measurable for students? One answer is to clearly frame a goal referencing a specific Habit of Mind, develop observable indicators with your students, and consistently focus upon those indicators during formative and summative evaluations. Rubrics are a way to frame and assess these goals. Four rubrics to be used with every project are included in the

16 Habits of Mind goals:

- Persisting
- Managing impulsivity
- Listening with understanding and empathy
- Thinking flexibly
- Thinking about thinking (metacognition)
- Striving for accuracy
- Questioning and posing problems
- Applying past knowledge to new situations
- Thinking and communicating with clarity and precision
- Gathering data through all senses
- Creating, imagining, innovating
- Responding with wonderment and awe
- Taking responsible risks
- Finding humor
- Thinking interdependently
- Remaining open to continuous learning

Arthur L. Costa and Bena Kallick, 2000

Readings and Resources section of *California Coastal Voices.* Designed by the Buck Institute for Education, these rubrics cover critical thinking, creativity and innovation, collaboration, and presentation skills. Two additional rubrics are also available for the evaluation of scientific writing in formal papers, student journals, and exit tickets.

Assessment with Science Notebooks

Notebooks can help document changes in student thinking and can be a place to build out conceptual models or otherwise make thinking visual. The *California Science Framework* and the *California English Language Arts/English Language Development Framework* support science notebooks as a tool to differentiate learning and support student thinking and reflective self-evaluation. Throughout the Projects, students are encouraged to use their notebook for Daily Phenomenon analysis, developing and revising models, and individual reflection on daily Guiding Questions, as well as to keep track of their group project work.

Standards Connections

Teacher-Guided Projects articulate state education standards within the activity instructions and in a detailed table following each unit.

In *Student-Driven Projects*, learning goals connecting to standards are co-authored with students and included in personal learning plans.

Pismo Beach Pier. Photo: Janet Veta

Visualizing the Classroom

What are the students and the teacher each doing during the different stages of the 5E cycle in *California Coastal Voices* Projects? The following chart (modified from Bybee, San Diego County Office of Education, and J. Spiegel) offers an overview of both the routine of a single class session as well as the arc of an entire project.

	Enhanced 5E Stage	Student Role	Teacher Role
Invitation to Engage	Initiates the learning task, accesses prior knowledge, and organizes student thinking toward outcomes of current activities.	• Shows interest • Engages in problem and expresses own ideas • Asks questions such as, Why did this happen? What do I already know about this? What can I find out about this? How can this problem be solved?	• Raises questions or problems with a dynamic engaging event • Elicits responses that uncover students' prior knowledge • Helps students make personal and place-based connections to project • Posts challenging question and performance task (real world problem to be solved)
Explore Questions	Common base of experiences within which concepts, processes, and skills are developed.	• Creates conceptual models, questions new ideas • Discusses problems with others. Records observations and ideas in project notebook (Continues every week)	• Helps students develop a detailed question • Provides common experience • Observes and listens to students • Acts as a coach for students • Gathers final evidence of student understanding
Explain & Reflect	Students demonstrate their understanding. Teacher provides resources and information to support student learning. Formal definitions and science details are provided.	• Explains possible solutions or answers to other students • Listens critically to and questions other explanations • Refers to science and engineering practices • Uses evidence and vocabulary	• Encourages students to explain concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally provides definitions, explanations, and new vocabulary through mini lecture, text, or Daily Phenomenon • Builds on student ideas and explanations
Elaborate & Extend in to Application	Students' understanding is challenged and extended, Habits of Mind are further developed. Knowledge is applied to real world issues in the community.	• Applies new understanding and skills to community action • Proposes solutions, makes decisions, designs further experiments, or completes a challenge • Creates models and arguments from evidence	• Supports students as they use vocabulary, definitions, and explanations previously developed from experience • Encourages students to apply the concepts and skills in new situations • Provides alternative explanations
Evaluate with Public Product	Teacher and students assess understanding and skills. Assessment is formal and informal, summative and formative.	• Gives another student feedback • Self-assesses progress and knowledge • Checks work with a rubric	• Asks reflection questions: Why do you think…? What evidence do you have? Where could you go from here? • Gathers final evidence of student understanding

Part B: More Guidance for Student-Driven Projects

Effective management of learning experiences and careful implementation of classroom routines are the foundation of the *Student-Driven Projects*. Links to additional resources for teaching using the project-based learning model can be found on the *Coastal Voices Website* at **www.coastal.ca.gov/coastalvoices**, but three recommended actions for teachers are briefly explored here:

- Initiate a **culture of inquiry** emphasizing creative questioning, continuous improvement, and student leadership.
- Design and execute **project entry events** and other invigorating, shared learning experiences.
- Deploy **process management tools**: process guides, learning rubrics, contracts, checklists, project roles, and discussion protocols to scaffold learning.

Create a Culture of Inquiry

Project-based learning classrooms are like road trips in that the quality of the experience depends on who steers, controls the speed of movement, and chooses the destination, with the goal that burdens are shared, questions are raised and answers are sought jointly, and accomplishments and failures are regarded as equal opportunities to learn. Consider reserving a regular period for class activities that support desirable Habits of Mind such as student independence, an inclination to question, attention to quality, personal growth mindset, and team spirit. Visit the *Coastal Voices Website* for suggestions.

Launching Projects with a Powerful Entry Event

Effective projects are launched by great entry events, encouraging sustained activity driven by personal interest and the desire to understand. They must be exciting for students, convey the teacher's enthusiastic commitment to the subject, and raise questions that need to be answered. It is these questions that guide the project forward to success. In *Student-Driven Projects* you are encouraged to start with a high quality speaker with direct experience of the challenging question. If this is not possible, good alternatives include videos or online meetings such as those facilitated by the PORTS program of California State Parks.

Process Management Tools included in the Student-Driven Projects

I. Teacher Guides include preparation tasks specific to the Project and may provide background reading for teachers along with weekly questions. To encourage strategic questioning by students, an option is to have one student from each group investigate a question in the *Teacher Guide* and report out to the group. Another strategy is to support the students in finding their own way to these questions. Individual or small group guidance should be provided as needed to ensure that significant facts, concepts, and principles are understood.

II. Teacher Checklist for Student-Driven Projects is found in the Readings and Resources section and guides the teacher in their responsibilities from a Project's start to finish.

III. Student Readings in the *Student-Driven Projects* orient students to the tasks inherent to each phase of the Project and provide a tool for accomplishing the task. The readings align to the following sequence (a version of the 5E instructional cycle):

1. **Invitation to Engage:** This first reading states the challenging problem introduced during the engaging entry event, helps students understand why the Project is important, and helps them determine with whom they will share the work. The *Student Checklist* points the way forward and should be handed out soon after the *Invitation to Engage*.
2. **Explore Questions:** *Asking the Right Questions*, found in the Readings and Resources section, provides structure and a question formation tool for students as they ask need-to-know questions related to the challenging problem. Teachers use the *Teacher Guide* to support student efforts to ask significant questions, direct students towards Next Generation Science Standards disciplinary core ideas and performance expectations, and help students find trustworthy sources.
3. **Explore and Explain Arguments** with the *Claims, Evidence, and Reasoning Guide*, found in the Readings and Resources section. This tool makes student thinking visible as it provides a template for developing evidence-based arguments. Teachers provide guidance and instruction to groups and support students' self-assessment efforts during this time. Students use the claims, evidence, and reasoning tool to construct arguments from evidence.
4. **Extend (Elaborate) into Application:** These readings, which are specific to each Project, give guidance on performing the concept-reinforcing, out-of-classroom activity (leading a field experience, joining a volunteer restoration project, or informational interviewing) that is designed into the *Student-Driven Projects*. Teachers support students with direct instruction and assist in making connections with organizations and individuals as needed. If necessary, Projects can be altered to remove the out-of-class component.
5. **Evaluating, Communicating, and Reflecting:** Part inspiration, part instruction, *Tips for Effective Communication in Public Settings* and *Students Taking Action* (both found in the Readings and Resources section), guide students as they publicly present the group's learning product. This may be handed out as early as week three when students begin practicing their presentations. Teachers help students self-evaluate, provide peer feedback, and facilitate reflection.

IV. Personalized Learning Plans, co-authored between the teacher and each student, are key to a *Student-Driven Project*. Your objective is to:

- Include the student's interests.
- Link to significant performance expectations (NGSS/CC), essential content knowledge, and local environmental issues.
- Create a foundation for reflective self-assessment, personalized teacher feedback, and parent reporting.

One strategy for launching the development of Personalized Learning Plans is to start with a whole group discussion about goal setting by considering the Challenging Question, required learning products, and the rubrics. Do this after the engaging

event—if possible the same day. Frame the conversation around desirable Habits of Mind such as persisting to completion or communicating with clarity and precision.

The SMART (Specific, Measurable, Achievable, Relevant, Timely) goals format is a tool that can be used for creating personalized learning goals. There are many variations on this goal-setting prompt. A suggested *Student's Guide to Personalized Learning Plans* can be found in the Readings and Resources section.

Kelp wrack in Monterey. Photo: Amy Williams

Essential Elements of Project-Based Learning

The following is based on work performed by John Larmer, John Mergendoller, and Suzie Boss of the Buck Institute for Education (authors of *Setting the Standard for Project Based Learning*), and describes the essential elements of project-based learning and how they are reflected in *California Coastal Voices.*

Student Learning Goals

Project-based learning is one of the instructional strategies highlighted in the *California Science Framework* as "congruent with the principles" of three-dimensional learning—the notion that learning should weave together skills and practices, crosscutting concepts, and content knowledge acquisition. Each *California Coastal Voices* Project supports this type of learning. Equal emphasis is placed on acquiring specific knowledge and on thinking and working like a scientist or engineer. Knowledge is most effectively retained through habitual application; skills are honed through practice towards measurable mastery.

> "When teachers integrate all three dimensions of the CA NGSS, their classrooms look different...Both the *NRC Framework* and the CA NGSS highlight a vision for student learning centered on the development of practices and knowledge that will transfer beyond the classroom and beyond formal K–12 schooling. In particular, the aim is to prepare all students graduating from high school to be critical consumers of information and capable problem-solvers and to engage in public discussion using evidence-based argumentation across a broad range of topics."
>
> *2016 California Science Framework*

Essential Project Design Elements in California Coastal Voices

Entry Event and Challenging Question: Each Project begins with an entry event that inspires, excites, and engages the students (often a guest speaker but sometimes a video or video conference), and a Challenging Question that students respond to, modify, or discard in favor of co-authoring a related question. The question prompts the use of science and engineering practices to learn significant content and requires thinking across traditional content boundaries guided by the crosscutting concepts.

Sustained Inquiry: The Projects are designed to last three to six weeks and may in some circumstances lend themselves to longer time periods. Supporting sustained inquiry is a primary task for teachers as students are asked to go beyond internet searching to interviewing professionals, finding primary source documents, and performing field work. Each student team must explore the needs and perspectives of a variety of stakeholders and constituents. Content learning is supported by placing knowledge into action in the *Student-Driven Projects* by restoring natural environments, proposing solutions to government agencies, conducting field activities with community members, or helping peers explore coastal career opportunities.

Authenticity: Using real world issues as context for learning increases student interest and motivation (NRC and Larmer, 2016) and so are emphasized in all the *California Coastal Voices* projects. Service to the community is part of the *Student-Driven Projects*.

Student Voice and Choice: Meeting the challenges facing the world today and in the future requires leaders and problem-solvers who will take initiative. Schools can help create these citizens by letting kids explore what matters to them and teaching them how to tackle real-world problems. In *California Coastal Voices*, various levels of student voice and choice are designed into each Project. In the *Teacher-Guided Projects*, student voice and choice ensures student activation. In the *Student-Driven Projects*, students are given more latitude, up to full co-authoring of goals, methods, and presentation options if circumstances allow.

In all of the Projects, teachers have the flexibility to alter the amount of student choice. In the final analysis, teachers will consider student readiness, school culture, students' comfort with student-led projects, and other constraints before deciding on the degree of voice and choice. One key exception relates to organizing project teams; for effective groups, classroom teachers should control this process.

Reflection: If experience is the teacher, structured reflection is the pathway to performance. Science notebooks, self-assessments, and peer reviews are built into each Project. These reflection tools offer students structure as they make their way through the messy business of questioning, exploring, explaining, and extending into action. Teachers should share their own reflective thinking during conferences, casual conversations, and progress checks to demonstrate this important Habit of Mind for students.

Critique and Revision: Frequent feedback from teachers (formative assessment) is a key influencer of quality learning environments. Research by John Hattie of the Melbourne Educational Research Institute supports self-assessment, peer review, professional mentoring from working adults, and teacher evaluation routines. As Dr. Hattie states in *Visible Learning for Teachers: Maximizing Impact on Learning*, "The student's role is not to simply do tasks decided by teachers, but to actively manage and understand their learning gains. This includes evaluating their own progress, being more responsible for their own learning, and being involved with peers in learning together."

In *California Coastal Voices*, significant content knowledge is monitored over the entire course of a Project and is assessed via individual drafting, revising, and editing of written products. This gives teachers many opportunities to adjust instruction. Rubrics are used to evaluate critical thinking, communication, collaboration, creativity and willingness to innovate.

Public Product: This is the culminating activity of many of the Projects in *California Coastal Voices*. Making the learning product public creates a positive pressure towards accuracy and clarity of expression. Knowing that the work can make a difference in the community is also part of the motivation equation.

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:

Art by Emily Li, 11th grade

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.

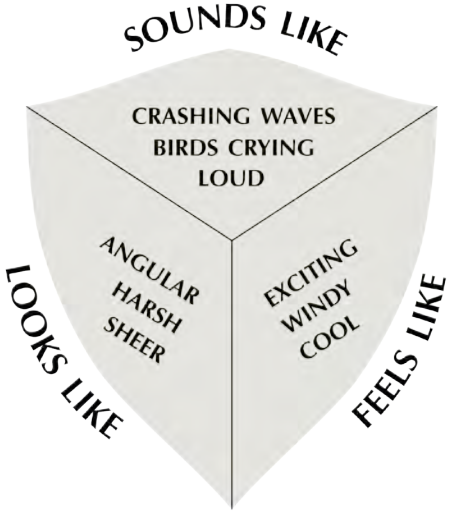
Explore

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)

Concrete Questions: Engineering Solutions for a Changing Coast

A California Coastal Voices Teacher-Guided Project

Main Beach, Laguna Beach. Photo: Mitch Ridder

Challenging Question:

How can we use engineering practices to protect natural and human communities on sandy shores?

For this Project:

Golden Gate Bridge, Photo: Kim Aikawa

Challenging Question:

How can we use engineering practices to protect natural and human communities on sandy shores?

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

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

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.

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

Concrete Questions: Engineering Solutions for a Changing Coast

Overview

A variety of natural processes and human factors have combined to damage and even occasionally eliminate California beaches and coastal recreation opportunities and threaten backshore development such as homes, roads, and other structures. With climate change causing sea level rise and increasing extreme storm events, the challenge will only grow in the foreseeable future. When the sea level rises, a beach will shift inland, but only if it has space to do so. If a beach is backed by a seawall, the rising ocean results in a "coastal squeeze" as the beach is prevented from migrating inland. In communities where private homes are located in close proximity to popular coastal recreation areas and on eroding coastal bluffs and beaches, there can be a clash between the interests of residents and the interests of others who use the area. For example, surfers maintain that certain shoreline protection methods have negative consequences upon surf quality, wave patterns, and ecosystems. While coastal property owners may not disagree, some may feel that protecting their homes should be prioritized above protecting sandy beaches and surf spots. Transforming these conflicts into broadly agreed upon, technically sound plans for balancing coastal priorities is an ongoing challenge for California.

In *Concrete Questions* students will develop an understanding of the Earth systems and human factors that sculpt the shoreline and result in beaches with unique characteristics, answer technical questions about coastal processes, communicate with explanatory models, and evaluate methods for protecting natural and human communities along our sandy shores.

Students will work in groups to evaluate place-based solutions for protecting both sandy beaches and adjacent beachfront structures in real world locations along the California coast. Students will investigate a specific coastal community of their choosing and evaluate a solution that has been implemented in the past or is proposed for the future. Each group will present their evidence, arguments, and conclusions in the final session of the unit.

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*.

Students will provide evidence of learning by:

- Conducting a presentation of their evaluation of a planned or already implemented coastal erosion solution.
- Developing a conceptual model of beach-building coastal processes.

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

Prior to Beginning the Activities:

Students should read the *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 activity descriptions are structured to provide core content learning and support the open-ended inquiry process of the project.

1. Invitation to Engage: What Forces Act on Beaches?
2. Exploration: A Home on the Edge
3. Explanation: Teacher-Led Earth Systems Lab
4. Elaboration: Student-Led Earth Systems Lab
5. Extend and Evaluate: Crafting Consensus at Surfers Point
6. Evaluation: Communicating Science Concepts

Sunset Cliffs Natural Park, San Diego. Copyright (C) 2013 Kenneth & Gabrielle Adelman, California Coastal Records Project

Activity

Concrete Questions Invitation to Engage: What Forces Act on Beaches?

Guiding Questions:

- What forces act on beaches?
- What are some options for protecting beachfront homes and beaches?

Materials Required:

- Individual student notebooks
- *Making Sense of Images* and *Guiding Questions for Image Analysis*, found in the Readings and Resources section
- Note cards
- Poster paper

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

- Daily Phenomenon #1
- "Swept Away: Paradise in Peril," 2011 KCET news clip
- Coastal armoring article from California Sea Grant

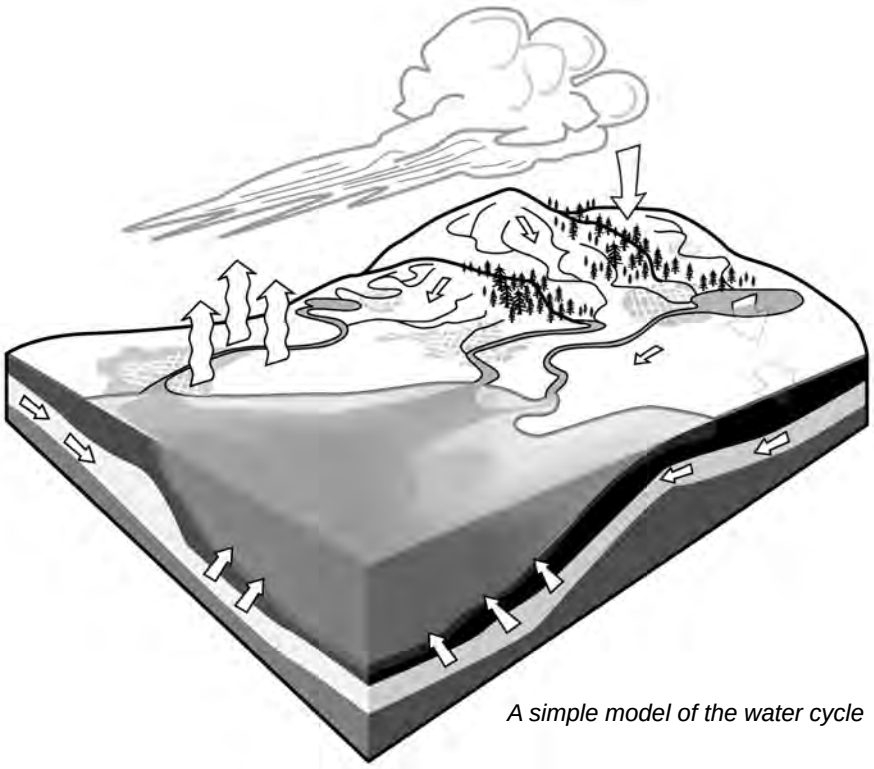
During this session students draw and revise an explanatory model of the forces that act upon beaches.

Daily Phenomenon

Ask students to examine the sediment bloom image (Daily Phenomenon #1) using the *Guiding Questions for Image Analysis* worksheet. In their notebooks, students should propose answers to the following questions: What is a beach? Where does the sand come from? What makes these dynamic places special, and potentially tough to manage from an engineering perspective? Students respond in their notebooks in prose writing, artistically, or with a conceptual model.

Explore - Beach Models

1. In three minutes, students individually respond on note cards to the following: How can groups reach consensus on difficult science and policy questions? Cards are turned in to the teacher.
2. Teacher leads a brief discussion on the development of conceptual models. The *Next Generation Science Standards*



A simple model of the water cycle

Conceptual Models Should Include:

- Components of the system under investigation. Label each depicted component and note boundaries.
- Relationships between components. Identify and label quantities, units, and energy conversions.
- Connections to scientific theories and crosscutting connections.
- Revisions. Use a distinct color from the original draft. Once the model is too cluttered for easy comprehension, use another page.
- A statement about the model's predictive power.

provides this explanation: "In science, models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others...In engineering, models may be used to analyze a system to see where or under what conditions flaws might develop, or to test possible solutions to a problem. Models can also be used to visualize and refine a design, to communicate a design's features to others, and as prototypes for testing design performance." Teacher demonstrates a conceptual model using a familiar concept of the water cycle as an example.

3. Following this, the class brainstorms responses to the guiding questions for this activity: What forces act on beaches? What are some options for protecting beachfront homes and beaches? Teacher captures student thinking by writing out ideas on a board or poster.
4. Form groups of four students. These groups will work together throughout the project on evaluating a coastal erosion solution and presenting their conclusions during the final class session.
5. Students meet in their groups to draw a first draft conceptual model of how forces act on beaches. It is understood that creative guessing may be required.
6. Students perform a gallery walk to view other groups' models and collect ideas to add to their own explanatory model.
7. Students watch KCET's 2011 news clip "Swept Away: Paradise in Peril" (as a whole class or in groups depending on classroom resources) and read California Sea Grant's coastal armoring article.
8. Students decide how to revise their models based on this new information and perform another gallery walk.
9. Hang models on the wall, if possible, and have groups share insights or questions.

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. Each group will choose a California coastal location to study. It should be a location that is dealing with or has dealt with a coastal erosion problem. Groups will evaluate a solution that has been implemented in the past or is proposed for the future, in relation to issues that may include cost, safety,

reliability, effectiveness, aesthetics, and social, cultural, and environmental impacts, taking into account expected sea level rise. Given that current projections show sea level rising by as much as two feet by 2050, this issue will have significant impacts on coastal development and must be of primary concern in future planning. Groups will provide reasoning for their answer to the question: If I were a California Coastal Commissioner, would I approve this project? (See the Readings and Resources section for an *Introduction to the California Coastal Act*. You may choose to lead your students in the activity from *Coastal Voices: Speaking up for the Beach*, "Interpreting the California Coastal Act," to introduce them to the law.) Students should begin their research through searches of news reports and local government and community plans, and on the California Coastal Records Project website, where they will find historical and recent photos of the coast.

Groups may consider these coastal locations or find others:

- Ocean Beach, San Francisco
- Sunset Cliffs Natural Park, San Diego
- Solana Beach
- Isla Vista Beach, Santa Barbara

This work may continue to out-of-class time.

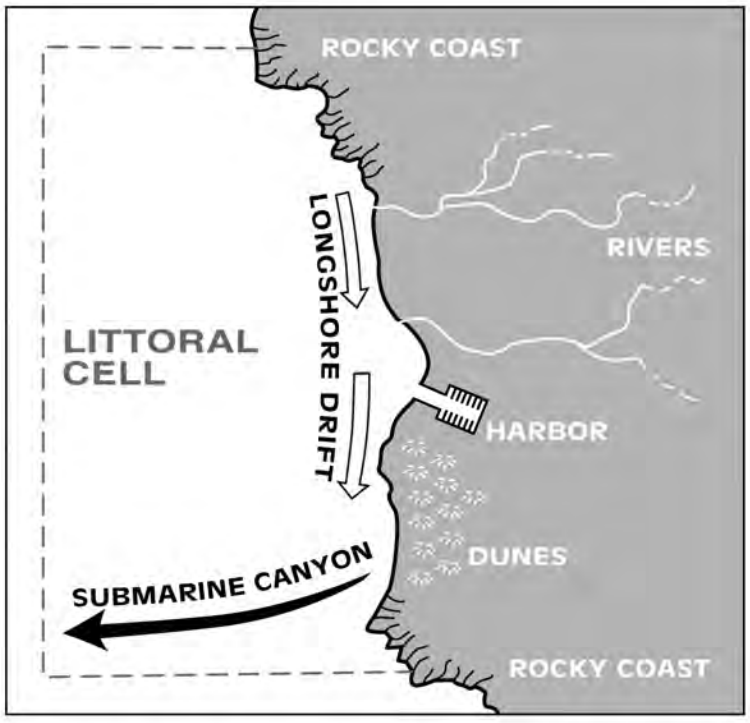
GO DEEP...

Find links on the Coastal Voices Website at www.coastal.ca.gov/coastalvoices for the following:

Read an article about sand movement on the coast from California Sea Grant.

Explore KQED's *Coastal Clash* interactive website, specifically "How Beaches Work" and "Coastal Armoring." The *Coastal Clash* 60 minute DVD looks at issues of beach access, development, erosion, and the many sides of the struggle for California's beaches, and can be borrowed from the California Coastal Commission.

Review *Littoral Cells, Sand Budgets, and Beaches: Understanding California's Shoreline*, a report for the California Department of Boating and Waterways.



Watch *Beach: A River of Sand*, a video by Encyclopaedia Britannica Films. Watch online or borrow a copy from the Coastal Commission.

Examine a littoral cell diagram to understand longshore drift of sand along the coast.

Activity

Concrete Questions Exploration: A Home on the Edge

Guiding Question:

- What is the best approach for reaching a community consensus on difficult science and policy questions?

Materials Required:

- Individual student notebooks
- *Making Sense of Images* and *Guiding Questions for Image Analysis*, found in the Readings and Resources section
- *A Home on the Edge* scenario and stakeholder roles
- *Dealing with a Retreating Coastline* reading

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

- Daily Phenomenon #2
- Pacifica bluff image set

GO DEEP...

Naturally Resilient Communities presents a variety of nature-based solutions to flooding and erosion on their website:

nrcsolutions.org

In this activity students play a coastal stakeholder role, consider a range of viewpoints, and debate the merits of coastal protection structures.

Daily Phenomenon

Teacher presents the image of Torrey Pines State Beach (Daily Phenomenon #2) to the class. Students examine the image using the *Guiding Questions for Image Analysis* worksheet and take notes in their notebook. They should revise their definitions of a beach, and propose a preliminary model for how waves will act upon beach sand. How do wave direction and strength interact to build sandy beaches in California?

Explore - Coastal Stakeholder Activity

Teacher presents the Pacifica bluff images as a real-life example of bluff erosion threatening a structure. Allow time for class conversation about the images, then transition to *Home on the Edge* activity:

1. Arrange chairs in the classroom in two concentric circles facing inward. Each student in the outer circle partners with a student in the inner circle. Teacher assigns each pair a *Home on the Edge* role. Student pairs read the scenario and prepare a position statement to present during discussion circle.
2. The inner circle of speakers assume their specified role for the case study and discussion. Outside observers will watch silently and coach the speakers at intervals.
3. Observers prepare to coach their partners by keeping track of their performance; for example, by tallying how many times the student participates, asks a clarifying question, or acts to encourage everyone's voice be heard. When discussion concludes, partners debrief privately.
4. Student pairs read and discuss *Dealing with a Retreating Coastline*, and then reverse roles. Be sure all students have turns as both the speaker and the observer during the learning activity.
5. Whole Group Critique: How did it feel to be a speaker inside the circle, or an observer outside the circle? Students share questions and insights into how to best develop consensus.

Construct Explanations and Models

In their notebooks, students individually write a Reflective Summary, stepping away from their assigned stakeholder role and describing what kind of engineering solutions they personally support. Students should cite evidence from the case study and structured academic conversation. Students revise their explanatory model of beach-building coastal processes.

Managing the Project

Students work in groups to research their chosen California coastal location and its existing or planned erosion control solution. In what ways is the solution appropriate or inappropriate for the location and the community? This work may continue to out-of-class time.

GO DEEP...

The MARE program at UC Berkeley's Lawrence Hall of Science has developed a hands-on sea level rise activity as part of their *Ocean Sciences Sequence for grades 6-8: The Ocean-Atmosphere Connection and Climate Change*. This activity, which can be downloaded from the *Coastal Voices Website*, will enhance students' understanding of the factors impacting coastal habitats and development.

Piedras Blancas. Photo: Gary O'Neill

A Home on the Edge

In this activity you will take on one of four stakeholder roles in a fictional situation, consider a range of viewpoints, and debate the merits of coastal protection structures. Improvise where appropriate, but please no messing with the facts or evidence as they are presented to you.

Scenario:

Al Jordan is worried about his home, and for good reason. The single family home he owns is on a bluff facing the ocean, and the bluff is eroding. The house was constructed during the last century and his family has lived there for the last five years. Jordan's house is currently 30 feet from the bluff face, but when he bought the property it was 50 feet back. Then strong storms and waves during the previous winter eroded the base of the bluff and 20 feet fell from the top in a sudden collapse.

The Jordan property is 0.2 acres in a small, well-to-do neighborhood, bordered by the bluff and beach to the west, a road to the east, and county parkland on north and south. The house is set 100 feet back from the road and the house itself is one story and 2,400 square feet. The bluff it sits on is 20 feet above the beach below.

Jordan's hired expert has determined that the average retreat rate for this bluff is nine inches per year since the house was constructed. However with an El Niño predicted for the following year, and more extreme storms expected due to climate change, Jordan is worried that the bluff retreat could happen faster.

The beach below the house is well-used by the public, particularly in the summer months. There is public access from the parks to both the north and south of the Jordan property. In the summer there is a sandy beach about 200 feet wide, which sometimes disappears during large, winter storms as the waves crash against the bluff. With sea levels in the area predicted to rise by as much as two feet by 2050, there is concern for the future of this beach.

Jordan invited interested and informed members of the community to his home for an informal gathering to discuss what to do about his property.

Coastal Zone Stakeholder:

I am Danielle Garamond, a coastal engineer with Protective Engineering, LLC. My interest lies in protecting the rights of property owners to preserve their assets by building coastal protection structures. I especially value the cherished oceanfront homes that define the good life in California. With respect to arguments about public beaches, it is clear to me that legal property rights are of higher value. Besides, there are many beaches in California.

Claim: Coastal armoring preserves homes, increases the tax base in coastal communities, and rewards hard working citizens who have earned the right to live on the coast. There is a relationship between coastal armoring and loss of sandy beaches, but the higher value is the protection of homes and other coastal structures. No precedent should be set limiting coastal armoring activities.

Evidence: Seawalls and other coastal protection structures have been shown to preserve oceanfront property values. In addition, the US Army Corps of Engineers has spent decades building such structures, investing billions. Would they do this if it did not make sense? At least 10% of California's coastline is protected by armoring. Why should a homeowner in need of a sea wall today be denied protection?

Reasoning: My evidence supports a goal of retaining the right to build any type of coastal protection that will serve a property owner's needs.

Coastal Zone Stakeholder:

I am Bob Larkin, a coastal engineer with Tomorrow's Engineering, LLC. My interest lies in protecting the rights of property owners by using soft engineering solutions that increase biodiversity and the quality of a beach, even as property rights are respected. Nature provides value to our society through ecosystem services.

Claim: By mimicking natural processes we can protect structures while enhancing the coastal environment and increasing recreational opportunities. Beach nourishment (bringing more sand to the beach), dune building, and planting vegetative cover are my preferred methods. It will be necessary to repeat the beach nourishment as the sand is naturally washed away over the years, but it preserves the beach where hard solutions do not.

Evidence: Experts in the field (like me) can design soft engineering solutions that protect the shoreline. Even when sand that has been deposited is moved offshore by the current, it can still protect the shore by causing waves to break farther out. FEMA has recognized the value of soft engineering by reducing flood insurance premiums in some instances, and the US Army Corps of Engineers has undertaken beach nourishment projects on the eastern US coast for decades.

Reasoning: While soft engineering solutions take expertise, time to implement, and maintenance commitment, they protect the beach and private property so my belief is that they are worth the investment.

Coastal Zone Stakeholder:

I am Mary Chang and I represent the local surfers' group. Our interest is in protecting the beach for public enjoyment and as a thriving habitat. We understand that private property owners care about and enjoy their homes, and that they've invested significantly in them. However, when someone chooses to purchase a structure on an eroding bluff, they are choosing to take significant risks. Oceanfront property owners enjoy the benefits of dramatic ocean views, waves, and easy access to the water; they should not then be allowed to destroy these pleasures for the public when natural forces do what they have always done. We place more value on the rights of a community of beach-goers than on those of a property owner who knew what he was getting into.

Claim: Coastal bluff collapse and retreat are natural processes. Sea walls fix in place the back of the beach instead of allowing it to move as it would otherwise. As sea level rises, it is particularly important that beaches be able to move landward. Sea walls also prevent a naturally eroding bluff from contributing sand to the beach.

Evidence: California Sea Grant as well as other coastal experts has made it clear that coastal armoring can increase erosion on the beach itself, which not only has recreation impacts but can reduce or eliminate habitat on the beach for shorebirds and other animals.

Reasoning: My evidence supports the goal of allowing the shoreline to retreat, even at the expense of private property owners. Local governments should act now to plan for the necessary removal of at-risk structures and where possible, existing coastal armoring in light of sea level rise forecasts due to global warming.

Dealing with a Retreating Coastline

The beach at Santa Cruz was a 10-mile hike to the west 18,000 years ago at the end of the last Ice Age. As glaciers retreated and ice sheets melted over the following centuries, sea level rose about 400 feet and gradually flooded the edge of California, moving the beach inland. The coast retreated about 300 feet per century during that era of warming and melting. Throughout this 18,000-year period, the sea cliffs marching back three feet every year didn't matter much. Although the Ohlone used the coast, harvesting fish and shellfish and hanging out on the beach, they didn't have permanent dwellings so the precise location of the beach and sea cliff didn't greatly impact their lives.

Things are different today. The shoreline and sea cliff from San Diego to Santa Barbara is almost completely urbanized. In Santa Cruz County, homes, businesses, roads, parks and parking lots cover the coastline from Manresa to Natural Bridges. It's probably fair to say that California's most valuable real estate is right on the edge. But that edge is never in the same place for more than a few decades. The shoreline moves back and forth over millennia as sea level rises and falls in response to climate change.

Around the Mediterranean Sea, civilizations have dealt with this phenomenon for thousands of years. In California, however, our coastal development and construction history is much more recent. Photographs of coastal bluffs in Santa Cruz County from the late 1800s reveal that people didn't build right at the edge. But today, it's pretty much continuous development of one sort or another. The closer to that ocean view, the more valuable the house and land.

So how have we dealt with the erosion and retreat over the past 50-100 years and what are we going to do in the future? This is a messy and emotional issue involving expensive and difficult questions, and it's not going to get any easier.

Historically there have been three basic options for dealing with coastal retreat: 1. retreat or relocation of development; 2. armor or protection; or 3. beach nourishment. These are not simple decisions.

Nobody with an oceanfront location is excited about moving back from the edge, but it has happened and will likely happen more often in the future. On Depot Hill in Capitola, six cliff top apartments were taken down after the Loma Prieta earthquake when concrete caissons were undercut, and foundations cracked and partially failed. Twenty years earlier, a house next to the apartments was picked up and moved back several blocks and put on a new foundation.

In other cases, failure to relocate houses led to cliff collapse and homes ending up on the beach below, which is what happened along the Esplanade in Pacifica in 1998. Sea level rise and a more severe storm climate claimed 28 villages along the southeast coast of England during the Middle Ages.

What Causes Shoreline Retreat?

Large waves arriving at high tide are the major force behind most coastal erosion and storm damage. Shoreline retreat may take different forms, however.

The change from low-energy summer waves to high-energy winter waves leads to beach erosion every winter. Sand is scoured off the beach in December and January and stored offshore, only to return again the next spring and summer when winter storms have abated and calmer waves return. This is an expected and normal process we can all observe.

Stilwell Hall, Fort Ord. Facing bluff erosion, this World War II era building was demolished in 2003. Copyright (C) 2003 Kenneth & Gabrielle Adelman, California Coastal Records Project

The coastal erosion that concerns cliff top residents as well as coastal communities isn't the seasonal beach erosion, however, but the erosion and permanent retreat of the cliff or bluff. This is not recoverable, at least within our lifetimes or by natural processes.

The rate at which cliffs or bluffs have historically eroded along the California coast varies from a surprising ten feet per year at some unfortunate locations, to a few inches or less in others. The former is obviously a cause for concern, especially if it's your front yard or patio.

Several different factors affect how rapidly a given cliff will retreat. The cliff's strength or resistance to wave attack is usually the most important. Rock strength varies widely, depending on the type of rock, the hardness or degree of consolidation or cementation, and the presence of weaknesses such as fractures or joints.

The amount of wave energy reaching any particular area of coastline is also a key factor, and while the waves approaching the central coast on any given day come from the same storms, nearshore bottom conditions or bathymetry will increase or decrease wave heights at specific locations along the shoreline.

A final factor is the regional rate of sea level rise, a natural phenomena that is accelerated by human influence via global warming from the accumulation of greenhouse gases in the atmosphere.

"Dealing with a Retreating Coastline" and "What Causes Shoreline Retreat" excerpted from *Our Ocean Backyard, Collected Essays*, by Gary Griggs

Activity

Concrete Questions Explanation: Teacher-Led Earth Systems Lab

Guiding Question:

- How do land features such as points, sea stacks, islands, and mountains influence nearshore ocean circulation?

Materials Required:

- Individual student notebooks
- For each group: 1 shallow tray, 3 rocks, 1 mixing stick, chart paper
- Food coloring (optional)
- Video camera/phone (optional)

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

- Daily Phenomenon #3
- Sea surface temperature image
- Teacher background information on currents

What is a Bight?

A bight is a long, gradual bend or recess in the shoreline that forms a large, open bay.

In this Earth Systems lab, students physically explore the movement of water around rocks. They use this hands-on experience and examination of remote sensing images to expand their understanding of California coastal processes.

Daily Phenomenon

Using the Southern California Bight image (Daily Phenomenon #3) as a reference, students draw an outline of the Bight in their notebooks. Instruct students to include coastal land features such as points or islands. Students then draw a preliminary model of how currents circulate in the Bight, labeling physical features and speculating about the driving mechanisms. It is understood that students will be guessing about mechanisms.

Explore - Waves and Rocks Lab

Teacher leads an interactive discussion and introduces key concepts of currents, wind-driven waves, and wave reflection and refraction. Teacher background information on current circulation can be found on the *Coastal Voices Website*.

1. Convene groups and place a water-filled tray at each group's table. Put rocks representing shoreline features into the tray and ask students to explore how water moves around the rocks. Teachers may add food coloring to the water to aid observation. Mixing sticks may be used to propel the water or students may gently blow upon the surface. If the technology is available, film the water movement and play it back in slow motion. Students then draw sketches of the results.
2. Students share existing knowledge of currents as groups sketch out a revised model of Southern California Bight circulation on chart paper. Teacher ensures that details are added, especially with respect to labeling mechanisms.
3. Hang chart paper and have students perform a gallery walk comparing models. Teacher encourages students to share evidence-based ideas, asks probing questions, and reminds students to think about the Guiding Question.
4. Groups explore a sea surface temperature image and notice the visible patterns. Teacher guides students toward exploring the connection between currents and thermal patterns.

5. Student groups estimate direction of the surface currents and speculate about the relative ability of water in motion to move sand, resulting in accretion or erosion. Students use graph paper to revise their Southern California Bight model with vectors showing the direction of currents.

Construct Explanations and Reflect on Thinking

In their notebooks, students individually write a Reflective Summary that responds to the Guiding Question. Students revise their explanatory model of beach-building coastal processes.

Managing the Project

Transition back to groups, which continue to develop their arguments and conclusions regarding their coastal location's erosion solution, and begin preparing their presentation and visual materials. This work may continue to out-of-class time.

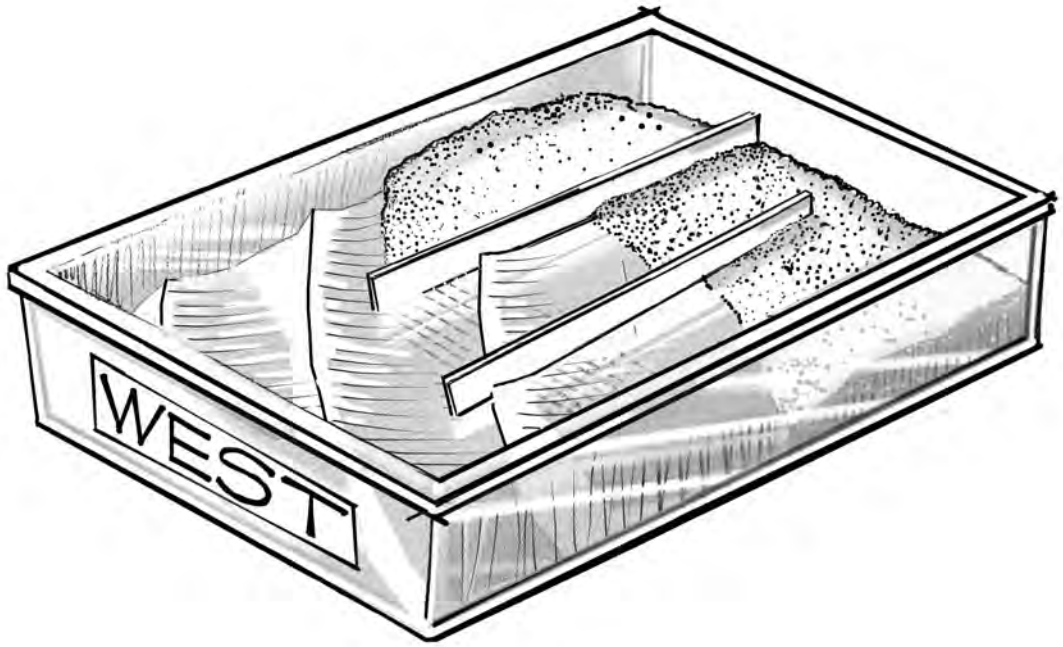
Student Preparation for Next Session

Students preview *Building a Beach Model* and review the *Presentation Rubric*.

Pfeiffer Beach. Photo: Dale Mead

Building a Beach Model

1. Label the shorter sides of a rectangular pan for the ocean and inland directions of the section of the coast you would like to represent. "East" and "West" are used as examples here. Pour up to four inches of sand into the east (inland) end of the pan.
2. Gently add tap water up to two inches deep on the west end of the pan. Draw your experimental model. Throughout this lab, be sure to label all elements of your drawings.
3. Use a ruler to create a gentle wave action in the pan, in a general west-to-east movement. Draw how the model appears after wave action. What are the effects of erosion? How has the coastline changed?
4. Position the sand to its original model configuration. Set two to three rulers on-edge into the sand lengthwise about four inches apart, representing groins. Use a ruler to create the same gentle west-to-east wave movement. What happens in between the groins? What happens to the shoreline? Draw the model. Make waves coming from the northwest. Do the beaches in between the groins change? Draw the model to indicate how the beaches look after completing this wave action.
5. Determine a way to model a seawall in the pan. What happens to the shoreline after wave movement? Gently add additional water to the pan and observe how "sea level rise" in your model impacts a beach in front of a sea wall. Draw the model before and after.



Activity

Guiding Questions:

- What forces act on beaches?
- What are the consequences of building concrete shoreline protection structures?

Materials Required:

- Individual student notebooks
- *Building a Beach Model*

For each group:

- Rectangular pan or plastic bin (9" or 12" deep, more than 12" long)
- All-purpose sand
- 4, 12" rulers
- Tap water
- Camera/phone (optional)

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

- Daily Phenomenon #4
- Spreadsheet of global absolute sea level change

Concrete Questions Elaboration: Student-Led Earth Systems Lab

In this Earth systems lab, students use a physical model to explore the movement of sand and water as they interact with coastal protection structions.

Daily Phenomenon

Instruct students to individually examine the image of Capitola Beach (Daily Phenomenon #4) and propose in their notebooks a preliminary model for how waves interact with coastal protection structures to build/erode sandy beaches in California.

Explore - Beach Model Lab

In groups, students take on the following roles for this lab: investigation leader, data collector, note-taker and asker of probing questions, and photographer/videographer.

Earth Systems Lab Procedure:

1. Before beginning the lab, review with the class the definitions of independent, dependent and controlled variables. Ask students to think about what variables influence the natural systems of a beach.
2. Group members consider the sandy shore environment and identify something interesting they have previously noted or observed during the Daily Phenomena. Students should then reframe these observations into testable questions (e.g. what is the relationship between _____ and _____?), or a hypothesis, taking care to consider the null hypothesis (that there is no relationship).
3. Each group performs the lab following the instructions in "Building a Beach Model." Groups may choose to modify the procedures after consultation with the teacher. Revise explanations and repeat procedure as many times as time allows. Photograph or film and record all data for subsequent interpretation.

Construct Explanations and Reflect on Thinking

In their notebooks, students individually write a Reflective Summary that responds to the Guiding Questions. Students should revise their developing explanatory model of how coastal processes sculpt beaches, adding color, detail, and labels.

In their Beach Models, students are investigating the impacts of groins and seawalls. What is a seawall, what is a groin, and how is it different from a jetty?

Seawall:

A structure built on a beach, parallel to the shoreline, designed to protect buildings form the action of waves.

Groin:

A structure built perpendicular to the shoreline designed to trap sand moving along the shore due to the longshore current. A groin or group of groins usually extend to the end of the surf zone and are used primarily to replenish or stabilize beaches.

Jetty:

Structures built in pairs that extend further into the ocean than a groin, to stabilize a navigation channel and keep the water calm for harbor entrances.

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* containing global absolute sea level change from 1880-2015. Global sea level is rising, mainly due to the expansion of ocean water as it warms and from the addition of freshwater to the ocean from melting land-based ice. Have students graph the change in sea level over time. Why is the adjusted sea level zero in 1880? What is the slope of change in sea level rise during the time period shown? Using this slope to extrapolate to 2040, what sea level rise amount would you expect? Have students make a claim as to whether this extrapolation produces a plausible prediction. Students should provide evidence for their claim. What environmental factors in the present and future are influencing the slope of the data and impacting the accuracy of their extrapolation? Starting in 1993, the spreadsheet shows data collected by satellite. What are the implications of using satellite data versus tide gauge data for sea level rise projections?

Managing the Project

Transition back to groups to continue work on presentations.

Student Preparation for Next Session

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

Read Case Study on Surfer's Point (see *Coastal Voices Website*).

Watch the California Coastal Trail episode, "Restoring Surfer's Point at Seaside Park" (see *Coastal Voices Website*).

Groin, Newport Beach. Copyright (C) 2004 Kenneth & Gabrielle Adelman, California Coastal Records Project

Activity

Concrete Questions Extend and Evaluate: Crafting Consensus at Surfers Point

Guiding Question:

- How have coastal communities successfully reached science-based community consensus on difficult science and policy questions?

Materials Required:

- Individual student notebooks
- *Making Sense of Images* and *Guiding Questions for Image Analysis*, found in the Readings and Resources section

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

- Daily Phenomenon #5
- Case Study Reading on Surfer's Point
- California Coastal Trail episode, "Restoring Surfer's Point at Seaside Park"
- Spreadsheet of Relative Sea Level Change Along U.S. Coasts

After learning about a real-world community response to coastal erosion, students will analyze the process and outcome and engage each other on the topic of consensus building.

In preparation for class, students have read the case study of Surfer's Point and viewed the California Coastal Trail episode "Restoring Surfer's Point at Seaside Park."

Daily Phenomenon

Teacher presents the images of Surfer's Point (Daily Phenomenon #5). Individually in their notebooks, students examine the images following the *Guiding Questions for Image Analysis* worksheet, revise their definitions of a beach, and propose a preliminary model for how wind will act upon beach sand. How do wind direction and strength interact to build sandy beaches in California?

Explore - Surfers Point Case Study Analysis

Students analyze the outcome at Surfer's Point via the reading and video and consider potential applications to other managed retreat controversies.

1. Teacher leads a review of assigned reading and responds to questions from homework before posting the following set of questions for the student groups to explore. Encourage students to use any available technology.

   What problem is being addressed in the case study?

   What obstacles were especially challenging?

   Who were the key players?

   What role did they play?

2. Each student group writes on chart paper a suggested procedure for guiding community groups to science-based consensus.
3. Teacher guides students in responding to the next set of questions:

   How did the community monitor progress on the project?

   Was funding for the proposed solution found?

   How did the group reach consensus?

4. Groups revise their proposed consensus-building procedures and post for peer review. Teacher leads a gallery walk.

5. Ask groups to consider whether they might do anything differently from the approach in the case study. Why?
6. To conclude the activity, speakers from each group argue for their proposed model of consensus building. Teacher evaluates.

Working with the Numbers

Show students the image titled "Relative Sea Level Change Along U.S. Coasts 1960-2015," available on the *Coastal Voices Website*. Land in different locations rises and falls due to causes such as tectonics and groundwater extraction, and that combined with ocean and atmospheric circulation patterns results in relative local sea level rise rates that may be higher or lower than the global average. From the data shown in the image, how much has sea level changed relative to land in the area closest to Surfer's Point? How does that compare to the absolute change in global sea level shown in the data analyzed in the last activity? How might future sea level rise impact the erosion solution at Surfer's Point? How might the erosion solution itself effect how sea level rise impacts this stretch of the coast?

Construct Explanations and Reflect on Thinking

In their notebooks, students individually write a Reflective Summary describing what kind of engineering solutions they support, citing evidence from the case study and structured academic conversation. Students complete their final explanatory model of beach-building coastal processes, due at the next session.

Managing the Project

Transition back to groups to complete preparations for their presentations, including all visual aids.

Surfer at Steamer Lane. Photo: Richard Osugi

Activity

Guiding Question:

- How can science concepts be communicated to public audiences?

Materials Required:

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

Concrete Questions Evaluation: Communicating Science Concepts

Each group will present their evaluation of a coastal location's erosion solution in a gallery walk.

Evaluate and Defend

Each group will be evaluated by rotating groups of peers. For a large class, 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. Groups conduct presentations for a portion of the class. If possible, rotate students so that each group's work is presented once by each group member. Audience members complete the presentation evaluation 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.

Pacifica. Photo: Jack Sutton

Connecting to the Standards

***Concrete Questions: Engineering Solutions for a Changing Coast* supports the following *Next Generation Science Standards* Performance Expectations.**

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

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.

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 II—People Influence Natural Systems	• Obtain and evaluate information from a video and an article on shoreline erosion and armoring solutions. (Invitation to Engage) • Argue stakeholder roles in a coastal erosion scenario, and analyze an article about real erosion incidents and responses. (Exploration)
Principle II—Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors	• Obtain and evaluate information from a video and an article on shoreline erosion and armoring solutions and consider methods of consensus building. (Invitation to Engage) • Argue for coastal erosion solutions within stakeholder roles with different priorities. (Exploration) • Analyze a coastal erosion case study. (Extend) • Evaluate a real worldcoastal erosion solution. (Evaluation)
Principle III—Natural Systems Change in Ways that People Benefit from and can Influence	• Perform a wave analysis lab and explore data to create a predictive model to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration) • Analyze a coastal erosion case study. (Extend) • Evaluate a real coastal erosion solution. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Disciplinary Core Ideas	ESS2.C – The planet's dynamics are greatly influenced by water's unique chemical and physical properties. (9-12)	• Perform a hands-on lab to investigate wave reflection and refraction, and incorporate knowledge gained from a coastal satellite image and sea surface temperature data. (Explanation) • Use a hands-on lab to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration)
	ESS3.B – Mapping the history of natural hazards in a region and understanding related geological forces can help forecast the locations and likelihoods of future events. (6-8)	• Evaluate a real world case study of a coastal erosion solution. (Evaluation)

	ESS3.B – Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales. (9-12)	• Obtain and evaluate information from an article about historic and recent coastal erosion. (Exploration) • Analyze a coastal erosion case study. (Extend) • Evaluate a real world coastal erosion solution. (Evaluation)
	ETS1.B – There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (6-8)	• Obtain and evaluate information from a video and an article on shoreline erosion and armoring solutions and consider methods of consensus building. (Invitation to Engage) • Argue stakeholder roles in a coastal erosion scenario, and read an article about real erosion incidents and responses. (Exploration) • Evaluate a real coastal erosion solution. (Evaluation)
	ETS1.B – When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (9-12)	• View a video and read an article on shoreline erosion and armoring solutions and consider methods of consensus building. (Invitation to Engage) • Argue stakeholder roles in a coastal erosion scenario, and read an article about real erosion incidents and responses. (Exploration) • Analyze a coastal erosion case study. (Extend) • Evaluate a real world coastal erosion solution. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Crosscutting Concepts	Cause and effect relationships may be used to predict phenomena in natural or designed systems. (6-8)	• Analyze an article about historic and recent coastal erosion. (Exploration) • Perform a hands-on lab to investigate wave reflection and refraction, resulting in revision of the student's model of a beach. (Explanation) • Use a hands-on lab to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration)
	Systems can be designed to cause a desired effect. (9-12)	• Argue for coastal erosion solutions within stakeholder roles with different priorities. (Exploration) • Use a hands-on lab to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration)
	Models can be used to represent systems and their interactions. (6-12)	• Draft and revise a conceptual model of a beach. (Invitation to Engage, Exploration, Explanation, Elaboration) • Use a hands-on lab to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration)
	When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (9-12)	• Draft and revise a conceptual model of a beach. (Invitation to Engage, Exploration)
	Systems can be designed for greater or lesser stability. (9-12)	• Analyze a coastal erosion case study. (Extend)
	Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (6-8)	• Analyze an article about historic and recent coastal erosion. (Exploration)

	Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (9-12)	• Analyze an article about historic and recent coastal erosion. (Exploration)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Science and Engineering Practices	Ask questions that arise from careful observation of phenomena to clarify and/or seek additional information. (6-12)	• Ask testable questions based on prior knowledge to design a hands-on lab investigating beach processes. (Elaboration)
	Ask questions to clarify and/or refine a model. (6-12)	• Draft a preliminary conceptual model of a beach and revise after a gallery walk. (Invitation to Engage)
	Develop and/or use a model to predict and/or describe phenomena. (6-8)	• Draft and revise a conceptual model of a beach. (Invitation to Engage, Exploration, Explanation, Elaboration) • Perform a hands-on lab to investigate wave reflection and refraction, resulting in revision of the student's model of a beach. (Explanation) • Use a hands-on lab to explore the movement of sand and water as they interact with coastal protection structures. (Elaboration)
	Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. (6-8)	• Argue for coastal erosion solutions within stakeholder roles with different priorities. (Exploration)
	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (9-12)	• Argue for coastal erosion solutions within stakeholder roles with different priorities. (Exploration)
	Construct, use, and/or present an oral argument based on data and evidence. (6-12)	• Throughout the unit during learning conversations. • Argue for a preferred consensus building model after analyzing a coastal erosion case study. (Extend) • Present an evaluation of a real world coastal erosion solution. (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. • Present an evaluation of a real world coastal erosion solution. (Evaluation)
	Communicate scientific and/or technical information or ideas in multiple formats. (6-12)	• Throughout the unit during learning conversations. • Present an evaluation of a real world coastal erosion solution. (Evaluation)

Coastal Voices: Speaking up for the Beach

A California Coastal Voices Teacher-Guided Project

Santa Monica Beach. Photo: Sarote Tabcum Jr.

Challenging Question:

How can Californians use the Public Trust Doctrine & the California Coastal Act to protect access to beaches?

For this Project:

Beach access sign in Sea Ranch

Coastal Voices: Speaking Up for the Beach contains material adapted with permission from the Constitutional Rights Foundation's Civic Action Project.

Challenging Questions:

What is environmental policy? Who makes policy? How can Californians use the Public Trust Doctrine & the California Coastal Act to protect access to beaches?

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

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

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Coastal Voices: Speaking Up for the Beach

Overview

The California Coastal Act of 1976 was designed to safeguard and increase Californians' ability to access the coastline, prevent overdevelopment, and preserve open space and wildlife habitat. Contemplating what is not visible on our coast is the best pathway to understanding the Coastal Act's success as a statute: development such as high rise condominiums, golf courses, and multi-lane freeways are limited in number along the 1,270 mile mainland coast.

The Coastal Act directs the state to "enhance and restore the overall quality of the coastal zone environment and its natural… resources" and "maximize public access to and along the coast and maximize public recreation opportunities in the coastal zone consistent with sound resource conservation principles and the constitutionally protected rights of private property owners." How Coastal Act policies apply to a particular development must be resolved through planning and permitting processes, considering the specific circumstances of the proposal and location.

In "Speaking Up for the Beach," students will study coastal law and policy in California and elsewhere in the United States, especially as it concerns public access to the coast. They will wrestle with complicated questions about policy and environmental responsibility. Students will engage in a mock California Coastal Commission hearing and create a guide to beach law in California. This project is different from the others found in *California Coastal Voices* in that it has a strong focus on the *History-Social Science Standards*, in addition to the *Next Generation Science Standards*. Good science is interwoven with and often the basis for good environmental policy, so understanding science concepts and how to apply science to policy decisions is a critical life skill, whether in a professional capacity or as a well-informed voter.

Students will provide evidence of learning by:

- Developing an Illustrated Citizen's Guide to California Beach Law. This graphical guide to the Public Trust Doctrine, California Coastal Act, and California Constitution may be presented as a comic book, storyboard, or another style that

This unit supports learning in the following History-Social Science Standards:

11.11. 5: Trace the impact of, need for, and controversies associated with environmental conservation, expansion of the national park system, and the development of environmental protection laws, with particular attention to the interaction between environmental protection advocates and property rights advocates.

12.3.2: Explain how civil society makes it possible for people, individually or in association with others, to bring their influence to bear on government in ways other than voting and elections.

12.7.5: Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.

This unit supports learning in the Speaking and Listening anchors of the California Common Core Standards and:

Reading Standard 11-12.8: Delineate and evaluate the reasoning in seminal U.S. texts, including the application of constitutional principles and use of legal reasoning and the premises, purposes, and arguments in works of public advocacy.

At the end of this unit you will find further standards connections, including the three dimensions of *NGSS*, California's *Environmental Principles and Concepts*, and the *History-Social Science Standards* broken down by activity.

includes fact-based original drawings and/or writing. Creative or innovative approaches are encouraged. This document may be created digitally or on paper depending on technology resources and preferences.

- Participating in a mock California Coastal Commission meeting: Students will act as Commission staff, local applicant groups, presiding commissioners, or other stakeholders.
- Each student will maintain a notebook that will be reviewed by the teacher for evidence of changes in student thinking.

Activities

These activity descriptions are structured to provide core content learning and support the open-ended inquiry process of the project.

1. Invitation to Engage: Speak Up
2. Explore: Roundtable Analysis of Environmental Policy
3. Explain: National Patterns in Beach Access Policy
4. Elabore: Interpreting the Public Trust Doctrine
5. Extend: Interpreting the California Coastal Act
6. Evaluate: Communicating Science, Policy, and Legal Concepts to Public Audiences: Mock Coastal Commission Meeting

Footprint in Oceano. Photo: Randolph Krauch

Activity

Coastal Voices Invitation to Engage: Speak Up

Guiding Questions:

- What does taking action look like in our society?
- Who has the power to make decisions about how society uses natural resources?

Materials Required:

- Individual student notebooks

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

- "Lower Trestles: A Surfline Feature," 2011 Surfline video
- Video of staff report closing comments at February 2008 Coastal Commission Hearing on the Toll Road through San Onofre State Park (Transcript also available)
- Orange County Register article, "Coastal Commission rejects Foothill South toll road"
- Video of public comment from an Acjachemen spokesperson

During this session students watch, identify, and respond to questions raised by a state official as he delivers a significant staff report.

Engage

Write the Guiding Questions on the board and instruct students to individually respond to the questions in their notebooks. Teacher captures student thinking by writing out ideas on a board or poster.

Explore - Public Speaking for a Cause

1. Show Surfline video of Trestles to establish a sense of the place under discussion. Invite students to relax, but to be thinking of how they would choose to participate in management of this place.
2. Pass out copies (or have students view online) the *Orange County Register* article on the Foothill South toll road. Students silently read the article.
3. Have students write the following probing questions in their notebooks:

   What is being decided during the meeting depicted?

   What legal or policy issues inform the discussion?

   How does the speaker support his or her assertions?

   What evidence is cited to support his or her assertions?

   Is there any other information you would like to have?

   What would you do differently?
4. Teacher explains that they will twice watch the video of the California Coastal Commissin Executive Director presenting the closing comments of the staff report at the hearing on Trestles; the first time without pause, before going through a second time to revise understanding and explanations. A transcript is available on the *Coastal Voices Website* to supplement or replace the video if needed. The teacher may choose to also show one or more of the videos in the Go Deep box on the following page.
5. After watching the video once, teacher leads a discussion of student response to the probing questions.
6. During the second viewing, pause as requested by students to deepen understanding and allow for revisions to initial explanations.

7. Show the video of public comment from an Acjachemen representative, who spoke at the meeting about the proposed toll road's impact on Pahne, a ceremonial site and burial ground of the Acjachemen people, the local American Indian tribe. Engage students in a discussion of the probing questions with respect to this speaker.

Reflect on Thinking

In their notebooks, students individually write a Reflective Summary that revises previous answers to the Guiding Questions of the day. Teachers should encourage students to respond with a cartoon or diagram, in addition to any prose they may deploy. Teacher guides, prompts, and evaluates student thinking.

Go Deep...

Find links on the Coastal Voices Website for the following:

- Video testimonials from Acjachemen elders and native activists.
- Video of the entire Toll Road hearing from the February 6, 2008 California Coastal Commission meeting, including full staff presentations and project applicant statements.
- Video of the crowd at the Coastal Commission meeting.
- *Surfer Magazine* article, "Coastal Commission Commits to Trestles."

Surfer, Trestles. Photo: Christina Viehoefer

Activity

Guiding Question:

- What is public policy?
- What is the connection between problems and policy?

Materials Required:

- Individual student notebooks
- *What is Public Policy* reading
- Sticky notes

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

- Carbon Beach image
- News articles on environmental policy (use the selected articles or choose others)

Coastal Voices Exploration: Roundtable Analysis of Environmental Policy

This activity is adapted from "Introduction to Public Policy" from Civic Action Project, Constitutional Rights Foundation. Students will conduct academic conversations on the topic of public policy and environmental policy in particular.

Engage

Students examine the image of Malibu's Carbon Beach before responding to the following question in their notebooks: How does the built landscape in the image provide evidence of the legal and policy environment in force when this place was developed?

Explore - Academic Conversation on Public Policy

1. Distribute *What is Public Policy* reading to small groups of about four students each. Students read the handout and respond to the following question individually in their notebook: What is public policy?
2. In their groups, students conduct an academic conversation on the following questions:

   What are some examples of policy? Remember to consider school, community, and state/federal government levels.

   Which of these are private policies and which are public policies?

   What are some institutions that create public policy in California?
3. Groups post their response on chart paper for classmates to view. Teacher leads a gallery walk to examine groups' responses to the questions. Students comment with sticky notes on each poster with clarifying questions or observations.
4. Read the following definitions of public policy written by political scientists:

   Clarke E. Cochran, et al.: "Public policy is the outcome of the struggle in government over who gets what."

   Thomas Dye: Public policy is "Whatever governments choose to do or not to do."

   B. Guy Peters: "Public policy is the sum of government activities, whether acting directly or through agents, as it has an influence on the life of citizens."

5. Students respond to the following questions in their journal: Which do you think is the best definition? How would you define public policy now?
6. Provide each group with one of the articles on environmental policy.
7. Student groups create a chart listing the individuals or groups impacted by their article's environmental policy in one column and their respective perception of the policy in the second column. How do the students think the policy "feels" to each impacted group? Post charts and perform a second gallery walk to compare student insights.

Evaluate Explanations and Reflect on Thinking

Students transition to individual journaling and complete a Reflective Summary in their notebooks that responds to the Guiding Questions of the day by making thinking visual. Teacher should encourage students to respond with a cartoon, concept map, or diagram, in addition to any prose they may deploy. Teacher guides, prompts, and evaluates student thinking.

Students in Seaside. Photo: Lauren Krohmer

What is Public Policy?

A starting point for understanding policy is to think of it as the rules that define how decisions are made in a particular organizational setting. Policy informs various decision makers (teachers, principals, business executives, government officials, presidents) as they govern schools, companies, government agencies, states like California, or entire nations. Typically, policy is written out in the form of a guideline, law, or agency procedure by leaders in the organization with intent to manage matters of importance with consistency and integrity. Public policy can be defined as the rules, decisions, and choices made by government entities that are implemented by government officials at many levels. Policy is made and implemented by humans, so it can be noble or ignoble, effective or ineffective, powerful or just plain silly.

Most students are aware of public policy, whether they call it that or not. For instance, school policies may come in the form of dress codes, minimum GPAs for sports participation, or attendance requirements. Outside of school, teenagers encounter public policy when seeking driving privileges, health care, or opportunities to participate in government. Students know that a good policy is sensible, adaptive, and fair. Most people of any age can also point to a policy that they felt was capricious, arbitrary, or unwise. Questions of fair implementation or access to resources are at the heart of many discussions about public policy. This is especially true when the resource is scarce compared to the number of people who would like access.

Activity

Coastal Voices Explanation: National Patterns in Beach Access Policy

Guiding Questions:

- How have policy makers responded to problems?
- How can the concept of cause and effect be used to understand the implications of a given policy?

Materials Required:

- Individual student notebooks
- *Case Study Analysis* worksheet
- *Six Coastal Access Case Studies*

This activity is adapted from "Introducing Policy Analysis" from Civic Action Project, Constitutional Rights Foundation. Students engage in academic conversation after analyzing coastal access case studies.

Engage

Individually in their notebooks, students respond to the following quote:

"Ruin is the destination towards which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."

- Garret Hardin, "The Tragedy of the Commons," 1968

Explore - Academic Conversation on Beach Access Policy

1. Divide the class into groups of four or six. Distribute *Case Study Analysis* and two *Coastal Access Case Studies* per group.
2. Each group will analyze two case studies chosen by the teacher. Provide half of a group with copies of one case study and the other half of the group with a different case study.
3. Teacher directs students to read one case study and work with team members to fill out the *Case Study Analysis* form. Students share information about the case study with group members who worked on the other case study.
4. Hold a brief discussion with the whole class to ask clarifying questions about the readings.
5. Debrief: Students respond to at least three of these prompts:

   What are some differences and/or similarities you can identify between the beach access policies depicted in the case studies?

   What levels and branches of government are involved in these policies? Explain.

   If public policy addresses problems, why might some people consider a policy to be a problem? Give an example from one of the case studies.

   What did you learn about public policy that you think all citizens should know?

GO DEEP...

Robert Garcia and Erica Flores Baltodano, with The City Project, authored *Free the Beach! Public Access, Equal Justice, and the California Coast* in 2005. This paper includes a history of discriminatory beach access and land use in California and efforts to increase equity. Find the link on the *Coastal Voices Website*.

Evaluate Explanations and Reflect on Thinking

Students transition to individual journaling and complete a Reflective Summary that responds to the Guiding Questions. Students respond with a cartoon or diagram, in addition to any prose they may deploy. Teacher guides, prompts, and evaluates student thinking.

Torrance County Beach. Photo: Steve Scholl

Case Study Analysis

Step One:

Read your case study.

Step Two:

Work with others in your group with the same case study to answer the questions below.

1. What is the problem in the case study? (You might identify more than one problem. Analyze one at a time.)

2. What is the public policy? (What is government doing or proposing to do about the problem?)

3. What group(s) supports the policy? Why? What group(s) opposes it? Why?

4. What institution, if any, is making or has made the decision on the policy?

5. What level of government is this institution (e.g., local, state, federal, tribal)?

6. Is there additional information you wish you had? How might you find it?

7. In your opinion, do you believe the policy is a good one? Why or why not?

Six Coastal Access Case Studies

Find links to read more about these case studies on www.coastal.ca.gov/coastalvoices

Cape Hatteras National Seashore, North Carolina - Beach Driving

Cape Hatteras National Seashore has long been a popular location for off-road vehicle use. Some members of the community maintained that this use of the beach and dunes is integral to their local traditions and vital for their economy. Surf fishers claimed that driving on the beach provides them with the mobility needed to fish successfully along the many miles of shoreline. Environmental groups and their members were concerned about the impact of beach driving on beach species and some residents feared for the safety of children who played on the beach among the cars and trucks. In 2007, a lawsuit forced the National Park Service to embark on a planning project to regulate beach driving to protect the Cape's coastal habitat and vulnerable species.

In 2012, the National Park Service issued their plan for off-road vehicles on Cape Hatteras. Drivers were required to purchase a permit for their vehicle. Driving at night was restricted to certain routes and times of year. Certain locations were closed between April 1 and October 31 for nesting birds and turtles, and locations may be closed at other times if needed for resource protection. In 2015 off-road permits brought in almost $2 million to the National Park Service. Some local business owners say that limiting off-road vehicle use has reduced the revenue of businesses that depend on those visitors.

In 2015, construction continued on a new road along the dunes to enhance access to much of the park while bypassing areas that are seasonally closed due to bird and turtle nesting. That same year, after continued protests that rules were too restrictive, the park service began holding public meetings to discuss potential changes to the off-road vehicle policy, such as increasing the dates and times when cars are allowed on the beach. Audubon Society representatives called for letting the current policy continue to protect shorebirds and turtles.

Greenwich, Connecticut - Private Beaches

In 2008, the town of Greenwich was sued by a man who was prevented from jogging along the beach. The town employed guards to keep people who did not live in Greenwich from traveling on or otherwise using the beach. Lawyers for the town argued that the public trust doctrine should not apply to their parks because in 1919 the state of Connecticut passed an act saying that Greenwich may establish parks, playgrounds, and beaches "for the use of the inhabitants of said town."

In 2001 the lawsuit landed with the Connecticut Supreme Court, which ruled that Greenwich's beaches are "public forums" which must be open to "expressive activity" of any kind, meaning that non-residents must have access to them.

While allowing non-residents to visit the beach, the City of Greenwich requires that they purchase a beach pass from a city office during business hours. As of 2015, a pass for the day costs $6. Guards are still present to enforce this policy. Some residents feel that since they pay taxes for park maintenance, that they should be the only ones to access the beach. Others think that there are too many regulations and people should have the right to go where they please. Some hope that more visitors will help diversify and support the businesses in town.

Wainiha, Kauai'i, Hawai'i - Defining the Beach

In 2000, a property owner planted and installed irrigation for vegetation in the shoreline area of his beach-front lot. In 2002, the owner hired a surveyor to identify the public shoreline. This private surveyor determined that the human-

planted vegetation line, rather than the upper wash of the waves, should serve as the official shoreline. This determination was agreed to by a state government surveyor. In Hawai'i, the public shoreline is the high water mark. Since this is often identified by a debris line or line of inland vegetation, the surveyors chose to use the more stable line of vegetation. Based on this survey, the property owner submitted an application for a new property line certification. A local activist contested the certification with photos showing waves washing inland of the vegetation line.

The activist filed a lawsuit. The State took the position that the property's shoreline was consistent with mature vegetation on adjoining properties and that the vegetation was no longer being irrigated and was stable and well established despite recent winter storms. The State submitted that "the edge of vegetation growth is the best evidence of the shoreline in this case, as it shows the result of the natural dynamics and interplay between the waves and the line of vegetation over a period of time for stability, as against a debris line which may change from week to week or from day to day," and that "the use of the edge of vegetation growth is advantageous over the debris line in that it is practical, easily identifiable and stable. "

The lawsuit finally reached the Hawai'i State Supreme Court in 2006. The Court noted that Hawai'i state law defined "shoreline" as, "the upper reaches of the wash of the waves, other than storm or seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of vegetation growth, or the upper limit of debris left by the wash of the waves," and that it did not state a preference for the vegetation line. The Court noted that a previous Supreme Court case found that "public policy…favors extending to public use and ownership as much of Hawaii's shoreline as is reasonably possible." They then stated that "the utilization of artificially planted vegetation in determining the certified shoreline encourages private landowners to plant and promote salt-tolerant vegetation to extend their land…, which is contrary to the objectives and policies of [state law and] public policy…"

Destin, Florida - Beach Nourishment

The law in Florida states that land that is gradually added to the shoreline (called "accretion") belongs to the beachfront property owner, but a sudden addition of land (called "avulsion") belongs to the State.

The state of Florida has artificially deposited sand on hundreds of its beaches in order to fight erosion. This process is called beach nourishment, and is done in order to protect coastal property from waves and storms and to restore the recreation area and habitat of the sandy beach. This is a very expensive process; between 1998 and 2016 Florida spent $626.6 million, in addition to local government contributions.

Beachfront homeowners in Destin, Florida, on the Gulf of Mexico, contended that the government's plan to deposit sand on their coast was for the purpose of increasing visitors in order to support a tourism economy, which they felt was not in property owners' interest. Before a beach nourishment project begins, the government establishes a fixed "erosion control line" which becomes the permanent property line. The Public Trust Doctrine holds that in Florida the State owns the land up to the mean high tide line. The setting of an "erosion control line" prior to depositing sand on the beach may result in a property line that is inland from the mean high tide line once the sand is deposited. The Destin homeowners felt that this would be taking property away from them, by changing their homes from waterfront to water-view.

The property owners sued the State, and the case eventually landed at the U.S. Supreme Court. In its 2009 decision, the Court stated that "the State as owner of the submerged land adjacent to littoral property has the right to fill that land, so long as it does not interfere with the rights of the public and of littoral landowners. Second, if an avulsion exposes land seaward of littoral property that had previously been submerged, that land belongs to the State even if it interrupts the littoral owner's contact with the water. Prior Florida law suggests that there is no exception to this rule when the State causes the avulsion. Thus, Florida…allowed the State to fill in its own seabed, and the resulting sudden exposure of previously submerged land was treated like an avulsion for ownership purposes." The new beach created by beach nourishment is public, not private, property.

Quinault Indian Nation - Beach Passes

The Quinault Indian Reservation includes 26 miles of coastline on the Olympic Peninsula of Washington State. In 2012, the Quinault Indian Nation closed their beaches to all except enrolled Quinault members. Non-members are only allowed if accompanied by a tribal member.

There is a lengthy and complex historical backdrop for this action. In 1887, the United States Congress passed the General Allotment Act, which divided up reservations into individual properties. Eventually, tribal members were allowed to sell property to non-members. Most of the Quinault reservation land was sold; however, the tribe continues to own all beach lands up to the ordinary high water mark. Prior to the late 1960s, the Quinault coast was open to the public without restriction, and included a popular surfing spot at Point Grenville. Problems, including litter and graffiti on the bluffs, prompted the Quinault Tribe to limit this access. As tribes across the country began asserting their authority over reservation lands during the American Indian rights movement, in 1969 the Quinault Nation closed Grenville Beach to surfing and began requiring a beach pass from the tribal office for any non-tribal member wanting to visit the beach. Access was further restricted in 2012, when the Tribe made the decision to stop issuing beach passes. According to the Tribe, the access is being restricted to preserve functional coastal ecosystems.

The Washington State Office of the Attorney General provided the following official opinion in 1970 regarding rights of coastal access:

> (1) Without regard to any other property interests or rights which the state may have, members of the public have the right to use and enjoy the wet and dry sand areas of the ocean beaches of the state of Washington by virtue of a long-established customary use of those areas. (2) The right of members of the public to use and enjoy the wet and dry sand areas of the ocean beaches of Washington by virtue of a long-established customary use of those areas does not presently extend to such ocean beach areas as are within the exterior boundaries of the Quinault Indian Reservation.

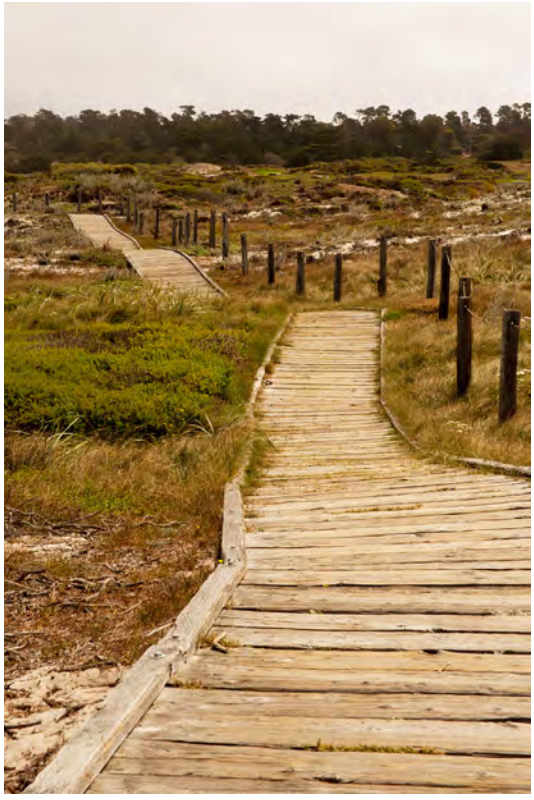
This opinion is based on an 1873 Executive Order by President Ulysses S. Grant that withdrew the reservation's lands from the public domain, reserving them for the exclusive use and occupancy of the Quinault and other area tribes. The Washington Attorney General stated that "If the public had any rights in the beaches fronting on the Quinault Reservation on November 4, 1873, those rights were extinguished by that Executive Order."

Sea Ranch, Sonoma County, California - Coastal Trail

In the 1960s, developers purchased a former sheep ranch in rural Sonoma County and

planned a private community of beach homes that would have closed 10 miles of the coast to the public. As part of the county approval of the development plan, developers gave to Sonoma County land adjacent to the proposed development that would become Gualala Point Regional Park. Although Sea Ranch was designed as an environmentally sensitive development, the proposed privatization of this stretch of coastline led local activists to propose a county initiative requiring public access whenever coastal property was developed. This initiative was defeated, with the opposition funded in large part by the Sea Ranch developers.

Spurred by Sea Ranch and other issues impacting the coast, the Sonoma County activists joined other organizations and individuals to bring a statewide initiative to the voters to create a California Coastal Commission, which would be responsible for regulating coastal development and protecting coastal access in California.



Pacific Grove. Photo: Kimberly Lohse

Approved in 1972, the California Coastal Zone Conservation Act (or "Prop 20") called for "maximum visual and physical use and enjoyment of the coastal zone by the public." In 1976, the state legislature passed the Coastal Act, defining the regulations the California Coastal Commission would uphold.

For years, Sea Ranch developers disputed California Coastal Commission jurisdiction over the Sea Ranch. While the initial subdivision had received approval from Sonoma County prior to the passage of the Coastal Act, lots were owned by individuals who still needed permits to build their homes and were now subject to this law. Individual owners were unable to provide shoreline access as demanded by the California Coastal Commission because common areas between residential lots were owned by the Sea Ranch Association. In 1981, in a case brought by the Sea Ranch Association, a district court upheld the California Coastal Commission's ability to impose coastal development permit conditions relating to public access and coastal views. The court concluded that "public access to the coastline and protection of the coastline's scenic and visual qualities are areas within the Commission's regulatory authority under the California Coastal Zone Conservation Act and that the Act empowers the Commission to implement its goals through the permitting process." The court found that "the permit conditions do not constitute a taking of either an individual lot owner's property or the Association's property."

It ultimately took the state legislature passing a law specifically for the Sea Ranch in order to settle the issue. Known as the Bane Bill, it required five public access points and a blufftop public trail within the property, as well as specific design guidelines. The bill authorized a payment of $500,000 from the State to the Sea Ranch Association in exchange for the public access easements and other concessions.

Activity

Guiding Questions:

- What are the legal foundations of coastal zone policy in California?

Materials Required:

- Individual student notebooks
- *Public Trust Doctrine* summary, found in the Readings and Resources section

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

- KCET article, "Why California's Beaches are Open to Everyone"

Coastal Voices Elaboration: Interpreting the Public Trust Doctrine

Using the "jigsaw" technique, students will read and discuss an explanation of the Public Trust Doctrine.

Engage

Individually in their notebooks, students respond visually or in prose to the following quote:

"By the law of nature, these things are common to mankind: the air, running water, the sea, and consequently the shores of the sea…"

- Institutes of Emperor Justinian, 2.1.1 (AD 529)

Explore - The Public Trust Doctrine

1. Assign each student to a "home group" of three students who reflect a range of reading abilities.
2. Assign one of the three sections of the Public Trust Doctrine document to each student in each home group.
3. Regroup the students according to the section that they're assigned. These are the "expert groups." You may choose to make three, large expert groups or several smaller groups for each section of the reading.
4. Teacher provides key questions to help the expert groups gather information from the assigned reading. For example:

   Expert Group 1 (Paragraphs 1 and 2):
   What is "sovereign land?" What does it mean for "lands to be held in trust" by the State of California? What is a "navigable waterway" and why might it be important to the public?

   Expert Group 2 (Paragraph 3):
   What is an "affirmative duty?" What are some public uses that the Public Trust Doctrine protects? What is the implication of the statement that public trust lands "cannot be alienated through sale into private ownership"?

   Expert Group 3 (Paragraphs 4 and 5):
   Has California's interpretation of the Public Trust Doctrine changed over time? Who decides how it changes? Who is responsible in California for administering the Public Trust Doctrine?
5. After reading and discussion with their expert groups, students spend a few moments jotting down their impressions and understanding.

Scripps Pier. Photo: Cia Farrar Knapp

6. Reconvene into home groups. Each student will explain their reading selection in their own words to the rest of the group and answer any questions from the other members. Groups discuss together what conclusions can be drawn from the reading as a whole.
7. With one student taking the role of recorder, each home group composes a paragraph summarizing their combined understanding of the entire reading, to be turned in to the teacher.
8. Reconvene the class and show the following section from the California Constitution on a screen (or passes out hard copies). Read it aloud or have students read it silently, and as a class discussion invite students to make (and refute or support) evidence-based claims about this section of the California Constitution and how it relates to the Public Trust Doctrine.

> No individual, partnership, or corporation, claiming or possessing the frontage or tidal lands of a harbor, bay, inlet, estuary, or other navigable water in this State, shall be permitted to exclude the right of way to such water whenever it is required for any public purpose, not to destroy or obstruct the free navigation of such water; and the Legislature shall enact such laws as will give the most liberal construction to this provision so that access to the navigable waters of this State shall always be attainable for the people thereof.
>
> Constitution of the State of California, Article 10, Section 4

Evaluate Explanations and Reflect on Thinking

In their notebooks, students write a Reflective Summary that responds to the Guiding Question of the day. Teachers should encourage students to respond with a cartoon or diagram, in addition to any prose they may deploy.

Teacher explains that students will develop an Illustrated Citizen's Guide to California Beach Law. This graphical guide may be presented as a comic book, storyboard, or any other style that includes fact-based original drawings and/or writing. This assignment is due at the end of the unit.

At-Home

Students read KCET's article "Why California's Beaches are Open to Everyone."

Activity

Coastal Voices Extend: Interpreting the California Coastal Act

Guiding Questions:

- What are the legal foundations of coastal zone policy in California?

Materials Required:

- Individual student notebooks
- *Introduction to the California Coastal Act*, found in the Readings and Resources section
- "Contesting the Coast" roles

Using the "jigsaw" technique, students will read and discuss excerpts from the California Coastal Act.

Engage

Individually in their notebooks, students respond in prose or with a drawing to the following quote:

"You can't take our relationship with the coast for granted, because it took a lot of sweat, blood and tears to preserve it so we have what we have today. These things didn't just happen. The coast is what it is because a lot of people worked really hard and sacrificed to protect it. And if we want it to be there for our children, we have to keep fighting to protect it. In that way, the coast is never saved, it's always being saved."

- Peter Douglas, California Coastal Commission Executive Director 1985-2011

Explore - The Coastal Act

1. Assign each student to a "home group" of three students who reflect a range of reading abilities.
2. Assign one of the four sections of the *Introduction to the California Coastal Act* to each student in each home group.
3. Regroup the students according to the section that they're assigned. These are the "expert groups." You may choose to make four, large expert groups or several smaller groups for each section of the reading.
4. Teacher provides key questions to help the expert groups gather information from the assigned reading. For example:

Carbon Beach Accessway. Photo: Steve Scholl

Expert Group 1:
Why was the Coastal Act created? What are the priorities of the Act? What are its goals?

Expert Group 2:
How can public accessways to the coast be created? What are some challenges in creating new public access?

Expert Group 3:
What is "priority coastal development" according to the Coastal Act? How does the Act address potential impacts of development on marine and coastal resources?

GO DEEP...

The documentary *Heroes of the Coast* recounts the political campaigns in the 1970s that passed the Coastal Act and created the California Coastal Commission, told through interviews with activists and political leaders of the movement. Access this video on the *Coastal Voices Website*.

Expert Group 4:

Why do you think coastal views are protected? In what way is shoreline armoring limited by the Coastal Act? Why does public participation matter in the Coastal Act? Who are the Coastal Commissioners?

5. After reading and discussion with their expert groups, students spend a few moments jotting down their impressions and understanding.
6. Reconvene into home groups. Each student will explain their reading selection in their own words to the rest of the group and answer any questions from the other members. Discuss together what conclusions can be drawn from the entire reading.
7. With one student taking the role of recorder, each home group composes a summary of their combined understanding of the reading as an answer to the Guiding Question of the day. This may be a bulleted list, a chart, or paragraph form, depending on the choice of the group or the preference of the teacher.

Evaluate Explanations and Reflect on Thinking

Individually, students continue work on their Illustrated Citizen's Guide to California Beach Law.

At-Home

Read "Contesting the Coast" roles to prepare for mock California Coastal Commission meeting.

Santa Monica. Photo: Ray Tschaeche

Contesting the Coast

A fictional coastal project and related stakeholder positions are described below. You will elaborate on your position in your presentation.

A New Hotel is Proposed in Small Coastal Town, CA:

A historic but dilapidated home on a coastal property has been sold to a new owner who would like to turn it into a small, luxury hotel and restaurant. The building had been home to a couple who allowed the public to pass along the edge of their property to reach a path to the beach behind the house. The new owners propose renovations that would not increase the footprint of the building but would include a new parking lot in front of the property and a fence around the perimeter. They plan to build a stairway to replace the dirt path leading to the beach. Their proposal includes an open gate during daylight hours, but at sunset would restrict access to the beach to hotel guests only. The owners propose replacing the current lawns with local native plants. The new parking lot would be equipped with solar-powered charging stations for electric vehicles and permeable pavement to allow rainwater to infiltrate into the soil rather than run off into the gutter. The hotel plans to hire twenty full-time employees from the local community. They are seeking a Coastal Development Permit from the California Coastal Commission.

Roles:

Permit applicants (owners): The proposed project will bring needed jobs and tax dollars into the community. It will result in a structure and landscaping that will beautify the area. It will use environmentally friendly techniques and construction. The owners assert that the new limits on coastal access are needed for the hotel managers to properly secure the property after dark and for the hotel guests to feel safe. It is more than fair to allow public access during daylight hours.

Mayor of the city: The mayor is in support of this project, with the belief that the jobs and tourism it will bring to the community will help the economy. The renovation will also help improve the appearance of a prominent building in town, which had been ill-maintained for years.

Chamber of commerce: The business community is in favor of this project for the same reasons as the mayor. The hope is that a luxury hotel and restaurant will attract good publicity to the community and start a wave of new, upscale development which would in turn help raise existing property values.

Local worker: This local citizen is excited about new jobs in this small community, after having recently lost a service job. A few restaurants in town have closed over the last year and the new project presents needed employment opportunities.

Native plant enthusiast: The project will replace lawn with plants native to this coastal area. This change would benefit a local endangered butterfly species that depends on a particular native plant as a food source. The new landscaping could also serve as an example to the community of how they could convert their yards to environmentally-friendly, attractive, drought-tolerant plants.

A local religious community: This group regularly holds bonfires on the beach below the property as a communal and spiritual ritual. For years they have passed through this property with no objection from the owners. On a monthly basis they head down to the beach in the late afternoon and return after dark, so would be negatively impacted by the proposed gate-closure.

Local historical society: This building was constructed in 1895 and is considered by many to be a local treasure. The historical society argues that the home not be altered, but should be kept as close to its original state as possible and be opened to the public as a museum, with the existing beach access remaining unchanged.

Youth group: A local youth group wants the property turned into a hostel rather than a luxury hotel. They express that there are few coastal lodging options for middle and low-income visitors, and this home could serve that role in their community. They would like a place to host gatherings with groups from around the state where visitors from all backgrounds could experience the beauty of the coast.

Surfers: Local surfers love the waves below the proposed project and often make their way down to the beach before sunrise for the best waves and quality time before the work day begins. If the project is approved as described, their dawn patrols would be impeded by a locked gate.

Neighbors: A group of neighbors are opposing the project due to concerns about increased traffic and a fear of changing neighborhood character. They dislike the idea of a parking lot being constructed on their previously residential street. They worry that the new fence will obstruct the views of the ocean that they currently enjoy.

Commission Staff: The job of the staff is to evaluate the permit application's consistency with the Coastal Act and provide recommendations to the Commissioners based on that evaluation. They can also recommend the permit be approved as submitted, develop recommended permit conditions to address Coastal Act issues, or recommend that the permit be denied.

Commissioners: The Commissioners must have a thorough understanding of the Coastal Act and bring that understanding to their evaluation of the permit application and the Commission staff report as they receive input from other stakeholders. They can approve the permit as submitted, approve the permit with changes recommended by Commission staff, approve the permit with changes they submit themselves, or deny the permit.

Activity

Coastal Voices Evaluation: Mock Coastal Commission Meeting

Guiding Questions:

- How are science, policy, and legal concepts communicated during formal public hearings?

Materials Required:

- *Contesting the Coast* roles, or information on real world coastal development stakeholders as teacher prefers
- *Creativity*, *Presentation*, and *Collaboration Rubrics*, found in the Readings and Resources section.
- Timer

Students will take on roles to carry out a mock California Coastal Commission meeting, spending one session preparing and a second session performing their roles at the meeting.

Day One, plus out of class work as needed:

1. Explain to students that making decisions about the coast can be contentious. Stakeholders who understand the law, are armed with high quality visuals, and are articulate have the best chance of being heard.
2. Students should individually read *Contesting the Coast* or a reading selected by the teacher on a local coastal zone access matter.
3. Assign students to act in specific roles for the mock meeting. Arrange the numbers to suit your class size. For a class of 35 students, you might assign five commissioners (including one Commission chair), three Commission staff, a group of three to represent the project applicant, and eight groups of three to be divided among project supporters and objectors. Consider carefully who occupies the commissioner roles as they will be responding to stakeholders rather than speaking from a prepared statement. All students will be using resources from previous activities in this unit, particularly *Interpreting the Coastal Act*.
4. Students break into their groups. Commission staff will prepare one three-minute oral report recommending approval or denial of the project based on its consistency with the Coastal Act. The applicant group will prepare a three-minute presentation on the merits of their project and why they feel it should be approved. Stakeholder groups will take on the personae of particular project supporters or objectors and each prepare a three-minute presentation, including a question that will require a verbal response from a commissioner. Each group (applicant, stakeholders, and staff) will either share speaking duties or designate a speaker as the teacher directs, keeping to the time limit. They will prepare visuals as appropriate to support their positions. Commissioners will familiarize themselves with the project and the Coastal Act in order to ask and respond to questions during the meeting. They should draft some potential questions for staff and applicant, and determine their preliminary positions on the project. Their votes are to be decided individually, but they should work as a group during class to understand the project.

Day Two:

The classroom may need prep prior to school or during a break between periods. Optionally, consider performing this activity in a district boardroom, council chambers, or other space where formal public meetings are held, or in the school auditorium.

1. The commissioners and staff will sit facing the stakeholders in public meeting fashion (theatre style). As students arrive have stakeholder groups fill out speaker's cards to determine their speaking order. The commission chair collects the speaker's cards.
2. Teacher calls the meeting to order and explains the public meeting procedure and demonstrates the timing system. Teacher should encourage students to take substantial notes about substance and speakers, so that they may make connections or validate previous speakers where possible.
3. Commission staff speak first, describing the Coastal Act issues raised in *Contesting the Coast* and making specific recommendations to the Commission. Next, the applicant speaks to the merits of their project, asking for Commission approval. Commissioners may ask questions following each speaker.
4. Stakeholder groups, as called to speak by the commission chair, deliver their statements. The chair is responsible for timing speakers and notifying them when their time is up. Commissioners should periodically ask probing questions in response to a statement. All students evaluate speaker performance and provide written feedback as assigned by teacher, via the *Creativity* and *Presentation Rubrics*.
5. The commission chair calls for a vote on the project, teacher tallies the response, and the chair adjourns the meeting.

Art by Joseph Dickinson, 9th grade

Construct Explanations and Reflect on Thinking

Students write a Reflective Summary that evaluates the process of a public meeting and answers the Guiding Question of this lesson. Ask groups to discuss whether they would change anything about the meeting format, physical setting, or timing of events to make it more effective.

At-Home Self-Evaluation

In their notebooks, students articulate their own opinion on whether the *Contesting the Coast* project would merit approval by the California Coastal Commission. This should be a personal conclusion based on the student's own knowledge, not as a representative of his or her assigned stakeholder group. Students

use the full set of rubrics (or as assigned by the teacher) for self and peer-evaluation to reflect upon their performance. Students complete their Illustrated Citizen's Guide to California Beach Law to be turned in at the next class session (or as assigned by the teacher).

Go Deep...

Check the Coastal Commission meeting calendar for upcoming meetings in your region: *www.coastal.ca.gov/meetings/mtgdates.html*

These meetings are public and your class is welcome to attend and submit comments, respecting the rules and procedure of the meeting. The monthly Coastal Commission meetings are also streamed live online and previous meeting videos are archived. Check the website for links.

Eureka Harbor. Photo: Linda Kay Isbell

Connecting to the Standards

Coastal Voices: Speaking Up for the Beach

Next Generation Science Standards
Coastal Voices: Speaking Up for the Beach **supports the following** ***Next Generation Science Standards*** **Performance Expection.** **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

History-Social Science Standards	Specific Connections to Unit / Activity Designation
11.11.5 – Trace the impact of, need for, and controversies associated with the development of environmental protection laws.	• Conduct academic conversations on public policy and explore particular environmental policies through news articles. (Exploration) • Engage in analysis and academic conversation about coastal access law case studies. (Explanation)
12.3.2 – Explain how civil society makes it possible for people to bring their influence to bear on government in ways other than voting and elections.	• Explore the public meeting and permitting process for a proposed coastal development. (Invitation to Engage) • Engage in analysis and academic conversation about coastal access law case studies. (Explanation) • Prepare for and carry out a mock Coastal Commission meeting. (Evaluation)
12.7.5 – Explain how public policy is formed.	• Conduct academic conversations on public policy and explore particular environmental policies through news articles. (Exploration) • Engage in analysis and academic conversation about coastal access law case studies. (Explanation) • Create an Illustrated Citizen's Guide to California Beach Law. (Elaboration, Extend)

Environmental Principles and Concepts	Specific Connections to Unit / Activity Designation
Principle II—People Influence Natural Systems	• Obtain and evaluate information on a proposed coastal development and its potential impacts. (Invitation to Engage) • Obtain and evaluate information on the implementation process and implications of environmental policies in the news. (Exploration) • Engage in analysis and academic conversation about coastal access law case studies. (Explanation) • Analyze and conduct academic conversations on documents and historical declarations relating to public lands. (Elaboration) • Prepare for and carry out a mock Coastal Commission meeting involving a proposed development. (Evaluation)

Principle V—Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors	• Obtain and evaluate information on a proposed coastal development and its potential impacts. (Invitation to Engage) • Obtain and evaluate information on the implementation process and implications of environmental policies in the news. (Exploration) • Engage in analysis and academic conversation about coastal access law case studies. (Explanation) • Analyze and conduct academic conversations on documents and historical declarations relating to public lands. (Elaboration) • Analyze excerpts from the California Coastal Act. (Extend) • Prepare for and carry out a mock Coastal Commission meeting involving a proposed development. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Disciplinary Core Ideas	ESS3.A – Resource availability has guided the development of human society, and the use of natural resources has associated costs, risk, and benefits. (9-12)	• Obtain and evaluate information on the implementation process and implications of environmental policies in the news. (Exploration) • Obtain and evaluate information on documents and historical declarations relating to public lands. (Elaboration) • Analyze excerpts from the California Coastal Act. (Extend)
	ESS3.C – Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (9-12)	• Obtain and evaluate information on the public meeting and permitting process for a proposed coastal development. (Invitation to Engage) • Obtain and evaluate information on the implementation process and implications of environmental policies in the news. (Exploration) • Engage in analysis and academic conversation about coastal access case studies. (Explanation) • Analyze excerpts from the California Coastal Act. (Extend)
	ETS1.B – When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural, and environmental impacts. (9-12)	• Obtain and evaluate information on the public meeting and permitting process for a proposed coastal development. (Invitation to Engage) • Obtain and evaluate information on the implementation process and implications of environmental policies in the news. (Exploration) • Engage in analysis and academic conversation about coastal access case studies. (Explanation) • Analyze excerpts from the California Coastal Act. (Extend) • Prepare for and carry out a mock Coastal Commission meeting involving a proposed development. (Evaluation)

Dimension	NGSS Citation / Grade Progression	Specific Connections to Unit / Activity Designation
Science and Engineering Practices	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, limitations, constraints, and ethical issues. (9-12)	• Prepare for and carry out a mock Coastal Commission meeting involving a proposed development. (Evaluation)
	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (9-12)	• Conduct academic conversations on public policy and explore particular environmental policies through news articles. (Exploration) • Engage in analysis and academic conversation about coastal access case studies. (Explanation) • Prepare for and carry out a mock Coastal Commission meeting involving a proposed development. Commissioner roles will issue an oral decision and students will express their individual opinions in writing. (Evaluation)
	Construct, use, and present an oral argument or counter-arguments based on data and evidence. (9-12)	• Throughout the unit during learning conversations. • Prepare for and carry out a mock Coastal Commission meeting in the roles of stakeholders, staff, and commissioners. (Evaluation)
	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. (9-12)	• Prepare for and carry out a mock Coastal Commission meeting involving a proposed development, in the roles of stakeholders, staff, and commissioners. (Evaluation)
	Communicate scientific and/or technical information or ideas in multiple formats. (9-12)	• Throughout the unit during learning conversations. • Prepare for and carry out a mock Coastal Commission meeting with oral and visual presentations from stakeholder roles. (Evaluation)

California Common Core Focus	Specific Connections to Unit / Activity Designation
Reading 11-12.8 – Delineate and evaluate the reasoning in seminal U.S. texts.	• Engage in an academic conversation on an explanation of the Public Trust Doctrine and an excerpt from the California State Constitution. (Elaboration) • Analyze excerpts from the California Coastal Act. (Extend)

A Sense of Nature: Who's at the Beach?

A California Coastal Voices Student-Driven Project

Etna Elementary School at Patrick's Point State Park

Challenging Question:

How can we expand park access for all Californians?

For this Project:

Teacher Guide: Who's at the Beach?

Art by Vaibhavi Patankar, 6th grade

Spending time at parks and beaches can result in many benefits to people in terms of physical and mental health, recreation opportunities, and freedom to explore the natural world. A goal of the California Coastal Act is to maximaze public access to the coast. However, the existence of access pathways and public beaches do not necessarily translate to access for all. Other barriers may exist, such as a lack of adequate bus routes or other affordable method of transportation, parking costs, or a feeling of not being welcomed to the public space. The City Project presented data from 2007 to 2009 showing that only two of the 25 California State Parks surveyed had more than 50% visitors of color, and for most of the parks the percentage was much less. California as a whole is 57% people of color. This project presents the opportunity to delve into these issues as well as explore the potential for conflict between public access and ecological impacts to natural areas.

In order to answer the Challenging Question, students are directed to assume roles as a geospatial analyst, transportation engineer, park policy analyst, or principal investigator for their group. In each case, they will be asked to analyze a variety of self-selected data sources before making strategic recommendations for increasing access to parks (or to a particular park, depending on their interest and teacher direction).

The final student reading helps students plan and lead a park experience that focuses on physical, cultural or ecological factors. You may choose to have students perform the field experience concurrent with the park access project or following it. Although you can opt to omit the field experience, getting students outside into California's parks and beaches is healthy, engaging, and powerful and reinforces the park access project.

This project is interdisciplinary with a solid foundation in the engineering design process as defined in the Next Generation Science Standards (NGSS). The National Research Council states that in the NGSS "we use the term 'engineering' in a very broad sense to mean any engagement in a systematic practice of design to achieve solutions to particular human problems. Likewise, we broadly use the term 'technology' to include all types of human-made systems and processes." NGSS describe the following components of engineering design:

1. Defining and delimiting engineering problems involves stating the problem to be solved as clearly as possible in terms of criteria for success and constraints or limits.

2. Designing solutions to engineering problems begins with generating a number of different possible solutions and evaluating them with regard to the criteria and constraints of the problem.
3. Optimizing the design solution involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

With entry points from Earth science, engineering, and the humanities, partnership with another teacher from a complementary subject area can strengthen this project.

Teacher Preparation Tasks:

- Review the *Teacher Checklist for Student-Driven Projects*, found in the "Readings and Resources" section. Review suggestions for Personalized Learning Plans and Group Contracts and decide if or how you will use these with your students.
- Review all student readings and handouts, listed on this project's cover sheet. Make copies for students as needed, or share electronically.
- Study the questions in this *Teacher Guide* and the associated reference links found on the *Coastal Voices Website*. Refer back to the Teacher Support Pieces in *California Coastal Voices* as needed.
- If desired, connect with a cooperating teacher from a complementary subject area for the project.
- Arrange a guest speaker to kick off the project. Options include a State Parks ranger or naturalist, a park activist or administrator, or a park docent or volunteer. California State Parks' PORTS program is an alternative that offers video conferencing with park staff.
- Consider what local parks are available for the student field project and whether you will assign locations, provide a list of choices, or have teams identify a park on their own.
- Research safety procedures and necessary permissions for the student field project. Plan to arrange for or assist with any needed supplies such as sunscreen, extra jackets, shoes appropriate for hiking, and transportation.
- For use in your classroom, you may want to choose Daily Phenomena from the Thematic Slideshows of Coastal Images available on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices.

The following questions are guides to help you prepare to support student questioning and learning. While not anticipating every place a student may go, the questions provide connections to significant content related *Next Generation Science Standards* performance expectations (NGSS PEs) and disciplinary core ideas (NGSS DCIs), and to *California's Environmental Principles and Concepts* (EP&Cs). Your role is to facilitate the process through which students find their own way to many of these and similar questions.

Visit the *Coastal Voices Website* for links to resources that help answer these questions and to the full text of California's Environmental Principles and Concepts. You will also find images for download, links to videos, park brochures, and teaching resources.

www.coastal.ca.gov/coastalvoices

Week One and Two:

- What is geo-spatial analysis and how can using this tool illuminate the relationship between human communities and the ecosystem services provided by natural systems? (NGSS DCI: ESS2.E; EP&Cs I)
- What types of geographic information may be needed to investigate physical barriers to park access? For example, is the weather typically very cold and windy? Is there public transportation that could be used to reach the spot? How long does it take? For drivers, is there parking? (NGSS PE: ESS3-4; NGSS DCI: ESS2.E)
- What remote sensing tools do geospatial analysts use to consider the impact on natural systems when attempting to protect and enhance human access to natural areas? (NGSS PEs: ETS1-1 and ETS1-2; EP&Cs II and V)

Photo: I Love A Clean San Diego

Week Two and Three:

- How can we define and delineate engineering solutions using the following parameters: cost, safety, reliability, aesthetics, social, cultural, and environmental impacts in a park access plan? (NGSS DCIs: ETS1.A and B; EP&Cs V)
- Can engineering or technology solutions increase access to natural areas (parks/ beaches) while still supporting the long term functioning of freshwater, coastal, and terrestrial ecosystems? (NGSS PE: ETS1-3; EP&Cs II)
- Are there areas where human access or specific activities should be limited within park boundaries? Why? (NGSS PE: LS2-7; EP&Cs I and V)

Week Three and Four:

- How can I increase access to and use of natural park areas while not degrading existing natural ecosystems? (NGSS PE: LS2-7; NGSS DCI: ESS3.C; EP&Cs I, II, and III)
- How will climate change create barriers to park and beach access? (NGSS DCIs: ESS2.A and ETS1.B; EP&Cs III)
- As California's population increases, what kind of management and decision making processes will help us negotiate the complex relationships between natural systems and the resource needs of human communities? (NGSS DCI: LS2-7; EP&Cs V)

Surfers on Jalama Beach. Photo: Tom Griffithe

Invitation to Engage:
Access and Equity in California Parks

Challenging Question: How can we expand park access for all Californians?

The Issue:

Too few young people and people of color are visiting outdoor parks or using them as learning environments due to physical, political, economic, and social obstacles.

Why is this important?

Access to nature for all communities and demographics can lead to better human and environmental health and greater civic engagement.

Photo: Bronya Hamel

Objective:

To investigate barriers and propose solutions to making California's parks accessible to all segments of California.

Audience:

Decision-makers ranging from state officials, district administrators, and teacher-leaders. People from nearby schools, churches, scout troops, afterschool clubs, and peers.

What will students do?

1. **Investigate Barriers to Access and Propose Solutions.** You will act as youth advisors to California State Parks, or other parks department as appropriate, by investigating barriers to park access and designing and proposing solutions. Teams will prepare and then present solutions as assigned or in a manner of their choosing (such as a report to park administrators, a newspaper article, a video, or other method).
2. **Lead a Field Experience.** You will work in a team to organize and lead a field experience at a nature area, local park, state park, beach, or national park. The field experience may focus on physical, cultural, or ecological features.

How will teams be organized?

Science, Engineering, and Policy (SEP) teams of four students will focus on parks of their choice. Students will adopt (or rotate) roles: geospatial analyst,

transportation engineer, and park policy analyst. A fourth student will act as the Principal Investigator, or team leader.

How will individual students document their work?

A Student Science Notebook will document visual landscape analysis, transportation analysis, review of park's current outreach, natural history material, and summaries of recommendations for increasing visitation as described above.

Two teens working with Youth Speak Collective and California Parks Now documented a trip from the San Fernando Valley to the beach. One of them took public transportation and one used a special summer "beach bus." They made a video to compare their experiences. Visit the *Coastal Voices Website* for the video:

www.coastal.ca.gov/coastalvoices

As you use geospatial analysis to get to know California parks, you may find helpful Esri's collection of "GeoInquiries," which take you step by step through image analysis challenges.

There are many ways to present data. "Story Maps" are a free resource combining maps and other images with text in a web-based format.

Visit the *Coastal Voices Website* for links:
www.coastal.ca.gov/coastalvoices

Photo: Channel Islands Restoration

Student Checklist:

Investigate Barriers to Access and Propose Solutions

Challenging Question: How can we expand park access for all Californians?

Add due dates to the following tasks and phases as instructed by your teacher.

Bedwell Bayfront Park. Photo: June Jordan School for Equity

Phase 1: Invitation to Engage, Explore Challenging Question, & Organize

Ask significant questions and define problems as you launch your project.

- O Read *Invitation to Engage: Access and Equity in California Parks*. Review rubrics.
- O After you are assigned to a group, you will adopt a role as a principal investigator, scientist, engineer, or policy analyst and develop a brief job description for the role. These roles may be adopted for the length of the project, or rotated within your group. Accept or modify the Challenging Question with your group and teacher.
- O With your group, create an initial need-to-know list of relevant questions to launch your park access investigation.

Phase 2: Explore Questions, Existing Models, and Knowledge

During the second phase of the project you will work in your group to question the status quo; specifically to explore, analyze, and interpret qualitative and quantitative data related to your need-to-know questions as you design a solution related to expanding access to parks or to a particular park.

Fishing off Redondo Pier. Photo: Amanda Cordova

- O Read *Asking the Right Questions*. Working in your groups, use the Question Formulation Technique to refine, prioritize, and if necessary narrow down your need-to-know list of relevant

questions developed in Phase 1. Assign specific questions to group members (by role, skills, or preference). Use these questions to launch your investigations. If your plan includes interviews, be sure to contact the subjects well in advance to set up appointments.

Bikers on Rodeo Beach. Photo: Kirke Wrench

- O Research and review existing access solutions and arguments for and against these solutions. Evaluate the strengths and weaknesses in the arguments. Evaluate the quality and credibility of your sources.
- O Synthesize existing ideas, science concepts, and solutions into a "better solution." What arguments and actions do you support? This becomes your draft project solution.
- O With your group, meet with your teacher to review and gain approval for your project plan.
- O Individually, perform a self-assessment of Phase 1 and 2 and a brief plan of improvement, as directed by your teacher.

Phase 3: Explain and Evaluate Claims, Argue from Evidence, and Reason

In this phase, you will evaluate and develop new arguments for your park access solution, and complete planning for your presentation.

- O Review the *Claims, Evidence, and Reasoning Guide*.
- O Use the Claims, Evidence, and Reasoning chart, found in the reading, to refine the arguments for your solution. Select your best arguments for your park access solutions. Share them as directed by your teacher, and revise based on feedback.
- O Read *Tips for Effective Communication in Public Settings*.
- O Complete planning for your park access solution final project. If it will be an in-person presentation (rather than an article or other medium), practice and review it with the *Presentation Rubric*.
- O Individually, perform a self-assessment and write a plan of improvement to turn in to your teacher. Confirm arrangements for any off-site presentations, if applicable.

Phase 4: Extend into Action: Communicate your Science, Engineering and Policy Solutions

Surfer. Photo: Alan Seaman

Your primary academic role towards the end of the project is to communicate your thinking using visual tools, models, media presentations, or written products.

- O If your final project is a presentation, perform technology checks on any equipment that will be needed and follow up with invited guests to confirm attendance at least 24 hours in advance. Present your proposed solutions to your audience. If your project is another format, publish, post, distribute, and publicize the final product.
- O Perform self-assessment and peer reviews, as directed by your teacher.
- O Submit individual project notebook to teacher for review.

Phase 5: Reflecting, Evaluating, and Celebrating

Ask yourself how you could improve while your successes and failures are still fresh in your mind.

- O Organize a group debrief with teacher. Have any new questions emerged?
- O Write thank you notes to any adult mentors and partners.
- O Perform a final self-evaluation, as directed by your teacher.
- O Celebrate with your hard working team!

Moonlight State Beach. Photo: Clare Jones Carbonell

A Guide to Leading a Field Experience

Like any public presentation, leading a field experience requires knowledge, practice, and planning. You'll find it's a wonderful way to connect with people; to share what you know and learn from one another, all while getting exercise and enjoying the outdoors.

Phase 1: Who, What, Where, When

As a group and in consultation with your teacher, choose a local park, beach, or nature area for your field experience. Start with a map of your community to explore your options. Questions to ask include:

- Determine how far are you able to travel and how you will get there.
- Identify the audience to which you will present. A nearby elementary school class, an afterschool program, a local church group, a scout troop, your parents and siblings…? Is your chosen location convenient for them to get to? Is there a way you can make it easier for them to attend?
- Decide on a focus for your park visit. Will you emphasize physical, cultural or ecological factors in your presentation? Your choice of park will influence or be influenced by this choice. What resources and educational elements are available at your park? Can you use them to guide your field experience?

Kids at Muir Beach. Photo: Margaret Prokurat

Phase 2: Creating Your Activity Plan

There are many resources available online so it's not necessary to design an activity from scratch unless that's what you want to do. Here are a few links to outdoor activities, which can also be accessed from the *Coastal Voices Website* at www.coastal.ca.gov/coastalvoices. If assigned, work with your teacher to establish a curricular connection to Common Core, History-Social Science, or Next Generation Science Standards.

- Resources for Outdoor Science Instructors, from UC Berkeley beetlesproject.org
- Exploring a Local Park, activities from Project Learning Tree www.plt.org/family-activities-connect-kids-to-nature-in-a-park
- California State Parks Guides for Educators www.parks.ca.gov/?page_id=25535
- Field activities from Our Wetlands, Our World www.coastal.ca.gov/publiced/UNBweb/owow.html

Phase 3: Planning the Logistics of a Safe Outdoor Field Experience

Before your field experience day it is critical to visit your site and scope out a meeting place, route or event location, points of interest, and potential hazards. If your event involves a hike, determine how long it takes to walk your route, taking into consideration slower walkers and pauses for conversation and interaction. The park shouldn't just be the setting of your event—it should be an integral participant.

Photo: Point Bonita YMCA

Partner with your teacher to create specific agreements and safety rules for your trip to the field site (a state, national or local park, or beach). Some things to consider:

- Choose a location that is safe for your chosen activity. Any known risks should be made clear to your participants.
- Is there cell phone service in your park? If yes, be sure to have a phone available. If not, notify your participants and create a plan for getting to transportation and to cell service in case of emergency. Have the park emergency phone number on hand during your event.
- Determine how many participants you and your partners can easily handle. Will you be doing hands-on activities with young children? Will you be leading a hike for teens and adults? You'll want a much smaller participant-to-leader ratio for young children. If you're planning a program for children, be clear in your invitation that parents or guardians must be present.

- Inform participants of what to expect. Let them know how they should prepare and what they should bring, such as sun protection, hiking shoes, jackets or rain gear, adequate water and food. If you as the leader are able to bring some extra supplies like sunscreen, water, and snacks, you'll head off some potential problems. Your teacher may be able to help with this.
- Pack a small first aid kit with bandages, antibiotic ointment, and tweezers. Discuss with your teacher if anything else should be included.
- Check the weather forecast and be prepared to adapt your program or reschedule as necessary.
- Give complete and accurate directions to your meeting place, including parking and public transit information if available, and let participants know the start and end times. Encourage carpooling.

Photo: Environmental Traveling Companions

Concrete Questions: Restoring Our Land and Water

A California Coastal Voices Student-Driven Project

Restoration volunteers at Upper Newport Bay

Challenging Question:

How can we use science, policy, and nature-based engineering practices for ecological restoration in California?

For this Project:

Teacher Guide: Ecological Restoration

Photo: Central Coast Natural History Association

Ecological restoration is an evolving field, and as such, its definition is debated. One definition of ecological restoration is an intentional activity that pilots a damaged site towards sustainable ecological function. Restoration is not a substitute for preservation. It may not be possible to replicate historic functions and values, and the activities of ecological restoration—disking soil, using chemicals to remove exotics, irrigating—can further strain an already stressed ecosystem. However in many situations, ecological restoration can improve habitat value and ecosystem functions. Ecological restoration is also valuable for the links it forms between humans and nature, building a long-term commitment between a natural place and the community that surrounds it.

Climate change introduces new complications into restoration planning. How do you restore a wetland when the sea level is rising, or a riparian corridor when spring snowmelt and precipitation patterns are changing? In order to plan intelligently for restoration projects, climate change predictions must be understood and incorporated.

In this project, students will address the Challenging Question by analyzing a variety of self-selected data sources before designing, evaluating, and refining a quantitative solution for reducing the impact of human activity on the physical environment and restoring biodiversity at a site. Students will develop a restoration plan and will present it to a public audience. Students will do this work in teams, assuming the role of scientist, engineer, policy analyst, or principal investigator for their group. The rest of this document provides guidance to teachers in facilitating this work.

The student reading titled *Guide to Volunteer Restoration Field Work* assists students in connecting with a local organization or government agency to participate in a real-life restoration project. Although it is possible to omit the field experience, there is great educational value in getting students outside to experience what the work they are studying looks like and how it gets done in their community. Ideally this volunteer work involves habitat restoration and informs the student's final project, but depending on what is available locally it may be as simple as a shoreline cleanup. Either way, the student will be engaging in the important, hands-on work of restoring the natural environment.

Teacher Preparation Tasks:

- Review the *Teacher Checklist for Student-Driven Projects*, found in the "Readings and Resources" section. Review suggestions for Personalized Learning Plans and Group Contracts and decide if or how you will use these with your students.
- Review all student readings and handouts, listed on this project's cover sheet. Make copies for students as needed, or share electronically.
- Study the questions and links in this *Teacher Guide*. Refer back to the Teacher Support Pieces in *California Coastal Voices* as needed.
- Arrange a guest speaker to kick off the project. Options include a restoration ecologist, land manager, planner, or volunteer organizer involved in a local restoration effort.
- Identify and arrange for professionals and decision-makers who will serve as an audience for the students' public presentations. These might be land managers, local planners, elected officials, parents, or other adults.
- Consider what local habitat restoration efforts are available for the student volunteer field experience and whether you will assign locations and partner organizations, provide a list of choices, or have teams identify a site on their own.
- Research safety procedures and necessary permissions for the student field experience. Plan to arrange for or assist with any needed supplies such as sunscreen, extra jackets, work shoes, and transportation.
- For use in your classroom, choose Daily Phenomena from the Thematic Slideshows of Coastal Images available on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices, or compile your own selection.
- Consider what type of guidance you want to give students in identifying a site for their group restoration planning project. Some possible options you might offer include:
  - Research a coastal location using existing habitat studies and photos in order to develop a plan for a site you're not able to visit.
  - Get out in your neighborhood and identify a local site that would benefit from restoration. Incorporate in-person observations and measurements. You might look for public open spaces that are accessible but degraded or not well-used, or for public walking trails with adjacent natural lands. Creeks, ponds, and parks are among the possibilities.
  - Look for a map of creeks that have been culverted under streets. Is there a location that might be appropriate for creek "day-lighting?"
  - Create a restoration plan for an area on your school grounds (which might involve removing pavement).
  - Identify an existing restoration project and develop a plan that extends or improves on the project.
- If you choose to identify potential restoration sites yourself, check in with the agencies that manage these lands. (Look for signage or do an internet search.) Creating this relationship may make visiting the site easier, expand the reach of the students' projects, and set the stage for the public audience for their presentation.

To act intelligently, restoration ecologists must have a significant body of discipline-specific knowledge from biology, ecology, and earth science. Consider exploring the following questions with your students as they develop a restoration plan. The following questions are guides to help you prepare to support student questioning and learning. While not anticipating every place a student may go, the questions provide connections to significant content related *Next Generation Science Standards* performance expectations (NGSS PEs) and disciplinary core ideas (NGSS DCIs), and to *California's Environmental Principles and Concepts* (EP&Cs). Your role is to facilitate the process through which students find their own way to many of these and similar questions. One strategy is to have one student from each group of four investigate one of the questions and report out to the group. Another strategy is to support the students in finding their own way to these or similar questions.

Visit the *Coastal Voices Website* for links to resources that help answer these questions and to the full text of California's Environmental Principles and Concepts. You will also find images for download, links to videos, park brochures, and teaching resources.

www.coastal.ca.gov/coastalvoices

Week One and Two:

- What types of interdependent relationships exist between nonliving and living components of ecosystems? (NGSS DCIs: ESS2.E and LS2.A)
- What are three key measures of biodiversity in ecosystems? (NGSS DCI: LS4.D)
- How do habitat fragmentation, water pollution, and climate change impact biodiversity at a restoration site? (NGSS DCIs: ESS3.C and LS2.C)
- How does habitat fragmentation, water pollution, and climate change impact the ability of an ecosystem to provide ecosystem services to human communities? (NGSS DCI: LS2.C; EP&Cs I)
- What types of cycles exist within natural systems linking the non-living and living components of ecosystems? (EP&Cs III)

Week Two and Three:

- What earth systems cause feedback cycles within California ecosystems? (NGSS DCIs: ESS2.A and ESS3.D; EP&Cs III)
- What distinctive properties of water enable life on our planet and at your restoration site? (NGSS DCI: ESS2.C)
- What factors influence climate within a given ecosystem? (NGSS DCI: ESS2.D)

- How have biogeochemical cycles, natural systems, and related ecosystem services in the atmosphere and hydrosphere been influenced by human-caused global warming? (NGSS DCIs: ESS3.C and D; EP&Cs II, III, and IV)

Week Three and Four:

- How can we define and delineate nature-based engineering solutions using the following parameters: cost, safety, reliability, aesthetics, social, cultural, and environmental, in a restoration plan? (NGSS DCIs: ETS1.A and B; EP&Cs V)
- How can global climate models be used to analyze cycles in natural systems? (NGSS DCIs: ESS2.A and ETS1.B; EP&Cs III)

Lanphere Dunes. Photo: Andrea Pickart

Invitation to Engage:
Restoring Our Land and Water

Challenging Question: How can we use science, policy, and nature-based engineering practices for ecological restoration in California?

Aldo Leopold, an author, ecologist, and conservationist, alluded to the human-altered landscape of the United States as a "world of wounds." We can find some of these wounds in California's coastal watersheds—in dams thwarting steelhead bound for spawning grounds, in low water flows, in algal blooms, in invasive species crowding out native plants and animals. Restoration ecology, an applied scientific discipline, can help us move toward a healing of these wounds.

Installing native plants at Upper Newport Bay

The fruits of restoration ecology projects are becoming visible in watersheds all over California from the South Coast's Tijuana River Estuary, to the North Coast's Mad River, and inland to the Sierra, by government agencies, nonprofit organizations, citizen scientists, landowners, and students. Effective action can take many forms. In some cases, the goal is to restore habitat that has been degraded or destroyed. In other cases, new habitat is integrated into a built environment. Some brief examples of the breadth of possibilities include:

Carpinteria Creek, Santa Barbara County
Federal, state, and local government, with nonprofit partners including South Coast Habitat Restoration, came together to restore this creek. Eleven barriers impeding steelhead trout spawning, including low bridges and related concrete channels built in the early 1900s, were removed. New bridges were built to maintain access across the creek. The creek channel bed was restored with rocks and woody debris and native riparian plants were installed along the banks. Funding was provided by a range of government entities and private landowners.

Hamilton/Bel Marin Keys Wetlands, Marin County
This wetlands restoration project includes 2,600 acres along San Pablo Bay. One hundred years of farming on the former marsh had resulted in a land elevation below the lowest tides, so a necessary part of the restoration was depositing six million cubic yards of sediment (dredged from the Port of Oakland). Once the land was high enough to establish wetland plants, a

levee was breached to allow water to flow between the restoration area and the bay. Public walking trails were established around the site and native plant restoration continues, some of it with volunteer labor. This wetlands restoration is a joint project between the US Army Corps of Engineers and the California State Coastal Conservancy.

Lanphere Dunes, Humboldt County
Dunes are subject to harsh conditions and have low soil fertility, to which their native plant species have evolved. Invasive species may over-stabilize the dunes and change the soil properties. For decades, the US Fish and Wildlife Service, the Nature Conservancy, Friends of the Dunes, and other government and nonprofit organizations have been working to restore Lanphere Dunes. Invasive European beachgrass and yellow bush lupine are removed with shovels or heavy equipment when needed. Native California dune grass is planted in place of the European species. This work continues with extensive community volunteer support.

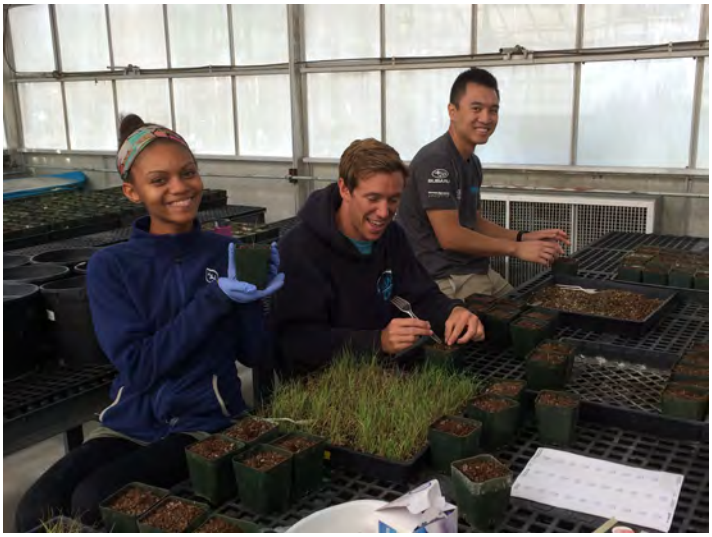
Eelgrass in Upper Newport Bay, Orange County
With a variety of local, state, and federal funding, Orange County Coastkeeper is engaging volunteers in eelgrass restoration. They are evaluating several different methods of installing the eelgrass, which are first harvested from nearby "donor" beds. While restoring habitat for wetland species, this project may also help fight climate change as research shows that eelgrass and other seagrass beds can store more than twice as much carbon per square kilometer as a typical forest.

Olympia Oysters in Elkhorn Slough, Monterey County
Elkhorn Slough National Estuarine Research Reserve is working to restore the Olympia oyster population in the slough. These native oysters are currently in danger of local extinction although they were once abundant there. Scientists are evaluating various methods of placing small reefs (made from clam shells) that provide a hard substrate on which the oysters can attach. Native oysters provide a variety of ecosystem services including shoreline erosion protection and water filtration.

Hubert Bancroft Elementary School, Sacramento County
Schoolyards are often overlooked seas of grass and pavement, but when the opportunity to create wildlife habitats and outdoor classrooms arise, campuses can be re-characterized as oases for students and wildlife. That's just what happened at Hubert Bancroft Elementary School when students designed a Schoolyard Habitat masterplan for their campus that included an "Alphabet" pollinator garden, walking trails, and a gazebo. The project was funded and implemented by donations from various community partners, the U.S. Fish and Wildlife Service, as well as a school-wide jog-a-thon.

The Issue:

Restoration of degraded habitats is complex business, especially in a world where natural systems are fast changing due to accelerated global warming and associated sea level rise. Successful ecological restoration can support native species populations, improve ecosystem services, and bring communities together.



Interns working in the UC Irvine greenhouse

Objective:

To investigate the science and practice of ecological restoration and design a restoration project for a chosen location.

Complicating factors:

Ethical, cultural, scientific, and process questions must be considered before any restoration work can begin. Some of the complicating factors may include:

- Disagreements about the best use of a piece of land.
- Conflicts between the needs of wildlife and the needs of people. For example, should there be a trail in a restored area, and if so where should it be placed?
- Issues of long-term maintenance. If a restoration project is completed, who will make sure it is not overrun by weeds in future years?
- Questions regarding habitat functions—will the restored habitat provide the beneficial functions anticipated?
- Questions of land ownership and legal requirements.
- Projected future changes in the site conditions due to climate disruption.

What will students do?

1. You will work in teams to design, evaluate, and refine a quantitative solution for reducing the impact of human activity on the physical environment and restoring biodiversity in a chosen ecosystem.
    a. After investigating an example of a restoration project, teams will select a site for their restoration plan, with teacher input, and develop guiding questions for their research.
    b. Teams will launch their investigation and create a restoration plan that includes consideration of ethical, political, cultural, financial, and ecological factors. Teams will communicate their ecological restoration plan to a public audience.

2. You will partner with a local nonprofit or governmental organization to organize or participate in a restoration activity. The field experience may focus on living or nonliving features of the ecosystem and shall be at least six hours in length, preferably requiring two to three visits.

How will teams be organized?

Science, Engineering, and Policy (SEP) teams of four students will be developed to focus upon a project of their choosing. Students will adopt (or rotate) science, engineering, and policy roles for the investigation. A fourth student will act as the Principal Investigator, or team leader.

How will students document their work?

1. With their teams, students will draft, revise, and finalize a detailed restoration project plan with graphics, quantitative analysis, and images of the restoration project site.
2. Students will maintain individual science notebooks documenting daily progress.
3. Students will practice, revise, and present their group's proposed restoration plan to a public audience.

Audience for Public Presentation:

Adult decision-makers ranging from government officials, landowners, district administrators, and teacher-leaders.

Elements of a Restoration Plan might include:

1. History and ownership of the site, including impacts of human activity
2. Current features of the site (include a sketch of existing site conditions)
   a. Vegetation (dominant vegetation types, any rare species)
   b. Hydrology (including streams or other water features)
   c. Soil type (if relevant)
   d. Wildlife usage
   e. Man-made features (such as culverts, bridges, etc.)
3. Goals and objectives of restoration plan (include a sketch of proposed plan for site, including a plant palette, if relevant)
4. Projected climate change impacts to the site and explanation of how plan addresses them
5. Restoration activities (to meet goals and objectives e.g. site preparation, planting plan, irrigation, fencing, signage).
6. Maintenance and monitoring plan
7. Public outreach and reporting

Student Checklist:
Restoring Our Land and Water

Challenging Question: How can we use science, policy, and nature-based engineering practices for ecological restoration in California?

Add due dates to the following tasks and phases as instructed by your teacher.

Phase 1: Invitation to Engage, Explore Challenging Question, & Organize

Ask significant questions and define problems as you launch your project.

- O Read *Invitation to Engage: Restoring our Land and Water*. Review rubrics.
- O After you are assigned to a group, you will adopt a role as a principal investigator, scientist, engineer, or policy analyst and develop a brief job description for the role. These roles may be adopted for the length of the project, or rotated within your group. Accept or modify the Challenging Question with your group and teacher.
- O Investigate an existing restoration project via online reports and news articles, documenting what you learn in your science notebook. Discuss within your group ethical, political, cultural, financial, and ecological factors influencing the decisions that were made in the process of completing the project.
- O With your teacher's guidance, work as a team to identify a project site for which your team will create a restoration plan.
- O Through your research, get familiar with what constitutes a restoration plan. There will be a range of options and solutions for any given site. Create an initial need-to-know list of relevant questions to launch your site investigation.
- O Research and begin to make contact with a local organization or government agency to arrange for your local volunteer field experience. Read *Guide to Volunteer Restoration Field Work*.

Phase 2: Explore Questions, Existing Models, and Knowledge

During the second phase of the project you will work in your group to explore, analyze, and interpret qualitative and quantitative data related to your need-to-know questions.

Photo: Tolowa Dunes Stewards

- O Individually, perform a self-assessment of Phase 1 and write a brief plan of improvement to turn in to your teacher.

- O Read *Asking the Right Questions*. Working with your group, use the Question Formulation Technique to refine your need-to-know list of relevant questions developed in Phase 1.
- O With your group, develop a draft statement of the specific problem(s) your restoration plan will address. (This may change as your group conducts its investigations.) Meet with your teacher to review and gain approval for your site and problem statement.

Photo: Youth Exploring Sea Level Rise Science

- O Use your need-to-know questions to launch your investigations, assigning specific questions to group members by role, skills, or individual preference. If your plan includes interviews, be sure to contact the subjects well in advance to set up appointments. Once you have completed the investigations, work as a group to synthesize and record the results. (Your teacher may ask you to turn these in or share them with your class.) Discuss how you will use these results to develop a restoration plan for your selected site. Do you have all the information you need? If not, assign and collect the missing information. Review existing ecological restoration principles or philosophies.
- O Participate in local volunteer restoration work as arranged.

Phase 3: Explain and Evaluate Claims, Argue from Evidence, and Reason

Take time now to compare and contrast claims within your group. Each claim is a response to either the challenging question or a related, need-to-know question. In this phase, you will complete planning for the presentation of your ecological restoration plan.

- O Read the *Claims, Evidence, and Reasoning Guide*. Based on the results of your investigations, revisit and refine your problem statement and develop several alternative approaches to a restoration solution for your site. Group members can devise individual solutions or you can work as a group to come up with several alternatives. Review and compare these approaches. Record all the claims you can make regarding each approach, and the evidence to support each claim. Evaluate the strengths and weaknesses in restoration principles or philosophies as you consider your own proposed restoration approaches. Evaluate the quality and credibility of your sources.

Monitoring at Lake Merritt. Photo: City of Oakland

- O Select your best restoration plan elements. Share them as directed by your teacher, and revise based on feedback.
- O Read *Communicating Science and Policy to Public Audiences*.
- O Complete your restoration plan and create visual presentation materials. Practice and review your presentation with the *Presentation Rubric*.
- O Individually, perform self-assessment and write a plan of improvement, as directed by your teacher. Submit project notebook to teacher for review.
- O Confirm arrangements for any off-site presentations if applicable.
- O Participate in local volunteer restoration work as arranged.

Monitoring restoration at Upper Newport Bay

Phase 4: Extend into Action: Communicate your Restoration Plan

Your primary academic role towards the end of the project is to communicate your science, engineering and policy solutions using visual tools, models, media presentations, or written products.

- O Perform technology checks on any equipment that will be needed for final presentations and follow up with invited guests to confirm attendance at least 24 hours in advance of the scheduled presentation. Present your proposed restoration plan to your audience.
- O Perform self-assessment and peer reviews, as directed by your teacher.
- O Submit individual project notebook to teacher for review.
- O Complete local volunteer restoration work as arranged.

Phase 5: Reflecting, Evaluating, and Celebrating

Ask yourself how you could improve while your successes and failures are still fresh in your mind.

- O Organize a group debrief with teacher. Have any new questions emerged?
- O Write thank you notes to any adult mentors and partners.
- O Perform a final self-evaluation, as directed by your teacher.
- O Celebrate with your hard working team!

A Guide to Volunteer Restoration Field Work

For those contemplating restoration projects, the complexity of the process can be overwhelming. The field experience will make restoration tangible and will help bring clarity to this complex effort. To review your assignment:

- Students will partner with local professionals and their organizations to perform a restoration activity.
- The field experience may focus on restoration of living or nonliving features of natural environments and shall be at least six hours in length, preferably requiring two to three visits. Some examples of field activities are planting native plants, removing invasive species, removing trash and/or other human-caused environmental harm, and conducting water quality monitoring.
- Teachers will facilitate the process, but students are responsible for arranging the field experience.

Photo: Cachuma Resource Conservation District

Note that this activity will most likely qualify for any community service requirements that your school may have; be sure to coordinate as needed.

Installing willows at Upper Newport Bay

What does restoration ecology look like in the field?

The Society for Ecological Restoration (SER) defines ecological restoration as: *the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.* Robert Cabin, an author, restoration ecologist, and college professor advocates for "intelligent tinkering," an approach to restoration that weaves formal science together with hands-on practical experience in the field, celebrating both knowledge that originated in a university lab as well as traditional ecological knowledge. Traditional ecological knowledge is a term for "the knowledge, practices, and innovations" of indigenous people or local communities (SER, 2016).

Photo: San Mateo County Resource Conservation District

For the purposes of this field experience, we adopt a broad definition of restoration ecology that encompasses a range of positive actions that will contribute to healing the planet. This is where intention turns to impact, academic knowledge grows into action, and students evolve into practicing restoration ecologists.

Use your own community knowledge to identify three organizations with whom you might work, then narrow down your choice. If you need help, take a look at the Creeks to Coast Directory at www.coastal.ca.gov/creekstocoast, and at the list of organizations at the bottom of this reading. In addition to nonprofit organizations, you may find opportunities at national wildlife refuges, state and national parks, national forests, and water districts. Some organizations hold regular volunteer days that you can easily join. If possible, choose one restoration project rather than dividing your time between multiple projects.

There are a many organizations doing restoration work in California. Gain a sense of the diversity of offerings by studying some of the following organizations' websites and the reporting of them in the media. This list is organized by location, roughly from north to south.

Tolowa Dunes Stewards
Friends of the Dunes
Cosumnes River Preserve
Golden Gate National Parks Conservancy
Save the Bay
Return of the Natives
Sequoia Riverlands Trust
Santa Barbara Audubon Society
Friends of Ballona Wetlands
Friends of the Colorado Lagoon
Palos Verdes Peninsula Land Conservancy
Community-Based Restoration and Education Program at Upper Newport Bay
San Elijo Lagoon Conservancy
San Dieguito River Park
Lakeside's River Park Conservancy

Photo: Mattole Restoration Council

Coastal Voices: More than a Career

A California Coastal Voices Student-Driven Project

Morro Rock. Photo: Sam Peck

Challenging Question:

How can I make protecting and enhancing coast and ocean environments into a career?

For this Project:

Teacher Guide: More Than a Career

Many meaningful careers relate to the coast and ocean, in science, policy, technology, education, and communication fields. In order to access opportunities students must first know that they exist and be properly supported in their career progression. Bringing more people into coast and ocean careers will benefit the fields as well as the individuals by broadening the perspectives, voices, and talents that are working to protect the coast and ocean.

Aquarists at Aquarium of the Bay

In order to answer the Challenging Question, students will form groups of four to focus upon a particular coast or ocean profession and present it in a career fair. Individual students will create a profile of a coastal professional, including a sample resume, and will perform a job shadow (or acceptable alternative as negotiated with you).

In this project, students will exercise a variety of writing and speaking/listening skills as directed by the California Common Core State Standards as they conduct interviews, write resumes, and present their findings at the career fair. This project may also take the student into greater understanding of the "Nature of Science" as they explore real science careers and "Science as a Human Endeavor." Students will be learning and using 21st Century Skills, particularly "Life and Career Skills" as they take part in a job shadow. Student work on this project is likely to focus on one or more of the following Principles from California's Environmental Principles and Concepts: "People Depend on Natural Systems," "People Influence Natural Systems," and "Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors."

Photo: William Sutton

Teacher Preparation Tasks:

- Review the *Teacher Checklist for Student-Driven Projects*, found in the "Readings and Resources" section. Review suggestions for Personalized Learning Plans and Group Contracts and decide if or how you will use these with your students.
- Review all student readings and handouts, listed on this project's cover sheet. Make copies for students as needed, or share electronically. Refer back to the Teacher Support Materials in *California Coastal Voices* as needed.
- Contact coast and ocean organizations and lay the foundation for student job shadows. For the project's entry event, arrange for a few inspiring professionals to speak to the class about their coastal careers. Alternately or in addition, preview coastal career videos available on the *Coastal Voices Website* and select several for classroom viewing.
- Coordinate with the administration of your school or other venue on logistics of the Coast & Ocean Career Fair. If the school already holds a regular career fair, collaborate with the organizers rather than duplicating or competing with the existing event.
- Determine what paperwork needs to be completed to support the job shadowing activities.
- For use as a "bell warmer" in your classroom, choose Daily Phenomena from the Thematic Slideshows of Coastal Images or coastal career videos available on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices.

Photo: Tolowa Dunes Stewards

Invitation to Engage:

Protecting the Coast and Ocean as a Life's Work

Challenging Question: How can I make protecting and enhancing coast and ocean environments into a career?

Photo: National Park Service

Imagine yourself at work building the California Coastal Trail, or as a lawyer making arguments on the value of coastal access, or a lifeguard saving swimmers caught in a riptide. Jobs exist (or can be created!) that go far beyond the beach into environmental justice, marine and coastal engineering, or policy analysis. Coast and ocean lovers work in aquariums, government agencies, and on board ships at sea. The possibilities are as extensive as the Pacific and there is an ocean of opportunity for those who want to make protecting and enhancing California's coast their profession.

Many coastal careers can be organized into three, broad categories:

1. **Coastal science careers such as geologists, marine biologists, GIS specialists, habitat restoration practitioners, or science communicators.** Many important roles exist in this category, ranging from enforcing fishing regulations as an onboard fishery observer, to the pursuit of new knowledge as a satellite oceanographer working at NASA's Jet Propulsion Lab, to developing habitat restoration plans as a consultant, to working as a ranger in a coastal park. These careers typically weave technology into daily activities. Some jobs offer the opportunity to work outside. Other professionals work to bring marine science to communities as, for example, a writer, artist, video producer, aquarium exhibit designer, or classroom educator. Coastal science jobs are found everywhere from nonprofits like Heal the Bay in Los Angeles to government agencies such as California State Parks, to schools and universities.

2. **Coast and ocean engineering careers such as hydrographic surveyors, Remotely Operated Vehicle technicians, or aquaculturists.** This broad exciting career area focuses on making choices in the application of scientific, cultural, mathematical, technical, and practical knowledge to innovate, create, invent, and solve many types of issues. On the coast, engineers are devising habitat-protecting access routes and operating underwater robots. Engineers are maintaining ships, designing wave energy machines, and creating

structures and processes that will help coastal communities adapt to rising sea levels. Coastal engineers are working to understand shoreline processes as they interact with shoreline structures. With only five percent of the world's ocean explored, career prospects are ripe for engineering solutions that support exploration and discovery.

3. **Coastal policy careers such as government officials, research analysts, urban planners, policy advocates, financial analysts, economists, and lawyers.** Leadership opportunities abound for young people who choose coastal planning and public policy as a field. These professionals apply environmental planning, science, and engineering to real-world decision making. Coastal policy professionals are cross-boundary thinkers who are called upon to deploy knowledge of the California Coastal Act and other laws, varied science disciplines, and knowledge of coastal community issues to protect and enhance the coast. Financial analysts and economists can apply their skills to budgeting, grants, and valuation of coastal resources. Climate change and associated sea level rise are critical issues for planners working along the coast, as is agricultural sustainability and affordability for residents and visitors. The same type of integrative policy skills may be brought to bear in government, nonprofit settings, and the private sector.

Photo: Victor Simon, NOAA/NMFS/NWFSC

The Issue:

The California coast is and will remain vulnerable to a host of threats, human and otherwise. More voices, more perspectives, and more talents are needed to succeed in the goal of protecting the coast and ocean.

Objective:

To explore a range of coastal careers and the paths to reaching them. To enhance college, career, and civic readiness through guided practice in key job seeking skills.

Audience for Public Presentation:

Students from your school and nearby schools, churches, after-school clubs, or siblings; parents, college students, and coastal champions of every type.

What will students do?

Personnel of NOAA Ship THOMAS JEFFERSON
Collection of Gretchen Imahori, NOAA/NOS/OCS

1. Teams of four students (assigned by your teacher) will focus upon a particular coast or ocean profession. Teams will explore at least three coastal professions before selecting one profession for their group work. The team will develop guiding questions that focus upon investigating that profession, establish a group work contract, and launch their investigation into their team's chosen career. Each team will work together to identify a professional to interview in their group's chosen career, draft interview questions, and set up and conduct the interview.
2. Each student will also choose a career to profile individually (which must be different from their team's chosen career). Students will identify a coastal professional in their individually-chosen career, draft interview questions, and set up and conduct the interview. Students will draft, revise, and finalize a profile of an early career coastal professional in their individually-chosen career. Although drawing from the interview and additional research, the profile will be of a fictional person (not the person interviewed). Digital products are encouraged if the technology is available. Profiles should include a course of study leading to the profession, including examples of classes or experiences that could prepare for that work. Individual students will also develop and submit an example resume reflective of an early career professional in the field.
3. Students will perform a job shadow, or acceptable alternative as negotiated with their learning advisors.
4. Teams will organize and lead a Coast & Ocean Career Fair. Each team of students will represent their team's chosen coastal profession at the event. Teams will develop a table display including visual aid and multimedia exhibit if technology permits. Students will be prepared to discuss and answer questions about their group's career. Teachers will support teams by providing class time and insight, but students are responsible for designing, organizing, and delivering the experience to career fair attendees.
5. Throughout the project, individual students will maintain a project notebook detailing their questions, appointments, notes from interviews and job shadow, and progress toward their project goals.

Student Checklist: Coast and Ocean Careers

Challenging Question: How can I make protecting and enhancing coast and ocean environments into a career?

Add due dates to the following tasks and phases as instructed by your teacher.

Phase 1: Invitation to Engage, Explore Challenging Question, & Organize

Ask significant questions and define problems as you launch your project.

- O Read *Invitation to Engage: Protecting the Coast and Ocean as a Life's Work*. Review rubrics.
- O Review *Student's Guide to Personalized Learning Plans* and develop a Personalized Learning Plan.
- O Form your project team as assigned by your teacher.
- O Read *Exploring Coastal Careers*.
- O Create an initial need-to-know list of relevant questions to launch your investigations into coastal careers. What will you need to know in order to develop a career profile and a Career Fair exhibit? Separate but related, create an initial list of questions to ask the professionals you'll be interviewing.
- O In your group, explore at least three professions and then work together to decide on a career for your group profile.
- O Begin research on your job shadow target and interview subjects. Initiate contact.

Phase 2: Explore Questions and Knowledge

Your task during the second phase of the project is to explore, analyze, and interpret qualitative and quantitative data related to your need-to-know questions. You will make arrangements for your interviews and job shadow, and begin organizing for the career fair.

- O Review *Exploring Coastal Careers*. Refine your need-to-know list of relevant questions developed in Phase 1.
- O Decide which team members will investigate which need-to-know questions. Conduct research to respond to your qestions.
- O Choose a career for your individual profile.
- O Read *Guide to Informational Interviewing* and revise your interview questions.
- O Set up appointments for interviews.
- O Individually, perform a self-assessment of Phase 1 and write a brief plan of improvement to turn in to your teacher.

- O Work on individual career profile and create a template for the resume.
- O With your group, create a project plan for your Career Fair table and submit to your teacher.
- O Follow up on arrangements for your job shadow.

Phase 3: Explain and Evaluate

- O Review the *Guide to Informational Interviewing* and complete interviews.
- O Organize and classify your group's need-to-know questions and associated research evidence. Share them as directed by your teacher, and revise based on feedback.
- O Read *Tips for Effective Communication in Public Settings*.
- O With your group, complete planning for the Career Fair table. Practice your public interaction and review it with the presentation rubric.
- O Individually, perform a self-assessment and write a plan of improvement, as directed by your teacher. Submit project notebook to teacher for review.
- O Confirm details of your job shadow.

Phase 4: Extend into Action: Communicate About Your Coast and Ocean Career

- O Perform technology checks on any equipment that will be needed for final presentation. Present your Career Fair product to your audience.
- O Complete your job shadow.
- O Perform self-assessment and peer reviews, as directed by your teacher.
- O Submit individual project notebook to teacher for review.
- O Complete and submit individual career profile and resume to teacher for review.

Phase 5: Reflecting, Evaluating, and Celebrating

Ask yourself how you could improve while your successes and failures are still fresh in your mind.

- O Organize a group debrief with teacher. Have any new questions emerged?
- O Write thank you notes to any adult mentors and partners.
- O Perform a final self-evaluation, as directed by your teacher.
- O Celebrate with your hard working team!

Exploring Coastal Careers

Photo: Bette Boren

This project is focused on exploring a rewarding career. To help organize that outcome we will use a conceptual model from the sustainable business community called the "triple bottom line," a concept that imagines a world where work is valued based on the financial, environmental, and social benefits it produces. John Elkington developed the concept to help corporations fully assume responsibility for their actions. During your exploration of careers you can begin engineering a triple bottom line outcome for yourself. One way to do this is to draw a chart with three columns, labeled People, Planet, and Profit. For each career you evaluate, rate it under each category on a scale from one to ten. For example, how well does a career address the way you want to work with others? Place that rating under People. How well do you see the career addressing environmental issues? Place that rating under Planet. How much money are you likely to make in this career? Place that rating under Profit. These ratings are yours alone and might look different for someone else evaluating a given career. What is also individual is how much you value each of the categories. Looking at these factors and their relation to your values can help you make conscious decisions as you plan a path to your future career (and to the products of this school project).

A Survey of Coastal Careers

First, let's survey the available careers on the coast. The following five sites should be investigated before you go into a brainstorming session with your partners. Some of the sites are national in scope, but similar jobs exist on the California coast.

www.marinecareers.net

Be sure to look at the overview and to individually examine each type of work: science, engineering, and policy. The first question in the FAQ page addresses your interview assignment. One of the ocean professionals profiled is George Matsumoto, Biological Oceanographer and Educator, who speaks about being able to combine research and education in his role at the Monterey Bay Aquarium Research Institute. The site is maintained by NOAA's Sea Grant office.

www.womenoceanographers.org

This site celebrates and makes visible the ocean science accomplishments of female oceanographers. Consider a web search for each scientist to get updates

on her career. One of the scientists profiled is Dawn Wright, also called Deep Sea Dawn, who is a leading authority in the field of marine GIS. This career blends ocean science with tech innovation.

www.oceanexplorer.noaa.gov/edu/oceanage

Nice photographs show the job activities, work setting, and other important factors. Don't miss the profile of submarine driver Hugo Marrero. Ocean exploration is a growing field. Technically inclined people can find work at universities, private companies, or government agencies. Also profiled is underwater filmmaker and photographer Jill Heinerth, who explains how her career requires technical expertise, communication skills, and artistic talent.

www.marinetech.org/workforce

This Monterey Peninsula College website offers both career guidance and projects you can do while still in high school. This site includes knowledge and skill guidelines for a variety of technical careers, especially those related to Remotely Operated Vehicles. ROVs are underwater robots that offer safety, economy, and reliability to ocean explorers. Jobs in this field as operators/ technicians are examples of what is possible with the right two-year degree from a community college.

More Examples:

Coastal Careers with Government Agencies: Federal, State and Local

Photo: Deborah Leon

NOAA, the National Oceanographic and Atmospheric Administration, offers many jobs, for many education levels, located in many different regions and settings. NOAA's career site describes the mission this way: "Unlock secrets in the deep oceans, track rapidly moving storms, operate state of the art environmental satellites, chart the Nation's waterways, formulate models to forecast climate trends, protect and preserve our living marine resources. It's all in a day's work at the National Oceanic and Atmospheric Administration! Join a dedicated workforce committed to a vital mission: safeguarding the public, protecting natural resources, strengthening the economy. NOAA: a career that makes a world of difference!"

The California Coastal Commission is a small state agency charged with protecting and enhancing California's coast and ocean for present and future generations. It does so through careful planning and regulation

Photo: Allen Shimada, NOAA/NMFS/OST

of environmentally-sustainable development, rigorous use of science, strong public participation, education, and effective intergovernmental coordination. Employees at the Commission work on a broad range of issues to plan for and manage coastal land uses while protecting important coastal resources including habitats that support rare and endangered species, scenic landscapes and views to the sea, public shoreline access, coastal agriculture, and recreational opportunities. The Commission's staff includes planners, biologists, geologists, engineers, environmental scientists, educators, GIS specialists, attorneys, and administrative staff. The Commission's main office is in San Francisco, with five smaller district offices located to the north and south. The Coastal Commission's "sister" agencies are the State Coastal Conservancy and the San Francisco Bay Conservation and Development Commission (BCDC). The State Coastal Conservancy is a non-regulatory state agency based in Oakland that supports projects to protect coastal and watershed resources and increase opportunities for the public to enjoy the coast. BCDC is a state planning and regulatory agency based in San Francisco, with regional authority over the San Francisco Bay and its shoreline. Its mission is to protect and enhance San Francisco Bay and to encourage the Bay's responsible and productive use for this and future generations.

County and city governments provide many of the functions that people associate with beach living. Lifeguards and firefighters keep residents and visitors safe. In government offices, other professionals plan adaptation strategies for sea level rise or help improve access and transportation to finite resources like beach access. Many of these organizations have programs that prepare young people for careers on the waterfront. For example, the LA County Junior Guards program has a long history of providing a pathway to coveted jobs at the beach.

Park rangers and naturalists work in city, state, and national parks to protect natural resources and engage with visitors.

Coastal Careers with Nonprofit Organizations

The nonprofit sector has many opportunities to explore, with a large number of these careers being found in conservation organizations, aquariums, and other institutions. These organizations may employ just a few people or more than a thousand. You'll find positions in community organizing, policy research and advocacy, volunteer management, habitat restoration, environmental education, veterinary services, law, recreation, communication, and much more. Often in

these organizations, volunteering is the way to learn the ropes and get a leg up on a paying job.

Coastal Careers in Business

Your ideal coastal job may be in a private company. This category of career also runs the gamut. You might choose to work in sustainable fishing or aquaculture, responsible whale watching, marina management, surfboard designing, ocean-friendly landscaping, environmental consulting as a biologist or geologist or economist, or countless other opportunities.

General Guiding Questions for Career Exploration (From San Jose State)

Explore the following questions as you develop your career profiles, resumes, and career fair booth.

My Function:

- What type of activity motivates me to get up in the morning?
- What tasks do I enjoy performing?
- Is working with machines, or writing, or leading groups satisfying to me?
- What class activities work for me? What does this say about how I learn?

Working with People, or Not:

Do I prefer to work mostly with people or do I prefer working mostly by myself? What kinds of people (e.g., youth, students, working adults, seniors) do I like to work with as colleagues or clients?

Photo: Ian Barin

Physical Setting:

- Where do I see myself working? Is it a quiet environment or a busy, hectic setting?
- Is the work always changing, or predictable?
- Do I prefer to work more with machines and technology or answering questions and assisting people?
- Do I want a work setting that is academic or corporate, highly structured or more informal?

"Planning your Future" is an online resource from UC Berkeley's Career Center that describes eight specific tasks all career explorers should consider: career.berkeley.edu/Plan/Plan

All URLs will be kept updated on the Coastal Voices Website:
www.coastal.ca.gov/coastalvoices

A Guide to Informational Interviewing

Informational interviewing is an important skill and a particularly effective means of making sense of the world of work. In this project you will interview two working professionals (one with your group and one individually) and if possible execute a teacher-supported job shadow. Since you will be asking professionals for their valuable time, it is incumbent on you to be prepared, well-informed about their field, and sincere. Interviewers also must know how the material will be used, for example for a school project, research on future careers, or as a path to finding an internship.

Photo: Officers and Crew of NOAA Ship PISCES

Four Rules of Interviewing…

1. Learn about your target and their work. This is respectful, encourages conversation, and enables you to say things like: "I read your article in Coastal Planning about desalination plants. Your thoughts on how desalination technology is evolving are interesting, can you tell me more?" Right away you will have a friendly conversation instead of an awkward formal interview.
2. Prepare relevant, thoughtful, and open-ended questions. Except for warm up questions, avoid simple yes or no types of questioning. See UC Berkeley's page on informational interviewing for examples: career.berkeley.edu/Info/InfoQuestions
3. Practice, practice, and practice again. One very useful technique is to have a friend video you doing mock interviews and also to watch videos of other interviewers at work. Some videos from NOAA can be found at www.voices.nmfs.noaa.gov. As you seek interviewers to emulate, avoid commercial media sources.
4. Act in a professional manner signaling your intention to be serious and productive. If conducting your interview in person or over video, dress professionally and make eye contact. If interviewing over the phone, be sure to have good reception before making your call. Start by introducing yourself and thanking your subject for their time. Use titles (e.g. Dr., Captain, Mr., Ms.) unless asked to do otherwise. This is a formal setting, like a job or college entrance interview.

Potato Harbor, Santa Cruz Island. Photo: Chuck Graham

Informational Interview Guide

Adopted from UC Berkeley Career Center's Six-Step Process

Photo: U.S. Army Corps of Engineers

1. Research coast and ocean career fields.
2. Identify people to interview, through means such as teacher connections, staff contact webpages, professional organizations, and authors of articles and reports.
3. Initiate contact with potential interviewees. Start this as soon as you are able to identify potential targets. It can take a long time to secure a meeting in this busy world and you must be persistent. Persistence for the purposes of this project means three documented attempts before asking for help from your teacher.
4. Prepare for the interview.
5. Conduct the interview. If possible, one of your interviews should be in person so make that your scheduling priority. If this interview can be coordinated with the job shadow, that will ease the demands on your time.
6. Follow up with a thank you note. This often leads to more conversations and is respectful. Most people are pleasantly surprised to get a hand-written thank you, so consider that approach.

Photo: Seymour Marine Discovery Center

Job Shadowing

Spending a day or a half-day with a coastal professional is often very rewarding, but it takes work and persistence to arrange. Call or email a professional organization related to your interest to ask for help. Make a call to the human resources department of your desired organization or business to ask if they can put you in touch with an employee you might shadow. Many local governments and professional organizations have workforce development boards that may be able to help. Your teacher will provide assistance as needed.

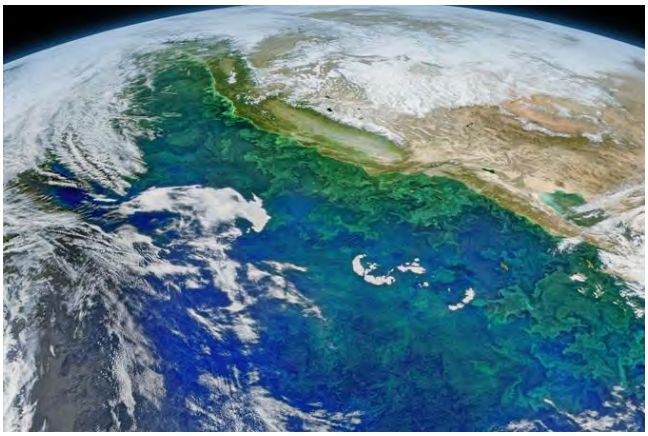
Readings and Resources

California Coastal Voices

Ocean Beach, San Francisco. Photo: Tom Mikkelsen

Contents:

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?

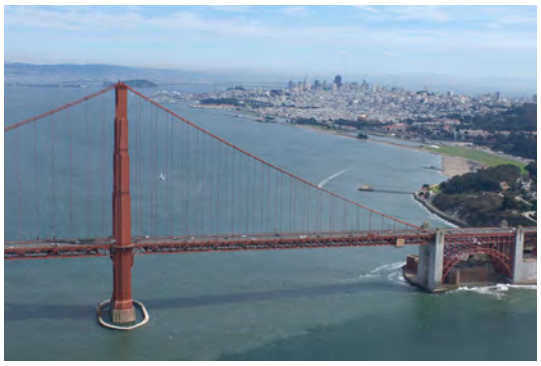
Use clues like plant communities or size of rivers to place the image in either the North, Central, or South Coast regions. Recognizable human-built landmarks can help. Distinctive types of trees (redwoods for example), or distinctively contoured points of land are the most common starting point for 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.

The Public Trust Doctrine

From the California State Lands Commission

Group 1

The common law Public Trust Doctrine protects sovereign lands, such as tide and submerged lands and the beds of navigable waterways, for the benefit, use and enjoyment of the public. These lands are held in trust by the State of California for the statewide public and for uses that further the purposes of the trust. The hallmark of the Public Trust Doctrine is that trust lands belong to the public and are to be used to promote publicly beneficial uses that connect the public to the water.

The Public Trust Doctrine is steeped in history traceable to Roman law concepts of public rights and common property ownership that the air, the rivers, the sea and the seashore are incapable of private ownership because they are dedicated to public use. English common law refined this principle to state that the sovereign, i.e. the entity exercising authority, holds navigable waterways and the lands underlying them as a trustee for the benefit of the public for water-related uses. After the American Revolution, each of the original thirteen states succeeded to this sovereign role and became a trustee of the navigable and tidal waterways within its boundaries for the common use of the people. When California became a state in 1850, it too succeeded to the same sovereign rights and duties under the Equal-Footing Doctrine.

Group 2

The foundational principle of the Public Trust Doctrine is that it is an affirmative duty of the state to protect the people's common heritage in navigable waters for their common use. The traditional uses allowed under the Public Trust Doctrine were described as water-related commerce, navigation, and fisheries. As a common law doctrine, the courts have significantly shaped the Public Trust Doctrine in a number of important ways. Courts have found that the public uses to which sovereign lands are subject are sufficiently flexible to encompass changing public needs. The courts have also found that preservation of these lands in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, are appropriate uses under the Public Trust Doctrine. Courts have also made clear that sovereign lands subject to the Public Trust Doctrine cannot be alienated through sale into private ownership.

Group 3

Another way that the courts have shaped the Public Trust Doctrine is by addressing the roles and responsibilities of the state in managing sovereign lands. In California, the Legislature, as both trustee and trustor of sovereign lands, has enacted provisions involving the uses of sovereign lands found primarily in the Public Resources Code and uncodified statutes involving local governments. These laws are in addition to those contained in the California Constitution.

The State of California has entrusted the State Lands Commission with administering the principles of the Public Trust Doctrine. The Commission manages the state's sovereign public trust lands to promote and enhance the statewide public's enjoyment of the lands and ensure appropriate uses of public trust lands.

An Introduction to the California Coastal Act

Group 1

Alarmed that private development was cutting off public access to the shore, and catalyzed by a huge oil spill off the coast of Santa Barbara, Californians in 1972 rallied to "Save Our Coast" and passed a voter initiative called the Coastal Conservation Initiative (Prop 20).

Prop 20 created the California Coastal Commission to make land use decisions in the Coastal Zone, while additional planning occurred. Then in 1976 the State Legislature passed the Coastal Act, which made the Coastal Commission a permanent agency with broad authority to regulate coastal development.

The Coastal Act guides how the land along the coast of California is developed, or protected from development. It emphasizes the importance of the public being able to access the coast, and the preservation of sensitive coastal and marine habitat and biodiversity. It dictates that development be clustered in areas to preserve open space, and that coastal agricultural lands be preserved. It prioritizes coastal recreation as well as commercial and industrial uses that need a waterfront location. It calls for orderly, balanced development, consistent with these priorities and taking into account the constitutionally protected rights of property owners.

The Coastal Act defines the area of the coast that comes under the jurisdiction of the California Coastal Commission, which is called the "coastal zone." The Coastal Zone extends seaward to the state's outer limit of jurisdiction (three miles), including offshore islands. The inland boundary varies according to land uses and habitat values. In general, it extends inland 1,000 yards from the mean high tide line of the sea, but is wider in areas with significant estuarine, habitat, and recreational values, and narrower in developed urban areas. Coastal Zone boundary maps are available on the Coastal Commission website.

The Coastal Zone does not include San Francisco Bay, which is under the jurisdiction of a separate state agency, the San Francisco Bay Conservation and Development Commission.

Annotated Reading of Selected Coastal Act Sections

The following is a selection of excerpts from the Coastal Act, which contains many additional policies and procedures not addressed here. To read the entire Coastal Act, visit www.coastal.ca.gov/coastact.pdf. The quoted sections below are each referenced with their identifying section number in the Coastal Act.

The Coastal Act begins with a section (30001) on the **importance of the California coast and its ecological balance**:

> The Legislature hereby finds and declares:
> (a) That the California coastal zone is a distinct and valuable natural resource of vital and enduring interest to all the people and exists as a delicately

> balanced ecosystem.
> (b) That the permanent protection of the state's natural and scenic resources is a paramount concern to present and future residents of the state and nation.
> (c) That to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction.
> (d) That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone.

Thus, the law recognizes the importance of both the **natural** environment and **economic** development that is dependent upon the resources of the coast.

The Coastal Act (30001.5) declares that the basic **goals** of the state for the coastal zone are to:

> (a) Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources.
> (b) Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.
> (c) Maximize public access to and along the coast and maximize public recreational opportunities in the coastal zone consistent with sound resources conservation principles and constitutionally protected rights of private property owners.
> (d) Assure priority for coastal-dependent and coastal-related development over other development on the coast.
> (e) Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the coastal zone.

Chapter 3 of the Coastal Act contains the policies that are to guide coastal resource planning and decisions on individual development proposals. The Coastal Act recognizes that at times there will be conflicts between these policies, and states that "such conflicts be resolved in a manner which on balance is the most protective of significant coastal resources." (30007.5)

Group 2

The Coastal Act prioritizes the **public's right to access the shoreline** (30210 to 30214):

> [M]aximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.

Coastal development should not impede existing rights of access:

> Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization...

The previous statement makes reference to different ways public access rights are established. The government may establish these rights (such as by purchasing land to create a public path to the beach) or they are sometimes established through historic public use.

Acquisition through historic use is explained in the *California Coastal Access Guide,* published by UC Press:

According to court decisions, in order for the public to obtain an easement by way of implied dedication, the essential elements that must be established are that the public has used the land 1) for a continuous period of five years as if it were public land, 2) with the actual or presumed knowledge of the owner, and 3) without significant objection or significant attempts by the owner to prevent or halt such use.

The ultimate determination of prescriptive rights, if they are challenged, takes place in court. However, Section 30211 of the Coastal Act requires the Coastal Commission to make determinations as to the existence of these rights where there is evidence of historic use of a given area.

New public access is encouraged in the Coastal Act:

> Public access from the nearest public roadway to the shoreline and along the coast shall be provided in new development projects except where: (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or, (3) agriculture would be adversely affected.

In practice, most new accessways require that an organization (public or private) first accept responsibility for maintenance and liability before being opened to the public.

The Coastal Act (30252) recognizes that it is not sufficient to provide access to the coast; sensible planning for encouraging coastal recreation includes addressing transportation needs and other considerations, such as preventing overcrowding of recreation areas:

> The location and amount of new development should maintain and enhance public access to the coast by (1) facilitating the provision or extension of transit service, (2) providing commercial facilities within or adjoining residential development or in other areas that will minimize the use of coastal access roads, (3) providing non automobile circulation within the development, (4) providing adequate parking facilities or providing substitute means of serving the development with public transportation, (5) assuring the potential for public transit for high intensity uses such as

> high-rise office buildings, and by (6) assuring that the recreational needs of new residents will not overload nearby coastal recreation areas by correlating the amount of development with local park acquisition and development plans with the provision of onsite recreational facilities to serve the new development.

The Coastal Act (30221) calls for **lower cost visitor and recreational facilities**, addressing the concern that coastal recreational opportunities be available to all Californians regardless of income level. In addition, "Developments providing public recreational opportunities are preferred." Also:

> Oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area.

Group 3

The Coastal Act (30230) also **prioritizes ecological resources**. Marine resources, such as wetlands, rocky intertidal areas, and the open ocean are addressed as follows:

> Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

The Coastal Act (30240) includes **special protection for Environmentally Sensitive Habitat Areas**, often referred to as ESHA:

> (a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.
> (b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.

The law recognizes the importance of maintaining adequate **water quality** for coastal zone organisms and human health (30231):

> The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment,

> controlling runoff, preventing depletion of ground water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.

The Coastal Act **prioritizes certain types of activities and development** over other types in the coastal zone. For instance, visitor-serving commercial recreational facilities designed to enhance public opportunities for coastal recreation are prioritized over private residential, general industrial, or general commercial development, but not over agriculture or coastal-dependent industry (30222). Recreational boating and its related facilities are encouraged in the Coastal Act (30224).

The Coastal Act (30253) dictates that new development be designed and sited to minimize adverse impacts to coastal resources, both natural and visitor-serving, as follows:

> New development shall do all of the following: (a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard. (b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. (c) Be consistent with requirements imposed by an air pollution control district or the State Air Resources Board as to each particular development. (d) Minimize energy consumption and vehicle miles traveled. (e) Where appropriate, protect special communities and neighborhoods that, because of their unique characteristics, are popular visitor destination points for recreational uses.

Group 4

Views and local character are protected by the Coastal Act (30251):

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas.

The Coastal Act (30235) calls for **limits on the use of shoreline armoring**:

> Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.

The issue of whether new shoreline armoring should be allowed will arise with increasing frequency as global warming causes sea level rise. In applying the Coastal Act, the Commission tries to avoid shoreline armoring by locating new development away from hazard areas if feasible.

The Coastal Act (30006) includes a statement on the importance of **public participation** in its implementation...

> The Legislature further finds and declares that the public has a right to fully participate in decisions affecting coastal planning, conservation and development; that achievement of sound coastal conservation and development is dependent upon public understanding and support; and that the continuing planning and implementation of programs for coastal conservation and development should include the widest opportunity for public participation.

...as well as **public education** (30012):

> The Legislature finds that an educated and informed citizenry is essential to the well-being of a participatory democracy and is necessary to protect California's finite natural resources, including the quality of its environment. The Legislature further finds that through education, individuals can be made aware of and encouraged to accept their share of the responsibility for protecting and improving the natural environment.

The Coastal Commission

There are 15 California Coastal Commissioners. Twelve are voting members and three are non-voting members. The voting members are appointed by the Governor, the Speaker of the Assembly, and the Senate Rules Committee; each appoint four Commissioners, of which two are selected from the public at large and two are locally elected officials. The local officials on the Commission represent six coastal regions in California. The Governor's appointments must include at least one representative who resides in and works directly with communities with diverse racial and ethnic populations and communities with low-income populations burdened disproportionately by high levels of pollution and issues of environmental justice. The non-voting Commissioners are the Secretary of the Resources Agency, the Secretary of the Business and Transportation Agency, and the Chairperson of the State Lands Commission.

The Coastal Commission meets each month to hear from the public and make decisions. The meetings are held in different coastal locations and generally last three days. You can find out about these meetings on the Coastal Commission website at www.coastal.ca.gov. Meetings are open to the public as well as streamed live online, and previous meetings can be viewed in a video archive.

Student Guide to Personalized Learning Plans

A Personalized Learning Plan should include your personal learning goals for the project and the steps you will take to reach the goals. This plan will help you and your teacher track your progress toward mutually agreed upon learning outcomes.

Write **two personal learning goals** for use with the project. These goals can personalize the challenging question, refine the project products, modify the learning process, or connect your project to more than one subject area. Goals 1 and 2 should be:

1. An interest-based goal related to the project topic, your desired new knowledge, and/or how to apply the knowledge.
2. A Habits of Mind goal specifically related to applying knowledge in the real world.

List the steps you will take to reach each goal. How will you attain your goal? Try to phrase these steps as "I will" statements.

16 Habits of Mind Goals:

- Persisting
- Managing impulsivity
- Listening with understanding and empathy
- Thinking flexibly
- Thinking about thinking (metacognition)
- Striving for accuracy
- Questioning and posing problems
- Applying past knowledge to new situations
- Thinking and communicating with clarity and precision
- Gathering data through all senses
- Creating, imagining, innovating
- Responding with wonderment and awe
- Taking responsible risks
- Finding humor
- Thinking interdependently
- Remaining open to continuous learning

Arthur L. Costa and Bena Kallick, 2000

Specific:

Journalists ask themselves five questions when attempting to get complete stories: what, who, when, where and why. You can use this approach to write specific goal statements. For instance "What human actions (what) pose a risk to blue whales (who and why) in the Santa Barbara Channel (where) during the busy summer months (when)?"

Measurable (Observable):

What will your peers and teachers see and hear that demonstrates your success? For example, a choice to focus on developing your ability to persist to completion despite distractions would:

- Look like you continuing to work on your project tasks despite a busy classroom.
- Sound like you asking clarifying questions, considering alternative problem solving strategies, and asking for help when needed.

Consider quantifying your goals. For example, if asking clarifying questions is tough for you, set a goal of speaking twice per class period, even simple restatements or observations. If staying on task is an issue for you, set a goal of sitting where you will not be distracted by others or concentrating for increasing amounts of time.

Attainable:

Ask yourself if this is achievable goal? Removing an obsolete dam in just six weeks is an unrealistic goal. By contrast, bringing public attention to the damage caused by the dam to local watersheds and beaches by writing editorials, creating podcasts, or by taking local officials to the site is both doable and extremely valuable.

Relevant to your own life and education requirements:

Is the goal consistent with your greater needs and desires? Those students preparing for immediate college attendance after high school may want to set goals related to expected majors. A student planning to spend the summer watching their younger siblings might be interested in issues affecting children. Your teacher will lead the co-authoring of the education requirements section of the personal learning plan.

Timely:

Be sure to include realistic target dates for all elements of your plan.

NOTES FOR YOUR PERSONALIZED LEARNING PLAN:

Group Work Contract

Goals of the Group Contract

TEAM MEMBER NAME	TEXT NUMBER	EMAIL ADDRESS

Team Member's Role and Name	Team Member's Responsibilities. Be as specific as possible. Include performance indicators, tasks, and due dates.
Principal Investigator	
Scientist	
Engineer	
Policy Manager	

Option for Team Members: Share a goal from your Personalized Learning Plan

Group Agreements

Consequences for Breaking Agreements

1. Team members will issue one friendly reminder, as needed.
2. Team will issue a written formal joint warning. Teacher must know that warning was issued, but does not need to be involved.
3. Team member will be removed from the group and given an opportunity to re-join the group after make up work is performed. Team must schedule a problem-solving conference.
4. Team member will be removed permanently from the group. Team meets with teacher during office hours prior to permanent removal. If a team member is "fired," that person is responsible for completing an alternative project of the teacher's design.

Group Contract Page 2

Group Contract Signature Page

We have co-authored this contract, understand its contents, and agree to abide by every word. I am acknowledging my willingness to be held accountable to the group with my signature below.

Printed Name:
Signature:

Printed Name:
Signature:

Printed Name:
Signature:

Printed Name:
Signature:

Teacher Checklist for Student-Driven Projects

Prepare for Projects (3 to 6 weeks prior to entry event)

This is always the busiest time for a project-based teacher. With planning most projects go well, if not exactly where you thought they would. This is normal and expected in student-driven project-based learning environments.

- O Review project materials, standards, and teacher support pieces.
- O Organize a local guest speaker, videoconference, or a phenomenon for the project's Entry Event. Arrange space for public presentations of learning products if appropriate, and invite audience. Arrange speakers, adult mentors, and transportation for off-site activities.
- O Contact teachers from other departments and propose partnerships.
- O Perform a safety survey of any outdoor sites involved with the project.
- O Prepare for "just in time teaching" by reading the project's *Teacher Guide*.
- O Identify mutually reinforcing activities from existing curriculum guides.

Most importantly, prepare students for collaborative work, self-assessment, and sense-making conversations. See Create a Culture of Inquiry discussion in the Teacher Support reading titled *Organizing for Student Success*.

Launch Projects with an Engaging Entry Event (first week of project)

Your primary task when launching the project is to ensure a truly engaging entry event. Be sure that your speaker is prepped, knows how to connect to teenagers, and has visual aids or activities that prompt need-to-know questions. If quality speakers can't be found consider videos or video conferencing. Students receive the *Invitation to Engage* reading, *Rubrics*, and their *Student Checklist*; followed by the *Asking the Right Questions* reading.

- O Help students interact with guest speaker, video, or a natural phenomenon. Introduce the Challenging Question.
- O Encourage discussion of science, engineering, and policy viewpoints as students will be assuming these roles.
- O Check for prior knowledge and build place-based connections
- O Post the Challenging Question and create a calendar with student tasks. Use or revise the *Student Checklist* provided with the project or develop your own. (The *Student Checklist* and selected other documents are available in Word on the *Coastal Voices Website*, www.coastal.ca.gov/coastalvoices.)
- O Review the procedures for creating group contracts and personalized learning plans, if you are using them. Assign teams and create contracts. Make students aware of your grading procedure. One option is for groups to agree that they will be the ones responsible for dividing up points based on the level of work each student does on the group project.
- O Define the major learning products, which are typically the project notebook and a public presentation.

Manage the (Potentially) Messy Middle of Projects (3 to 4 weeks long)

This period of time is a cycle of questioning, knowledge building, explaining, revising understanding, and reflecting. Rarely is the middle of a project linear or predictable. Students may need all sorts of support ranging from direct instruction in process skills such as evaluating resources for bias, validity, and authority, to structured homework activities to clarify significant science concepts.

- O Distribute the readings: *Claims, Evidence, and Reasoning*, followed by the field experience reading, *Tips for Effective Communication in Public Settings*, and any readings specific to the particular project. An additional reading is available titled, *Students Taking Action on Science & Policy and Communicating to Public Audiences*.
- O In the second week, have students perform self assessment and write plans of improvement.
- O Use a Daily Phenomenon (as described in the Teacher Support piece, Organizing for Student Success) to build shared knowledge as needed.
- O Review project notebooks as often as time allows to ensure your ability to provide frequent feedback to students. Use exit tickets to track content knowledge and progress. Evaluate with rubrics.
- O Have content resources ready that relate to students' "need-to-knows" and personalized learning plans. Deliver when students ask. Resist the impulse to front load or deliver lectures. Remember, this is "just in time" instruction.
- O Perform weekly check-ins with groups using Habits of Mind descriptions. Perform additional team building activities as needed, however students should manage their own groups. In week three, meet with each group for debriefing on group work.
- O As you get to week three increase the frequency of formative feedback. Be sure to review drafts of any written products and especially the project notebook.
- O Use gallery walks as foundations for self- and peer-review.
- O Provide frequent opportunities for students to practice.
- O Confirm arrangements for public presentations and further adult mentoring opportunities. Send reminders to invited audiences.

Celebrate Student Work in Public Settings (last week of project)

Your primary role towards the end of the project is to facilitate reflection, support accurate student thinking by formally correcting when needed, and to celebrate the growth that you have noted during your regular formative assessment sessions.

- O Perform system checks on any technology that will be used in presentations at least two days prior.
- O Review rubrics, personalized learning plans, and performance expectations.
- O Review the questions created at the beginning of the project.
- O Have students perform self-assessment, lead reflection discussions, and write plans of improvement.
- O Meet with each group for debriefing on group work. Have students divide points per original contract agreements, if applicable.

Asking the Right Questions

Projects, in school or out, are driven forward by questions and a sustained pursuit of inventive, evidence-based answers. Creative questioning is the motive force and the fire that will light your path forward as a self-directed learner. A quote attributed to Albert Einstein is, "It is not that I am so smart, it is just that I stay with the questions longer." An inclination to persistently question, explore alternative explanations, seek answers for oneself, and communicate solutions are key job skills.

If asking the "right question" is a key to achieving meaningful results, what is the right question? One starting point is that the "right question" is one that interests you, connects to your life, and relates to significant real world processes, events, phenomena, or relationships. This is a prime opportunity for exercising your voice and choice to shape your learning and our society.

The next section (adapted from Rothstein and Santana's *Question Formulation Technique*) provides a strategy your group may use to organize your questioning in order to launch your investigation.

1. **Design a question focus:** Take this project's Challenging Question as posed and rewrite it as an assertion or a statement. Then reverse engineer (pick apart) the challenging question as a starting point to develop your own focus question. You will notice that the question as it is stated has implicit assumptions, clear goals, and a target audience. Decide for yourself what part of the question intrigues you and suggests a focus for further questioning. However, you should question the question before adopting it as a guide for your learning.

2. **Produce questions:** Begin developing "need-to-know" questions to guide your research into the Challenging Question. Use these rules to brainstorm:

   Ask as many creative and probing questions as time allows. Feel free to riff off one another to keep things moving. For now, more is better; in a later step you will work to prioritize your questions.

   Do not stop to judge, edit, answer, or respond to any question during question generation.

   Have one group member write down each question exactly as posed. You may wish to rotate this task as it can inhibit the scribe's creativity.

   Change all assertions or statements into questions.

3. **Work to refine questions:** Seek to convert closed questions (yes/no) to open ended questions that will require more thought and investigation. Aim for higher-level thinking questions that require analysis, synthesis, and

1. application of knowledge. Do you notice any patterns to the questions? Is there a way to investigate each question, and if not how can that question be restructured?

2. **Prioritize and classify questions:** You are being asked to investigate a complex issue. First, prioritize and narrow down your list of questions. Next, broadly categorizing the questions, for example, according to the group role (science, engineering, or policy) that will be leading each question's investigation.

3. **Plan how to investigate the questions:** What knowledge will be needed? Find out what is already known so your creative questioning will have the potential to explore new ground. The real skill lies in recognizing what data and information is valid, free of bias, and relevant to the question being asked.

   What will you be doing? Think carefully about what science, engineering, and policy practices will lead you to significant answers to the various questions. Observation, research, interviews, fieldwork, experiments, surveys, data mining, or a combination of approaches? Be sure to consider how you will obtain, evaluate, and communicate about these complex subjects.

   What will you be thinking about? Big ideas! Patterns, cause and effect relationships, policies that lead to stability or change. Models, of many system types: climate, transportation, communication, ecological, financial, or physical. How do the systems interact and function? What are the boundaries? Where do varied systems intersect? What are the component parts and what limitations exist?

4. **Commit to Next Steps:** This is an ideal time to finalize your learning contract and begin designing your investigation. See Student Checklist.

5. **Student Reflection:** Consider in your project notebook what steps you might take to improve your questioning skills. When does it feel most challenging to ask questions? How might you control circumstances that make you nervous? Consider setting a goal to ask a question every day.

Students of the art and science of questioning are doing far more than setting the learning agenda for themselves; they are training themselves in a new way of thinking that leads to innovation, career success, and mental habits that may be applied across subject areas, lifestyles, and geography. Author and poet Harvey Oxenhorn illustrates the ultimate positive outcome for questioners: "Being mindful...To notice everything, to make that level of awareness so habitual that it became unconscious…To get in the habit of asking questions was to get in the habit of answering them for yourself. What you gain in the process, when allowed to make your own mistakes, is self-reliance, ability, and independence."

Claims, Evidence, and Reasoning Guide

For our individual impacts to be positive, people of every age must practice speaking, arguing, and acting with clarity and precision based on carefully developed evidence. Today's complex social and environmental issues require nuance in expression, effective listening and speaking skills, and an ability to distinguish between closely related topics. Developing evidence for yourself, analyzing counter arguments, and making well-reasoned claims leads to confidence and assertiveness.

Key Terms and Concepts

Argumentation is the process of supporting claims, assertions, proposed solutions, conclusions, or models with solid reasoning based on valid evidence. This guide uses examples drawn from environmental science and policy; however, it is important to remember that arguing from evidence is an appropriate strategy for working in any career area.

The UC Berkeley Museum of Paleontology defines the word "evidence" as used by scientists and engineers as:

> *Test results and/or observations that may either help support or help refute a scientific idea. In general, raw data are considered evidence only once they have been interpreted in a way that reflects on the accuracy of a scientific idea.*

Notice that science is a conversation, an open process of testing ideas via practices that always converge on the use of evidence to revise knowledge. New evidence, once corroborated through peer review, will be used to revise existing theory. Engineers behave similarly and often use a process known as Evidence-Based Design, a method for everything from the design of buildings to medical studies. The emphasis is on observable, experiential, and testable phenomena.

Evidence is also important for professionals in legal and policy fields. Notice how the underlying principle of a claim being supported by evidence is expressed in the following definition from the California Legal Code:

> *"Evidence" means testimony, writings, material objects, or other things presented to the senses that are offered to prove the existence or nonexistence of a fact.*

For this project, we will define the terms "claim," "evidence," and "reasoning" as follows:

Claim:
As used for this project, a claim is a statement that answers the Challenging Question or an essential question developed by student teams. It will always be supported by evidence and scientific reasoning, and be consistent with logic. It is never an opinion, belief, or preference. Your ability to construct viable arguments, claims, and explanations rests upon obtaining, evaluating, and communicating from a foundation of evidence.

Evidence:
For this project we seek evidence in the form of organized data from relevant, reliable sources; direct observation of a phenomenon; experiments; or carefully constructed student surveys. Data must first be organized and interpreted before it is considered evidence supporting a claim.

Reasoning:
This is the link between your claim and the evidence supporting the claim. It is the rationale for why your claim is warranted based on your evidence. We can all recall a situation where a question was met with a dismissive "because it's in the text book." In this project we are looking for much more—typically three sources of evidence to support any claim.

Robust reasoning will have four distinct elements: First, you must clearly articulate your claim (your proposed answer to the Challenging Question). Second, describe any patterns or trends in the data cited. A complete description of how the data was obtained, what circumstances prevailed during collection, and any possible weaknesses in the evaluation process are markers of quality. Third, provide a statement of correlation that supports your claim. For example, if the claim is that "high park admission costs are a barrier to access for youth," a related correlative statement could be, "we expected an inverse correlation between admission price and park visits by young people. We did see this result in park data collected after price increases and in our surveys of 300 students." Finally, high quality reasoning considers alternative explanations for any claim or explanation: "We considered other explanations related to public transit access and availability of parking. These are factors, however our results strongly suggest that there is a relationship between cost and youth visits to parks."

Creating a Scientific or Policy Argument

Adapted from NSTA and the California NGSS Roll-Out

Goals: **1.** Create an argument consisting of a claim, supporting evidence, and reasoning. **2.** Revise the argument based on feedback from peers.

Our first draft of CLAIM-EVIDENCE-REASONING	Comments from peers on improving our work	Our improved draft of CLAIM-EVIDENCE-REASONING
CLAIM: Here is our claim (...we believe that X is caused by...OR we believe that Y has a role in how Z happens...)	Is the claim clear? Does it describe a cause and effect?	**Revised CLAIM**
EVIDENCE: Our evidence comes from (name the type of data and the activity it came from). We saw in the data (name the particular trend or outcome).	Is the data relevant to the claim being made? If two kinds of data or observations are being compared, do they make sense to use together? Is the data credible?	**Revised EVIDENCE**
REASONING: We think this evidence supports our claim because if these trends in data are happening, then it means that (state a brief causal chain of events—this chain has to be consistent with known science ideas/facts).	Do you need to make big inferences about what happened or why? Are there big gaps in the causal story here? If you saw this kind of data, does it mean that their claim can be the ONLY one that is true? Should they moderate their claim?	**Improved REASONING**

Tips for Effective Communication in Public Settings

Public speaking is a fundamental challenge, potentially stressful or frightening for many people, both adults and students. To find your voice, speak intelligently from evidence, and be self-confident when challenged about the questions of the day, is to find your own power and your own chance to change the world. Speaking in 2014, 17 year old Nobel Prize winner Malala Yousafzai said: "We should not wait for someone else to come and raise our voice. We should do it by ourselves."

Since sharing your work in public through presentations, field experiences, or media is central to this project, to civic participation, and to changing the world, this document describes some techniques of public speaking that with practice will grant anyone the ability to move from academics to action.

1. **Prepare well.** Georgia State Professor Michael Mescon puts it this way: "The best way to conquer stage fright is to know what you are talking about." This is a close cousin to the US Navy's principle of 7Ps. Here is the cleaned up, non-sailor version: Prior Planning, Preparation, and Practice Prevents Poor Performance. Reinforcing this from ancient Greece is Epictetus, who spoke to the importance of listening and learning before speaking with this anatomically apt reminder: "We have two ears and one mouth so we may listen twice as much as we speak." Listening is preparing. Once you are in command of the facts, the evidence, and the reasoning, it becomes natural to assert your claim.
2. **Practice, practice, practice, and practice again.** Audiences are forgiving of mistakes, nervousness, and stage fright; however, it is disrespectful to waste their time though lack of preparation.
3. **Speak only about what you know to be true and don't fake it.** In his letters home from the Middle East, Malcolm X wrote, "I'm for truth, no matter who tells it. I'm for justice, no matter who it's for or against." Speak only about what you know and be happy to offer a professional "I don't know but I will find out and get back to you." Once again, audiences expect you to be knowledgeable about your message, prepared to deliver in an effective manner, and honest, but no one expects you to know everything.
4. **Speak slowly and clearly.** Many people speed up their speech when they are nervous, but that makes you harder to understand and the audience might miss parts of what you are saying. Slow down your speech and take your time.
5. **Make eye contact with the audience.** This is a tip that will help engage your audience in what you are saying—making it feel more like a conversation than a speech. Don't just scan the audience—look at individual audience members one at a time. Try to give them an entire sentence or thought before moving on to another person.
6. **Say thank you.** Your audience's presence and applause are a gift. At the end of your presentation, always acknowledge your audience by thanking them.

Students Taking Action on Science & Policy and Communicating to Public Audiences

Testifying at a Public Meeting

Tension filled the quiet meeting room, where bodies were tightly held, faces grimly purposeful, and smiles mostly absent. It was clear that the meeting was significant, the participants highly motivated, and the stakes high.

Into this scene came a group of high school-aged students. Dressed in blue shirts emblazoned with "I love MPAs," they had come to take part in the decision-making. They huddled for a moment with their teacher, gave each other a round of fist bumps, and quietly took seats along the left side of the room. The commissioners filed in, seating themselves on a raised dais in the manner of judges, and began hearing public testimony related to California's proposed establishment of Marine Protected Areas.

Outbursts were occasionally heard, but the chairperson quickly restored order with a stern look and an admonition. The morning wore on and the audience was growing irritable when the students' turn to speak arrived.

As Jaime strode to the speaker's table, pride could be seen in his walk but grumbling could be heard from the audience. Just as he began to speak, a shouted "sit down kid" rose into the atmosphere. With poise and grace, Jaime replied, "Sir, I love this coast and ocean. I am here to speak my mind. No one tells me what to think. My voice matters." The mood in the room soared as the 16 year old spoke. It was clear that the future is in good hands. It was equally clear that public speaking skills matter enormously.

California King Tides

During a recent "king tide" event when San Francisco Bay rose over Marin's bike paths, streets, and into the manicured gardens of a nearby hotel, most people continued about their morning tasks. Drivers only rarely slowed to look at the water swelling up out of storm drains and across Tam Junction, an intersection in Mill Valley. One driver, distracted by his cell phone and not expecting flooded streets, hydroplaned across the intersection and lost control of his vehicle. Other drivers made eye contact, communicated their intentions with signals, and collaborated to make safe progress. They were partners with a shared purpose, if only for a moment, in managing the rising tide.

Like the distracted driver, many California coastal residents are not paying attention to climate change. This century will see increased coastal flooding, loss of road access to communities, and damage to homes and wastewater treatment systems. Accelerated beach erosion will harm habitats and buildings unless steps are taken to protect, accommodate, or move development inland.

Fortunately, students at Terra Linda High paid attention as they worked to gather scientific data in the field, interview stakeholders, gather visual evidence, and communicate their findings to public audiences. Teacher Jesse Madsen and his students sought out a partnership with Youth Exploring Sea Level Rise Science (YESS), an initiative focused on supporting students as they seek public audiences for science communications products. YESS and Mr. Madsen's class then worked with the County of Marin and USC-Sea Grant to move from concepts to civic communication. After collecting and analyzing data on sea level rise, the students created multiple communications products including a Spanish language video about coastal vulnerability in San Rafael, an environmental justice briefing for nearby San Mateo County, and posters for community events.

Watch the video students produced in partnership with the County of Marin and the Community Media Center of Marin in English at https://youtu.be/LxPefmccFq4 and Spanish at https://youtu.be/cpHo-3_VSuE

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.