

NOAA Teacher at Sea Program

Michael Wing, Aboard NOAA Vessel *R/V Fulmar*, July 17 – 26, 2015

Applied California Current Ecosystem Studies Survey

Activity Title: Make your own 3-D Diagram of the Bay Area's Summer Climate

Subject (Focus/Topic): Upwelling's effect on the land's climate

Grade Level: ninth and tenth (but good for middle school also.)

Average Learning Time: 90 minutes.

Lesson Summary (Overview/Purpose): Students will diagram the effect of upwelling and the prevailing westerlies on California's climate.

Overall Concept (Big Idea/Essential Question): Upwelling is caused by the prevailing westerly winds acting on the California Current. It cools the coast and creates fog, a productive ecosystem and good fishing.

Specific Concepts (Key Concepts): Upwelling, California Current, Coriolis effect, prevailing westerly winds, nutrients.

Focus Questions (Specific Questions):

- Why is it so cold and foggy at the beach in the summer?
- Why does the wind pick up all afternoon on the Bay?
- Why does it never rain in the Bay Area (in summer)?
- Why is it so much warmer inland?
- Why does it rain in the Sierras but not further east in Nevada?
- Why did California have a large sardine industry?

Objectives/Learning Goals: Students will individually draw an original annotated diagram that successfully shows how the following 19 terms relate to each other: North Pacific high, prevailing westerlies, California coast, upwelling, Coriolis effect, surface water, deep water, nutrients, plankton, sunlight, fish, condensation, evaporation, fog, San Francisco Bay, California's central valley, Sierras, Nevada, rain shadow. They will start the diagram in class and finish it for homework. Fifteen correctly portrayed relationships between two terms constitutes acceptable performance.

Background Information: Before doing this assignment students need to know global wind and ocean currents (Westerlies, trade winds, North Pacific Gyre, etc.) and basic information about plankton: diatoms and dinoflagellates and their dependence on nutrients and sunlight, copepods, krill, marine food webs. They need to be reminded that warm air rises and that as it rises it cools, and that cool air can contain less water vapor than warm air.

Common Misconceptions/Preconceptions: California's beaches are warm (actually they are quite cold and foggy in northern and central California.) Fish are equally distributed throughout the oceans (actually they are much more abundant in upwelling zones.)

Materials: 11" x 17" paper and colored pencils and pens.

Technical Requirements: A computer projector is useful for showing PowerPoint slides.

Teacher Preparation: The instructor needs to be familiar with the basic principles of physical oceanography, biological oceanography and meteorology. He or she needs to be prepared with a short introductory lecture and set out drawing materials and paper.

Keywords: Upwelling, Coriolis Force, California Current, North Pacific High, Prevailing Westerlies.

Lesson Procedure:

- 1) Instructor gives short whiteboard/PowerPoint lecture on how the prevailing westerlies acting on the California Current cause upwelling off the California coast, and how that upwelling leads to plankton growth and cools the coastline.
- 2) Instructor distributes the handout (below) and materials
- 3) Students complete the assignment and hand it in
- 4) Later on an exam, students successfully answer a question based on this lesson (see below.)

(Handout) Make your own 3-D diagram of the Bay Area's summer Climate:

Directions: On a piece of paper 11 x 17" draw a TOP VIEW and SIDE VIEW of the San Francisco Bay area's Summer climate. It will have text boxes explaining all the processes. It will address the following questions:

- Why is it so cold and foggy at the beach in the summer?
- Why does the wind pick up all afternoon on the Bay?
- Why does it never rain in the Bay Area?
- Why is it so much warmer inland?
- Why does it rain in the Sierras but not further east in Nevada?
- Why did California have a large sardine industry?

TOP VIEW:

1. The North Pacific High is a large zone of clear, relatively dry high-pressure air that sits off the coast of California in the summer. Since most of California is in the zone of the prevailing westerlies, our weather comes to us from the west. The North Pacific High acts as a great big barrier to storm systems- they get deflected around the High towards Seattle. ***Draw in the North Pacific High***
2. The prevailing westerlies go around the North Pacific High and so they strike the coast of California going slightly southeast, not due east. ***Draw in the prevailing westerlies***
3. Since the westerlies are blowing southeast and the coast of California trends Northwest-southeast, the winds are crossing the coastline at an angle. The winds push coastal seawater before them, but also to the right because of the coriolis force. **Draw in the California Current, and coastal water moving away from the coast to the southwest.**

SIDE VIEW

Draw in the North Pacific High, the prevailing westerlies, and the surface seawater moving away from the coast.

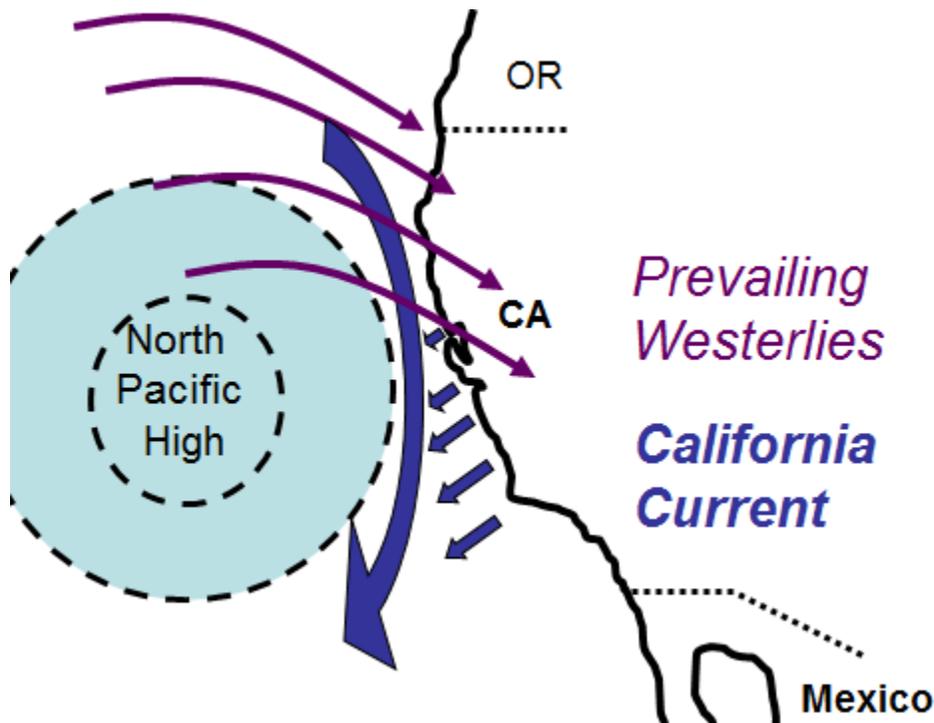
4. All that surface sea water being pushed away from the coast causes deep ocean water to be drawn up to take its place. This is called upwelling. **Draw in upwelling.**
5. The deep water is very cold (cold water is denser) but also has a lot of nutrients for plankton growth. All that deep water with nutrients is now exposed to sunlight. Plankton grow, and fish that eat the plankton thrive. **Draw a school of fish in the upwelling zone.** The same effect is important to the fishing industry in Peru. Peru is not yet fished out like California is.
6. The upwelling of cold water cools down the air of the prevailing westerlies as it approaches the coast. Since cold air can hold less moisture than warmer air, the extra moisture condenses out as fog droplets. **Draw fog in the air just off the coast and over the beaches. Label the air 55° F** The fog evaporates again as it moves over the warmer land. This effect is called “Bay Area Air Conditioning”
7. The central valley is a long way from the cold Pacific Ocean. The sun shines on it and it gets very hot- often over 100° F. All this hot air rises every afternoon. **Draw 100° F air rising over the central valley.**
8. That 100° F air rising over the central valley creates a suction that causes the westerlies to blow very hard across the Bay towards Sacramento. **Draw the afternoon westerlies blowing hard across the Bay.**
9. The westerlies also continue on across the central valley and rise up over the Sierra Nevada mountain range. **Draw that.**

10. As the air rises over the Sierras, it gets colder. It can no longer hold the moisture it has, so it rains on the western slope of the Sierras **Draw that.**

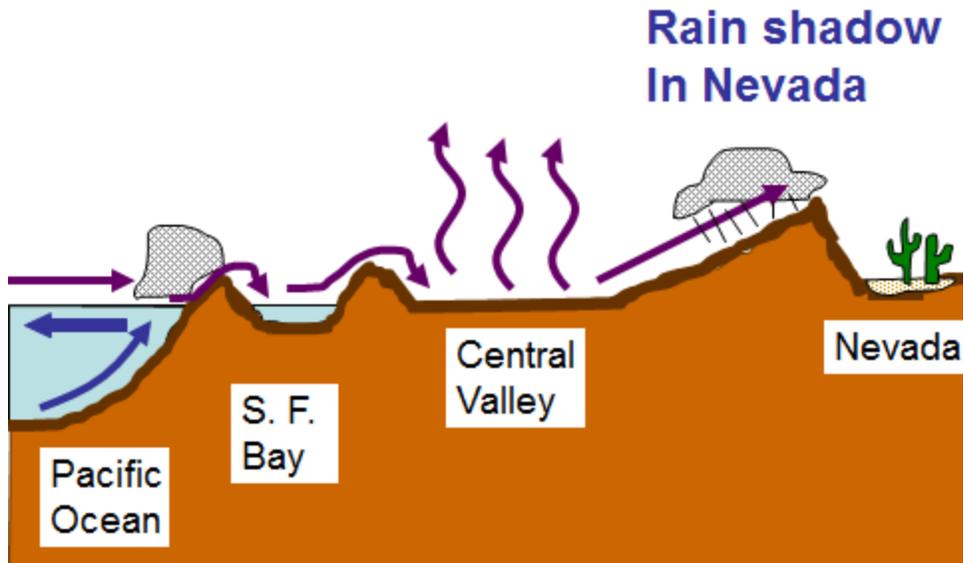
11. The air crosses the peaks of the Sierras and falls down onto the Nevada side. As it falls, it warms. Warm air can hold a lot of moisture, so now it has a lot less water vapor than it is capable of holding. It is dry, and that side of the mountains is a desert. **Draw sand, cactuses, etc. on the Nevada side.** This effect is called the “rain shadow”. It extends all the way to Denver!

In the Winter, these effects go away. The North Pacific High shifts south, leaving California unprotected against winter storms coming from the west. The central valley cools off, so the westerlies are not as strong across the Bay Area. There’s less fog, and more clear, mild still days on the beach. Sailboats find the Bay calmer and less blustery. The rain shadow effect still operates in the Sierras, but now it’s snow.

(Slides/ Whiteboard sketches):



SIDE VIEW:



Assessment and Evaluation: On a later exam, students will answer the following question using words and a picture:

Your out-of-state cousin is shocked at how cold it is at the beach in July. "I thought California was warm" she says. You pick up a stick, start drawing maps in the sand, and explain. What do you tell her?

The answer will include the following concepts, both written and drawn in their correct relationships: California current, prevailing westerlies, Coriolis force, upwelling, fog (five terms, both written and sketched equals ten points. Seven or more are considered acceptable.)

Standards:

National Science Education Standard(s) addressed:

Content Standard A – Scientific Inquiry
Communicate and defend a scientific argument (9-12)

Content Standard C – Life Science
Interdependence of Organisms (9-12)

Content Standard D – Earth and Space Sciences
Energy in the earth system (9-12)

Geochemical cycles (9-12)

Structure of the earth system (5-8)

Ocean Literacy Principles Addressed:

Ocean literacy Principle #3: The Ocean is a major influence on weather and climate.

a. The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.

State Science Standard(s) addressed: California has adopted the Next Generation Science Standards (NGSS)

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

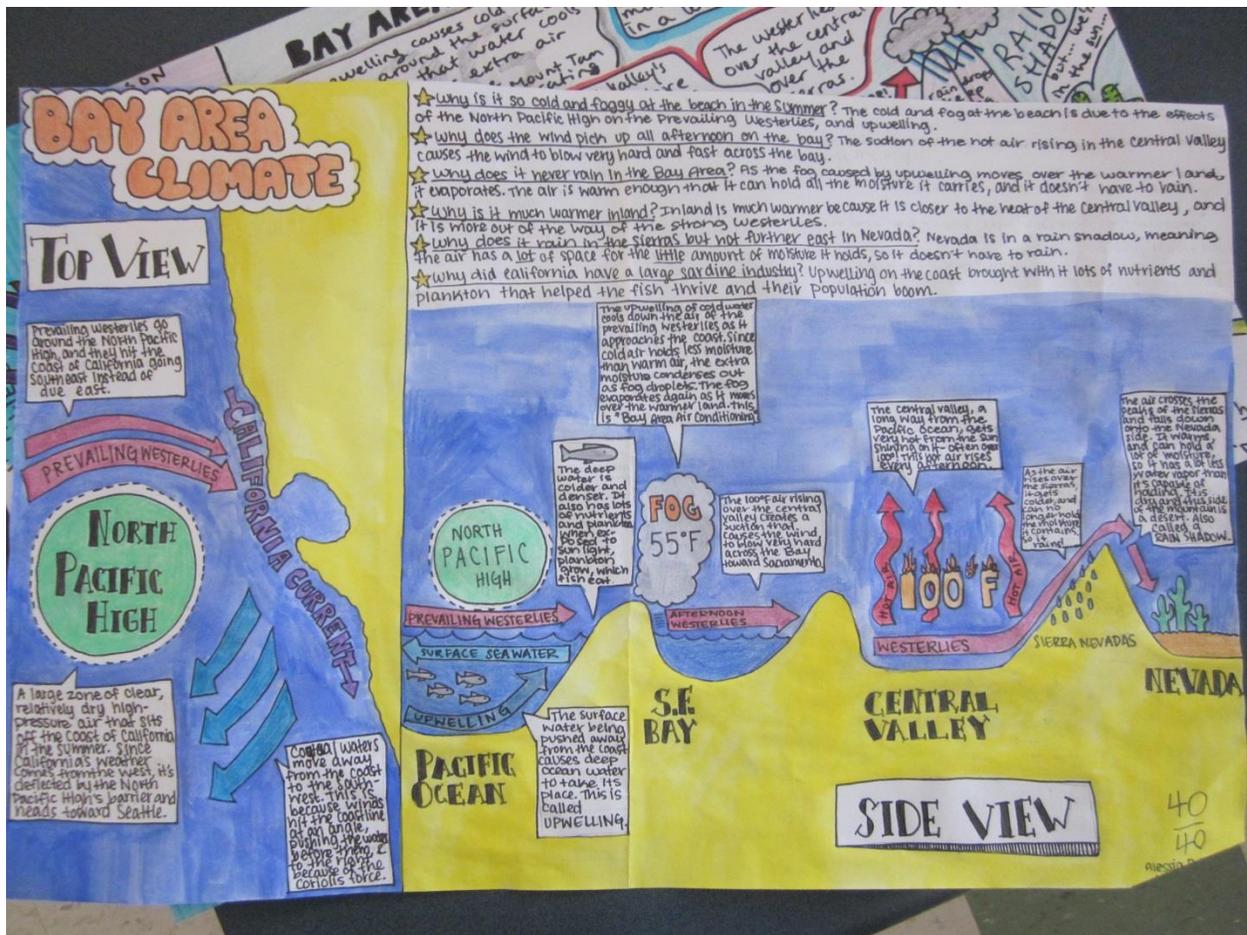
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Additional Resources:

"What is Upwelling?" <http://oceanservice.noaa.gov/facts/upwelling.html>

"California Current" <http://www.noaa.gov/iea/regions/california-current-region/>

Student Work:



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