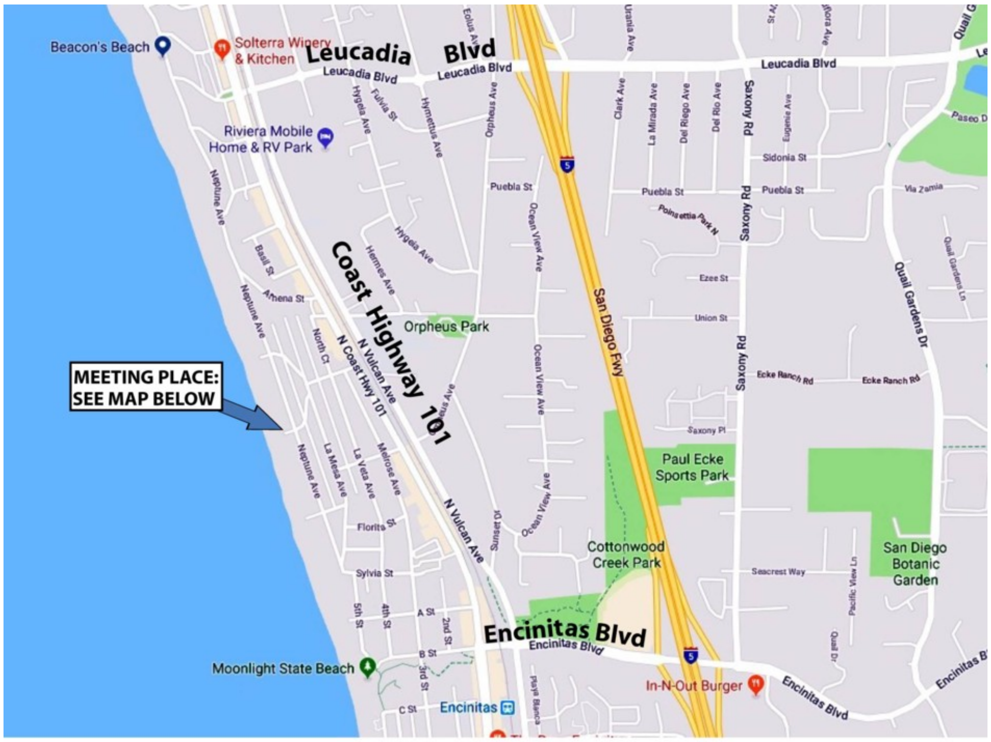
Coastal Erosion Field Trip Map

We will meet at the top of the stairs at **Stone Steps Beach Access** in Encinitas, located at the west end of South El Portal Street. Map location: **340 South El Portal St., Encinitas, CA 92024**

It will take about 25 minutes to get there from the Oceanside campus, or 15 minutes from the San Elijo Campus. We will be walking north along the beach from Stone Steps to Beacon's, a distance ¾ of a mile (1.5 miles round-trip). ***Note: there are no restrooms at the meeting location or along the beach; the nearest restrooms are at Moonlight Beach about one-quarter mile to the south.***



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Coastal Erosion Field Trip

During this lab, after an orientation at the top of the steps at Stone Steps, you will be walking north along the beach from Stone Steps to Beacon's beach access, about ¾ of a mile to the north. You will be observing the geologic materials that make up the bluffs, the effects of wave erosion and groundwater seepage on the bluffs, and human efforts to reduce bluff erosion.

As you walk, you will see things related to the photographs and descriptions below, in the order listed. Use the photographs to orient yourself, and answer the questions are you go. Some of what you will see relates to the information in the Pre-Lab exercise, and so some of your answers will relate to that information too.

STOP 1—An Emerging Coast. Head down the steps and stop at the platform about 20 feet above the beach, so that your view matches the view in the photo. The dashed line divides two major rock formations that you will see on this walk: the **Bay Point Formation** and the **Torrey Sandstone**. The boundary between them is marked by a change in slope: the Bay Point Formation makes a slope dotted with plants; the Torrey Sandstone makes a near-vertical cliff. The houses are built on the top of the Bay Point Formation on a flat surface called a **marine terrace.**

The San Diego County shoreline is an **emergent coast**, meaning that, in the last several million years, the shoreline has been gradually rising. Consequently, the shoreline is relatively steep. Also, sea level has gone up and down worldwide because of repeated advance and retreat of glaciers during the Ice Ages. The combination of a gradually rising shoreline and the rise and fall of sea level means that the sea has cut a series of steps or notches on the coastline, forming **marine terraces**, which represent old **wave-cut platforms**. Many of these old wave-cut platforms form flat benches, like a flight-of-stairs, along our coast. If you look south to La Jolla from here, you can see this "flight-of-stairs" topography in the landscape.

The boundary between the Torrey Sandstone and the Bay Point Formation represents a *buried* wave-cut platform. About 125,000 years ago, waves cut a flat surface on top of the Torrey Sandstone. That surface was later buried by the layers of sand and mud that now form the Bay Point Formation. A new wave-cut platform is being cut today as the cliffs retreat. You can see this platform at very low tides.

- Look closely at the boundary between the Bay Point Formation and the Torrey Sandstone. What evidence suggests that the top of the Torrey Sandstone was once a wave-cut platform (i.e. an eroding flat surface where waves were breaking)? *Hint: think about what you see on the beach/wave-cut platform today.*

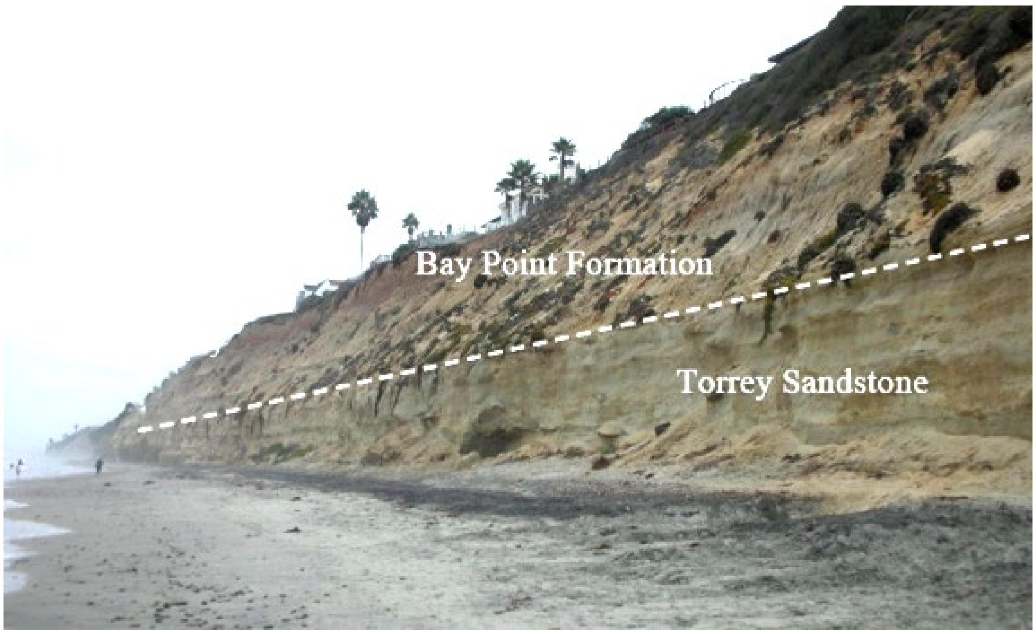
- When the tide is high, where do the waves break here?

- Global warming is expected to raise sea level by two to six feet in the next 100 years. What does this suggest about future erosion along the San Diego coast?

- The steep cliffs and many wave-cut platforms that we see along the San Diego Coast do not occur on the East Coast or the Gulf Coast of the U.S. Why might this be?

STOP 2—Bluff Erosion. Go down to the beach and look north so that your view matches the photo.

You can see here how the **Bay Point Formation** forms a slope, while the **Torrey Sandstone** forms a cliff.



Using some dry sand on the beach, push the sand into a pile and see how steep a slope you can make.

Then take some wet sand (wet enough so that it sticks together), and do the same thing, seeing how steep a slope you can make.

- How do the steepness of your dry sand and wet sand piles compare? Why is there a difference?

The important concept that you have just illustrated is called the **angle of repose**, defined as the maximum slope that a geologic material can maintain before it slides downhill. The main idea is that loose, weak materials have a lower angle of repose (meaning more like a slope than a cliff), whereas stronger materials have a higher angle of repose (closer to vertical like a cliff).

- Based on the above, which of the two rock formations—the Torrey Sandstone or the Bay Point Formation— is harder and more resistant to erosion? Which one is softer and more likely to erode?

- What evidence do you see on the slope that suggests the Bay Point Formation erodes readily during rainstorms?

- Notice that people have planted **ice plant** as well as *Limonium* (a small shrub also sometimes called Sea Lavender) on the slope of the Bay Point Formation. How might these plants help reduce the erosion of the Bay Point Formation?

- What is a potential disadvantage of using ice plant to stabilize a slope? *Hint: what is it about ice plant that allows it to survive for very long periods without much water?*

- Now go look more closely at the Torrey Sandstone. See if you can find cracks or fractures in the cliff face. How do fractures in the Torrey Sandstone cliff affect erosion?

STOP 3—Gravity Block Seawalls. Walk north along the beach a few yards until you come to the first **seawall**, as shown in the photo below. Visible here are the first two of many seawalls that you will see on this walk (labeled on the photo as "1st seawall" and "2nd seawall").

This type of seawall is known as a **gravity block wall**. It is relatively simple, and it is not physically attached to the Torrey Sandstone cliff but instead stays in place by its own weight (hence the name "gravity block"). Moreover, it is low, designed to protect only the base of the bluff from wave erosion. Keep these features in mind when you compare this type of seawall to other, more sophisticated seawalls that you will see later.

- You can see that these seawalls have been constructed to have a "naturalistic" look that attempts to mimic the natural bluff. Who mandated this naturalistic look? Why did they do so? What does the look tell you about when this seawall was built? *Hint: This relates to a question from the Pre-Lab exercise.*

- Stand back from the seawalls and look up to the top of the bluff. Trace imaginary vertical lines upward from the edges of the seawalls to the top of the bluff. Why do these seawalls begin and end at these particular places along the bluff? *Hint: the answer relates to who pays for seawalls, as discussed in the Pre-Lab exercise.*

- Look at some of the unprotected areas of Torrey Sandstone where no seawalls have yet been built. How effective are the seawalls at protecting the base of the bluffs from erosion?

- Compare the sand level at the base of the 1st seawall in the photo on the previous page to the sand level shown at this same seawall in the photo below.

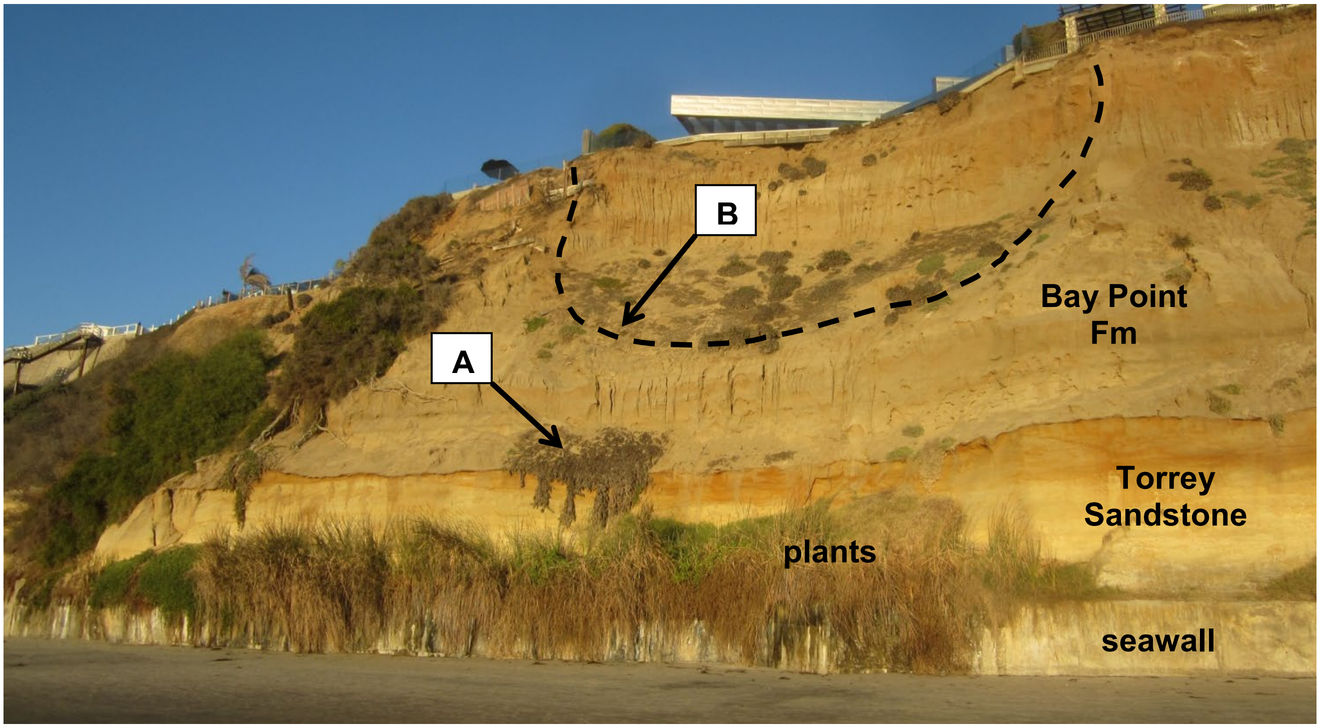
  - Which of these photos was taken in the winter, when we typically have larger waves? Explain.

  - How might the amount of sand on the beach affect the erosion rate of the bluffs? Based on this, at what time of year are bluff erosion problems usually the worst?

STOP 4—Erosion of the Torrey Sandstone. Continue north along the beach until you come to the rough-textured seawall shown in the photo below.

This seawall is made of rough-textured concrete, somewhat like very coarse sandpaper. Observe the edges of the seawall, and the concrete patches on the bluff above the seawall, contrasting the erosion of the concrete versus the erosion of the rock (Torrey Sandstone) since the seawall was built. Which is softer and more easily eroded: the Torrey Sandstone or the concrete? How can you tell?

STOP 5--Groundwater Seepage. Continue north until you come to the area shown below. Here you see a very long seawall with lots of plants growing out its top. You may see water flowing out of the bluff and down the outside of the seawall. The plants are able to grow here because of water seeping out of the Torrey Sandstone above the seawall.



- What might be the source of the water that seeps out of the bluff here? List <u>three</u> possible sources.

- How might seeping water affect the strength of the Torrey Sandstone?

- Why is there a clump of plants at the area marked "A" in the photo?

- What has happened in the area marked by the dashed line labeled "B?" What does this foretell about the future of the home on top of the bluff?

STOP 6—Changing Geology. Continue north until you come to the area shown in the photo below, where you will find a large wooden seawall above the beach. Notice the big change in the bluff here. The Torrey Sandstone—a relatively hard, strong rock—ends here, and is replaced by a softer, weaker rock called the **Santiago Formation**. Like the Bay Point Formation above it, the Santiago Formation erodes easily. Together, these two weak rock formations make for severe bluff erosion problems in this area. As a result, more sophisticated—and expensive—bluff erosion-control efforts are necessary.

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- Note the large amount of vegetation on the bluff. What role does the vegetation play in erosion control?

- Below the vegetated slopes in this area, you can see several low seawalls made of stone blocks (see photo above). Keeping in mind current mandates for seawall construction, what can you say about when these seawalls were built?

STOP 7—Sheet Wall Construction. Continuing north from Stop 6, you will encounter larger and more sophisticated bluff construction projects, including seawalls that go most of the way up the bluffs. Walk until you come to the two tall, distinctive seawalls shown in the photos below. We call these the "Telephone Pole Seawall" and the "Prison Seawall," the latter because it looks a bit like a maximum-security prison wall.

Prison Seawall

Telephone Pole Seawall

The two seawalls above represent a construction style known as **sheet walls**. These are quite different from the **gravity block walls** that you saw earlier. The main differences are:

Gravity Block Walls	Sheet Walls
- low walls that protect the lowest part of the bluff from wave erosion	- tall walls that extend far up the bluff face; protect the lowest part of the bluff from wave erosion <u>and</u> hold the upper part of the bluff in place
- not attached to the bluff; held in place by their own weight	- attached to the bluff; held in place by deep holes that are drilled into the bluff and filled with cement + rebar
- no drain holes	- drain holes
- typically less expensive	- typically more expensive

- Why do you think that sheet walls have been built here, instead of less expensive gravity block walls? *Hint: relate your answer to the information about changing geology given for STOP 6.*

- Keeping in mind current mandates for seawall construction, what can you say about when these seawalls were built?

STOP 8—New Seawall. Continue north along the "Prison Seawall" until you come to the place shown in the photo below. Notice the major change here between the old style and new style of sheet-type seawall construction. The situation here illustrates the "grandfathering" principle. An old seawall built before the current specifications of the California Coastal Commission is allowed to stand. But if it fails, any new seawall replacing it needs to conform to current CCC specifications, in particular the requirement that new seawalls have a "naturalistic" look to mimic the appearance of the natural rock of the bluff.

- Compare and contrast the new seawall here to the older seawall. What are the similarities? What are the differences?

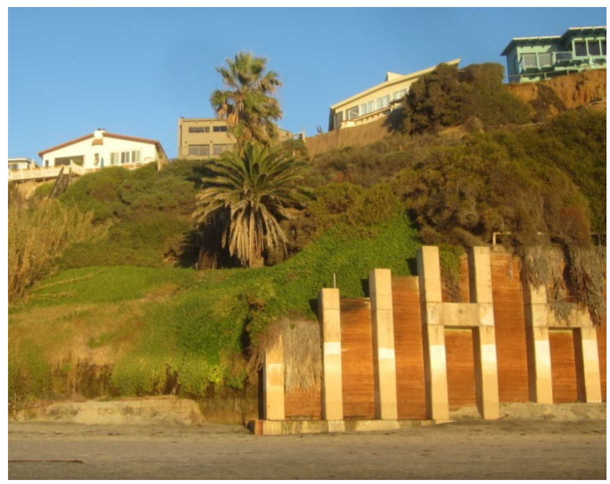
- Notice the drain holes in the seawalls. What's their purpose; why not just let groundwater build up behind the seawalls?

- What is your opinion about the relative merits of the old style versus new style of seawall construction shown here? Explain.

STOP 9—Slump. Continue north along the "Prison Seawall" until it ends at the place shown in the photo at the right.

From here north for several hundred yards, you'll notice a major change in the bluff. The top of the bluff curves back away from the beach, so that instead of a steep bluff rising straight up from the beach, we see a wide, scoop-shaped area filled with dense vegetation.

This change in the bluffs is very apparent from the air, as shown in the photograph below.



The scoop-shaped area of the bluff that you see here is known as a **slump.** Slumps occur when soft, weak rock slides down slope along curving surfaces. A vertical **scarp** marks the head of the slump. The main mass of the slump consist of a series broken, sliding blocks of rock. The base of the slump spreads out in an area called the **toe**.

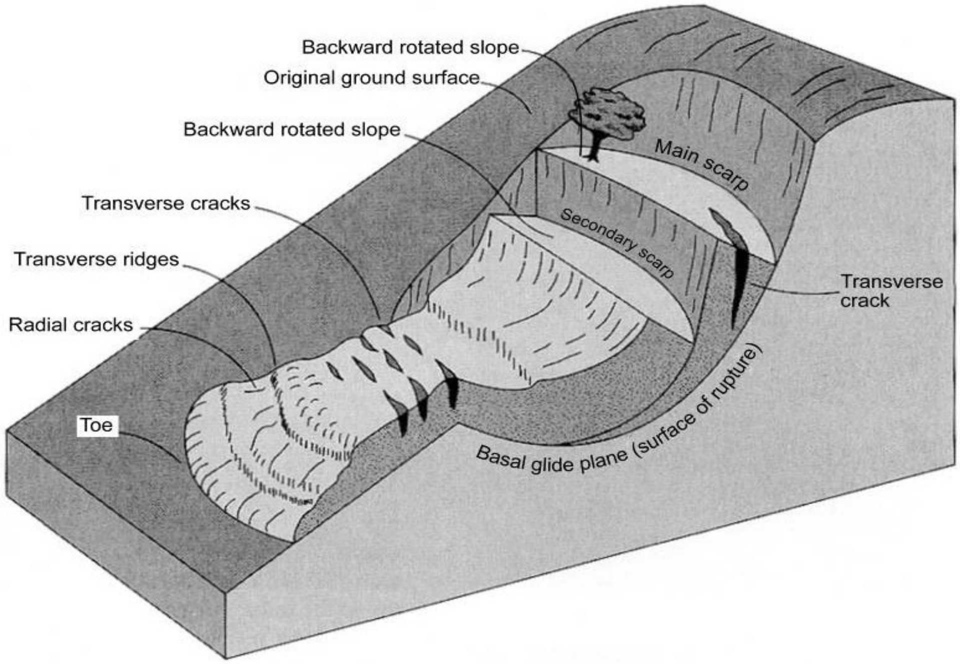


*Diagram of a **slump** in cross-section (U.S. Geological Survey)*

You did not see any slumps during the first part of the walk because the bluffs to the south are dominated by the relatively strong **Torrey Sandstone**. But remember, that in this area the Torrey Sandstone has been replaced by a softer, weaker rock formation called the **Santiago Formation**. The Santiago Formation has a lot of **shale** in it. Shale is mud that has compacted into rock, and just like mud, shale gets very soft and slippery when wet.

- What do you see in this area that might explain why the Santiago Formation has slumped so badly? *Hint: Go look at what is coming out from the slump area, and think about why the vegetation here is so dense.*

- Do you see any evidence that slump movement or other erosion has occurred in the time since the houses were built at the top of the bluff? Explain.

- On the slump diagram above, you can see that a slump normally has a <u>toe</u>. Why doesn't this slump have a toe? Where did the toe go?

- Based on what you have seen so far, compare and contrast the way that the Torrey Sandstone (Stops 1-5) erodes with the way that the Santiago Formation (Stops 6-9) erodes.

STOP 10—Slump Damage and Bluff Repair.

Continue north to where your view matches the right hand photo below. Compare this photo to the photo on the left, which shows the same area several years ago, shortly after catastrophic **slumping** occurred to the bluff here. So much of the bluff slumped that the original house was left hanging partway over the bluff edge! The owners subsequently (and at great expense) had to repair the bluff, demolish the original house, and add the new construction that you see today.

AREA SOON AFTER SLUMP DAMAGE ***AREA TODAY***

- Comparing the original damage (left photo above) to what you see today, describe what the owners had to do to deal with slump-caused damage to the bluff here.

- The low exposures of gray rock at beach level here are **shale** beds of the Santiago Formation. These are the wave-eroded remains of the toe of what was once a large slump that pushed out onto the beach when the bluff failed (see slump diagram on previous page).

  Look closely at the shale and check its softness by scratching it with a key or knife, especially parts that might be wet. What might be the connection between the softness of the rock and the occurrence of the slump here?