

COASTAL SEDIMENTATION: PAST, PRESENT, AND FUTURE

A LABORATORY AND HOMEWORK ACTIVITY

PURPOSE

This activity guides students through coastal sedimentation of the past, present, and future. Students will learn to read a sediment record as a story of past coastal migration due to sea level fluctuations (Part 1). Students will also estimate modern sediment transport visually and mathematically and hypothesize why discrepancies between theoretical predictions and real observations exist (Part 2). Finally, students will apply newly learned theories and their hypothesis by predicting how coastal environments may change in the future in response to a variety of stressors such as dam installation and climate change (Part 3).

EXPECTATION

Black questions are to be completed in lab. **Blue questions** should be completed outside of class if there is not ample time in lab to complete all activities.

Part 1: Geologic Deposits

1. [8 pts] The figure below shows a common shelf and beach profile and four possible cores. With the information in these cores as well as what we know of the modern environment, we can track the geologic history of this environment. With a PENCIL, fill in the blank space by correlating deposits between the cores.

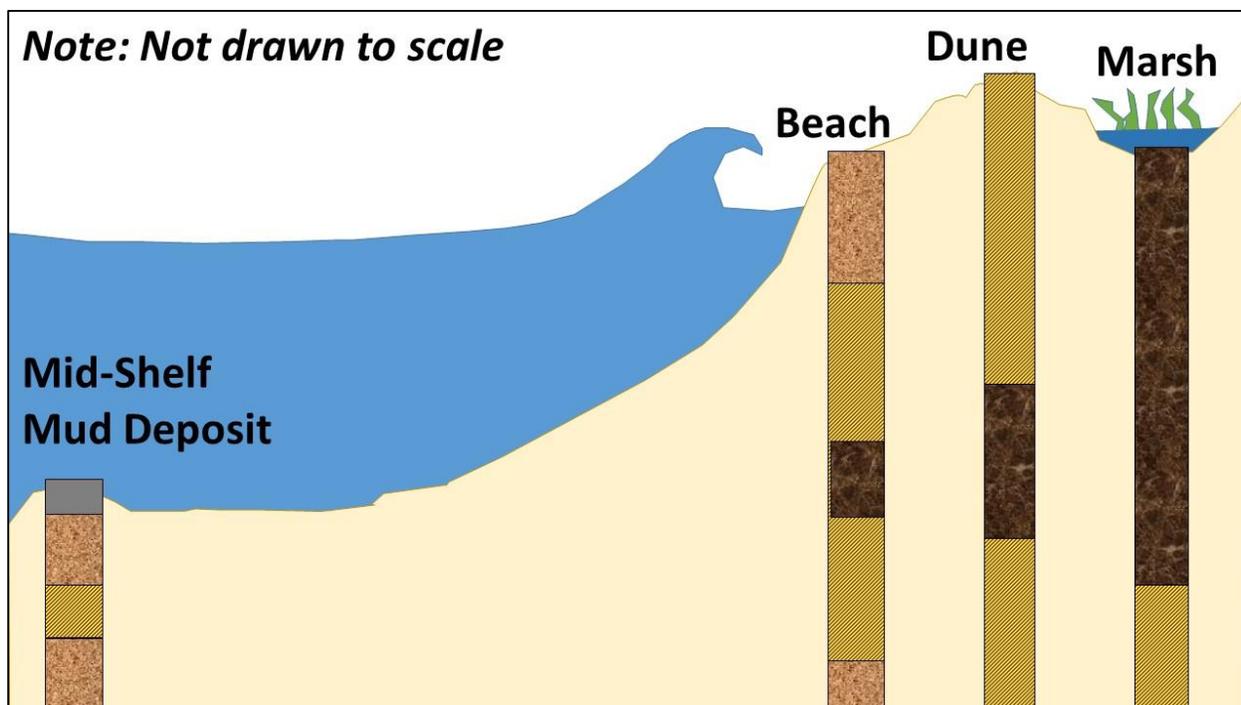
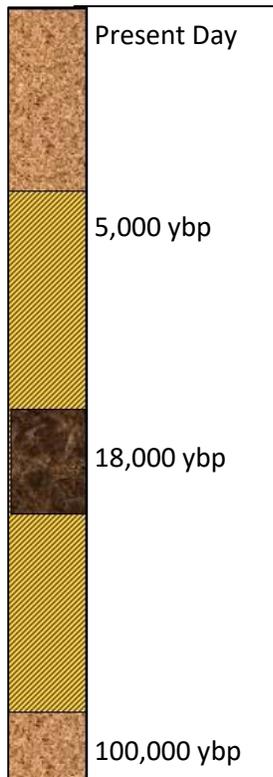


Figure 1.

Scientists were able to determine the age of the beach core, as shown below. These dates suggest that this geologic sequence was produced by sea level changes.



2. [4 pts] As sea level rises and falls, coastal environments will migrate to “keep up”. In a sentence or two, explain how sea level changed from 100,000 years ago to present day using information from the two figures. How do you know?

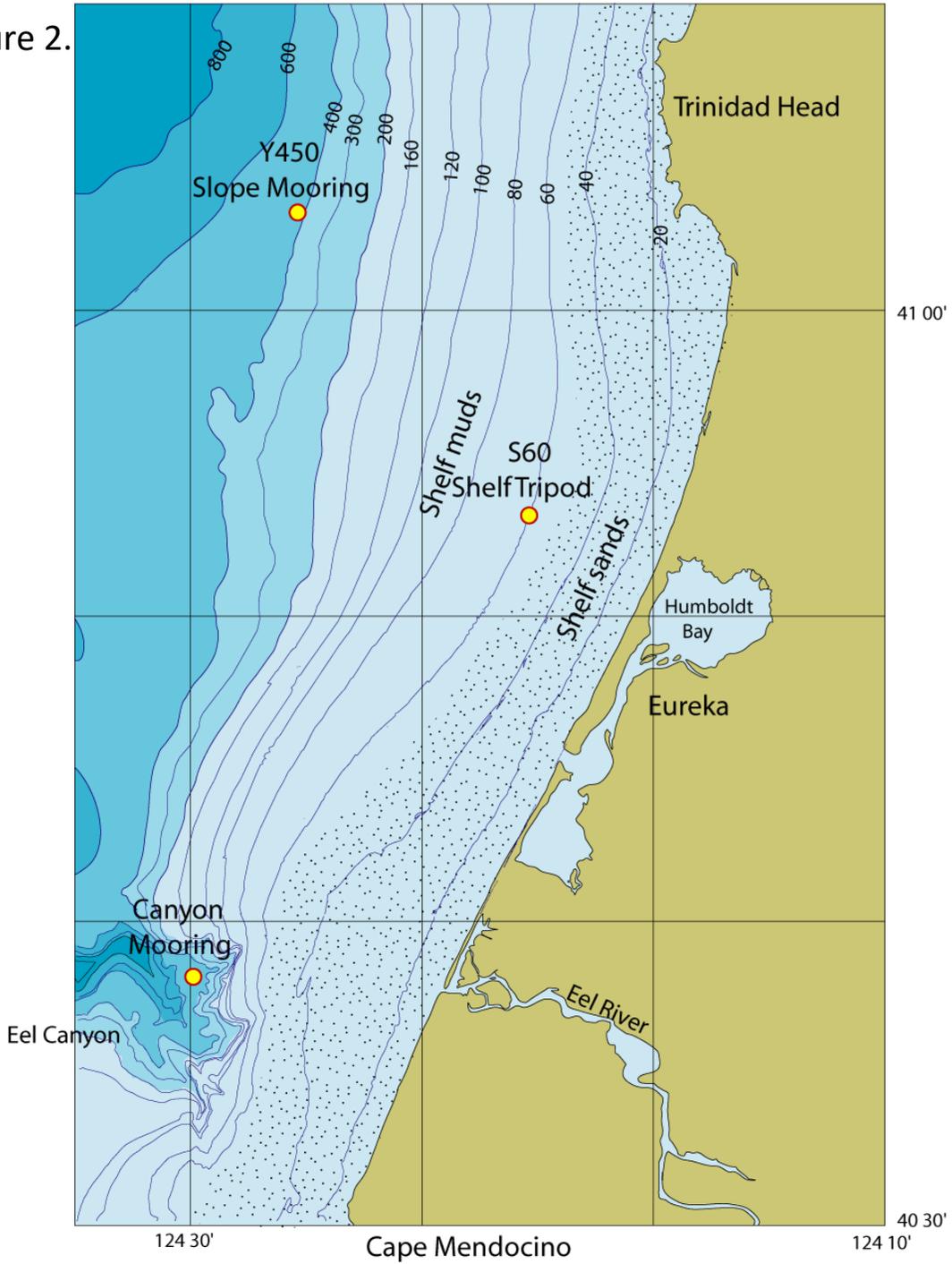
3. [3 pts] When was there a major shift in the sea level trend? What natural occurrence caused this shift in sea level? Feel free to use each other and/or the internet to answer this question.

Globally, sea level has risen about 6 cm in the past 22 years! Think about what this means for the future of current coastal communities. You do not have to write anything, just think and discuss with your working group.

Part 2: Modern Deposits

The coastline of northern California near the Eel River mouth is shown in the image below. Note that the contour intervals are irregular.

Figure 2.



8. [2 pts] Scientists studying this region have found that sediment deposits on the shelf only account for about 50% of the sediment being delivered by the Eel River. Using the map above as a guide, hypothesize at least two places where this “missing” sediment could have gone.

9. Math Time!

A clay sized particle 0.003 mm in diameter is delivered to the ocean from the Eel River. After the river mouth, it becomes entrained in a current flowing to the north at 0.14 m/s. The middle of the shelf has a water depth of ~60 m.

Using Stoke’s settling velocity equation given below, calculate how far the particle will travel before being deposited on the seafloor assuming no other processes influence its settling. Make sure your units work out!

$$W_s = \frac{D^2 \Delta \rho g}{18 \mu}$$

W_s = settling velocity (m/s)

D = particle diameter (m)

ρ_w = water density = 1027 kg/m³

ρ_s = sediment density = 2650 kg/m³

g = acceleration due to gravity = 9.8 m/s²

μ = kinematic viscosity = 1.39 g/m/s = 0.00139 kg/m/s

Step 1: [3 pts] Calculate the settling velocity of the particle (m/s).

Step 2: [3 pts] Calculate how long it will take the particle to settle 60 meters to the sea floor (s).

Step 3: [3 pts] Calculate how far the particle will have moved laterally with the current in the time it took to settle to the sea floor (m). This is how far away from the river mouth that the particle should hypothetically be deposited.

[4 pts] Your answer should be much farther than clay particles actually do travel at this location! Hypothesize what process could force the particle to settle at a faster rate than you calculated. You do not have to know the correct answer at this time as long as your hypothesis is thoughtful and justified. Feel free to use each other and/or the internet to answer this question.

Fill in the first row of the below table with your answers from above.

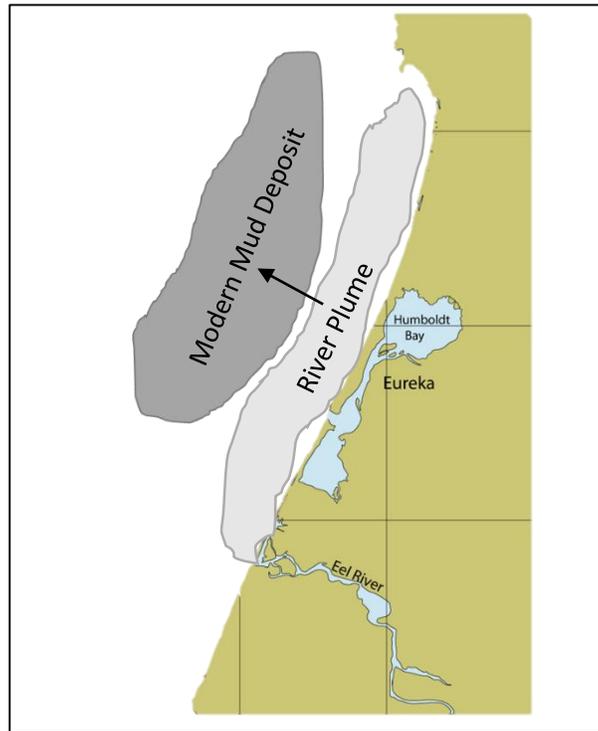
[16 pts] Outside of class, perform the same calculations for silt and sand sized particles and fill in the rest of the table.

[4 pts] Assuming that the current is to the North, map where you expect to find each size class on Figure 2.

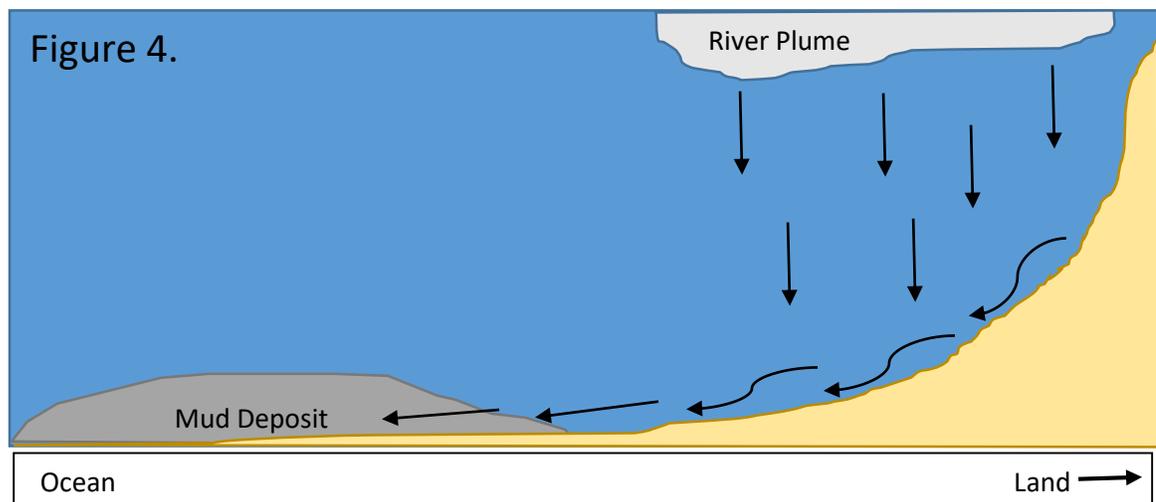
	D (mm)	D (m)	Ws (m/s)	Time to fall 60 m (s)	Distance traveled laterally (m)
Clay	.003				
Silt	.02				
Sand	.5				

10. The following figure shows the bulk of the modern mid-shelf mud deposit.

Figure 3.

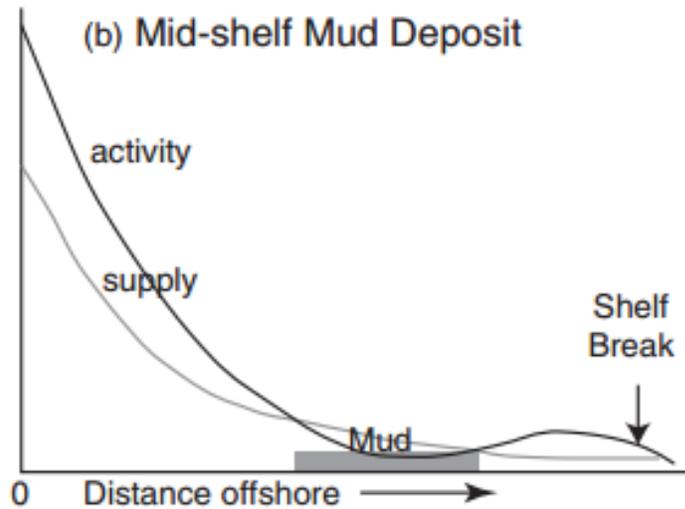


This mid-shelf mud deposit was not formed by sediment falling out of a directly overlying sediment plume. Instead, sediment falls from the plume shoreward of the mud deposit and is then reworked and transported toward the mid-shelf, as shown below.



Several factors influence the size and location of this mud deposit, including incoming sediment supply, currents, wave energy, wave direction, bathymetry, and sea level. In short, a mid-shelf mud deposit forms when the supply of mud overcomes the activity/energy of the environment as shown in Figure 5.

Figure 5.



Note: No bathymetry is shown on this plot!

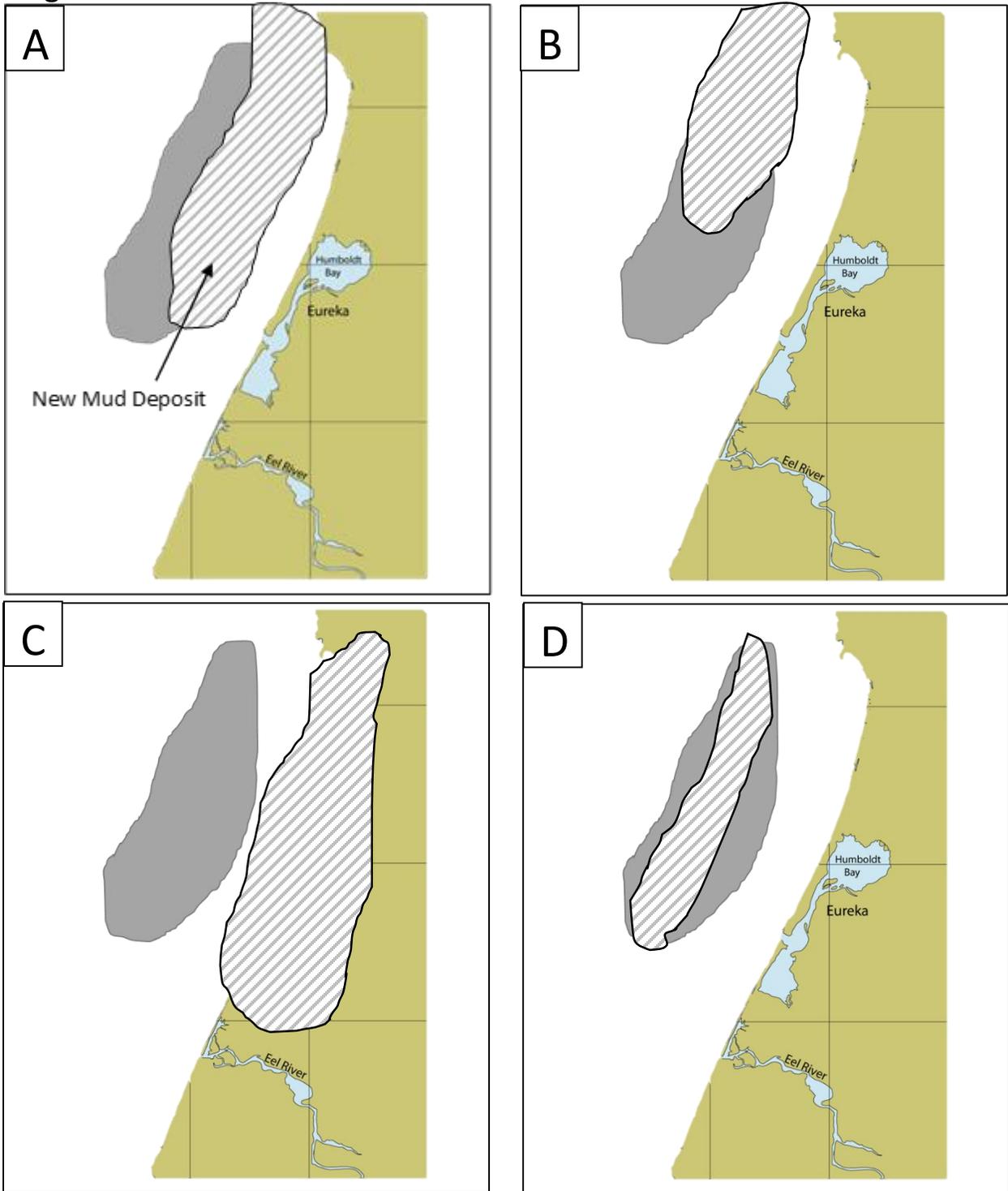
10a. [3 pts] On the shoreward side of the mud deposit, the mid-shelf mud deposit pinches out because the activity is so great. What causes the activity to be so high near the shore?
Hint: Think about how wave orbital velocity is related to bathymetry.

10b. [3 pts] On the seaward side of the mud deposit, the mud deposit ceases because of decreased mud supply. Why is the supply of mud so low this far offshore?

Part 3: Future Deposits

11. As a thought exercise to do outside of class, hypothesize what could cause the mud deposit to change as indicated in Figure 6. Justify your answers using a variety of factors (sediment supply, current velocity/direction, wave velocity/direction, bathymetry, sea level, etc.). Also note what could cause these factors to change (example – sediment supply decreased because of increased damming along the Eel River). There are many possible solutions to each scenario. Each answer should be 2 - 4 sentences long.

Figure 6.



Answers:

A. [8 pts]

B. [8 pts]

C. [8 pts]

D. [8 pts]

REFERENCES

This lab was created by Robin McLachlan (mclachlan.rl@gmail.edu) of University of Washington in 2016 for OCEAN 320, an undergraduate-level course on coastal oceanography.