Morphological Classification of Shorelines based on Hydrographic Regime

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Key Concepts: hydrographic regime, morphological classification of coasts
Key words: barrier island, tidal delta, estuary, beach ridge, marsh and tidal creek system, tidal flat, inlet, longshore transport, microtidal, mesotidal, macrotidal

Goals:
Content/concepts goals: You will understand the relationship between hydrographic regime and shoreline features along clastic depositional coasts.

Skills and higher order thinking goals acquired from completion of this lab:

Upon completion of this lab you will be able to:

1. use Google Earth to locate and measure landforms.
2. interpret tidal range using Jtides.
3. identify and describe deltas, barrier islands, and other features along depositional coasts.
4. interpret the relative influence of wave and tidal currents in shaping the coast.
5. determine the direction of longshore transport.

Basic skill goals:

1. visualizing landscapes from Google Earth satellite images
2. reading and plotting on graphs
3. summary writing

Requirements: You will need to bring your laptop with Google Earth and Jtides loaded and ready to go. See Appendix

Introduction

The distribution of deltas, beaches and barrier islands is controlled by sediment supply and hydrographic regime. This lab will focus on the latter. Geologists working along the coast have long observed that the shoreline morphology of depositional coasts is strongly tied to the wave energy and tidal currents, commonly referred to as ***hydrographic regime****.*

Waves transport sediment parallel to the coast while **tidal currents** move sediment perpendicular to the shore. Davies (1964) first classified shorelines by tidal range (Table 1A). The focus on tides was considered justified because tidal range controls the length of time waves act on any portion of the shore profile. Therefore, the effectiveness of wave energy decreases with increasing tidal range. Hayes (1975) subsequently documented the distribution and frequency of shoreline features (Fig. 1) for each of Davies' five tidal classes, and developed morphological models for both estuaries and barrier islands (Figures 2, Table 2). (See Figure 3 for details relating to barrier island morphology.)

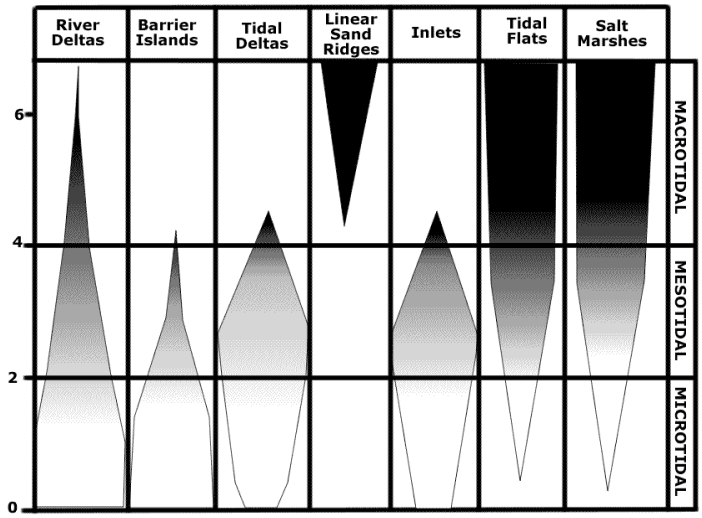

Figure 1. Distribution and frequency of shoreline features with respect to tidal range (after Hayes, 1975).

Table 1: Shoreline classifications based on tidal range.

A. Shoreline Classification by Davies (1964)		B. Refined classification by Hayes (1979) *Medium wave energy (H= 60-150 cm)*	
Microtidal	0-2 m	Microtidal	0-1 m
Mesotidal	2-4 m	Low-mesotidal	1 – 2 m
Macrotidal	> 4 m	High-mesotidal	2 - 3.5 m
		Low-macrotidal	3.5-5
		Macrotidal	> 5 m

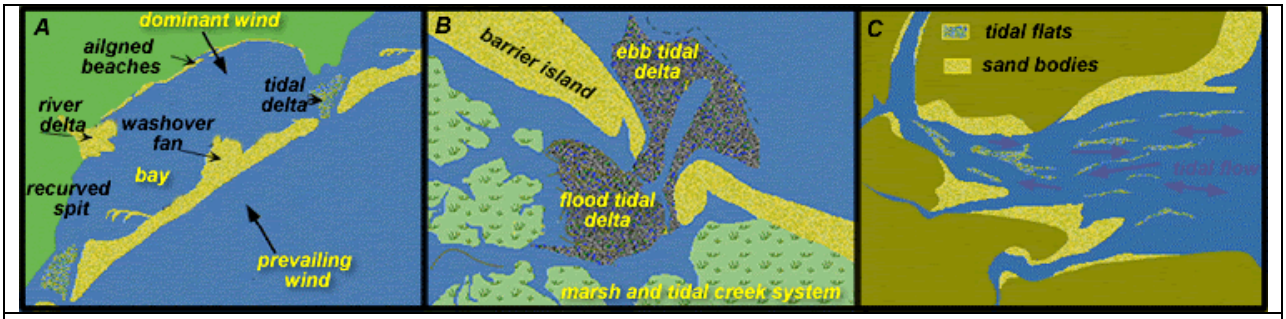

Figure 2. Microtidal (A), mesotidal (B) and macrotidal (C) estuary models. Redrawn from Hayes and Kana (1976)

Table 2. Geomorphic variations between microtidal and mesotidal barrier islands on coasts of medium wave energy (H = 60-150 cm). From Hayes (1979).

Barrier Type	**Length**	**Shape**	**Washover features**	**Tidal inlets**	**Flood-tidal deltas**	**Ebb-tidal deltas**
Microtidal	*Long (30-100km)*	*Elongated hot dog*	*Abundant; numerous washover terraces and fans*	*infrequent*	*Large, commonly coupled with washovers*	*Small to absent*
Mesotidal	*Stunted (3-20 km)*	*Drumstick With down-drift offset* 	*Minor; beach ridges or washover terraces; washover fans rare*	*numerous*	*Moderate size to absent*	*Large with strong wave refraction effects*

Although an excellent predictor of coastal variability, a morphological classification based only on tidal range without consideration of wave energy does not accurately fit all coasts. For example macrotidal forms can develop on mesotidal coasts where wave energy is low, and mesotidal barriers conceivably can develop on marcrotidal coasts exposed to high wave energy. Taking these variations into consideration, Hayes refined Davies classification (Table 1B) restricting it to shorelines of medium wave energy. And using the morphology and hydrographic regime of 21 coastal plain shorelines, he developed a broader morphological classification based on the ratio of tidal range and mean wave height (Fig. 4).

Your Mission:

You will be given a KZM file to load on to Google Earth. The file contains three info markers that will take you to different locations and introduce you to features along the coast. Once familiar with these shoreline forms, you can move to the red markers and complete the exercises A - H. Answer the questions and classify each shoreline--based on morphology, as microtidal, mesotidal, or marcrotidal. (Refer to Figures 1-3 and Table 2 for reference). Then use JTides to approximate the mean tidal range for each location. With the wave data provided, plot where each

shoreline fits into Hayes' (1979) morphological classification (Fig. 4). Evaluate the conditions where such a classification is and is not useful.

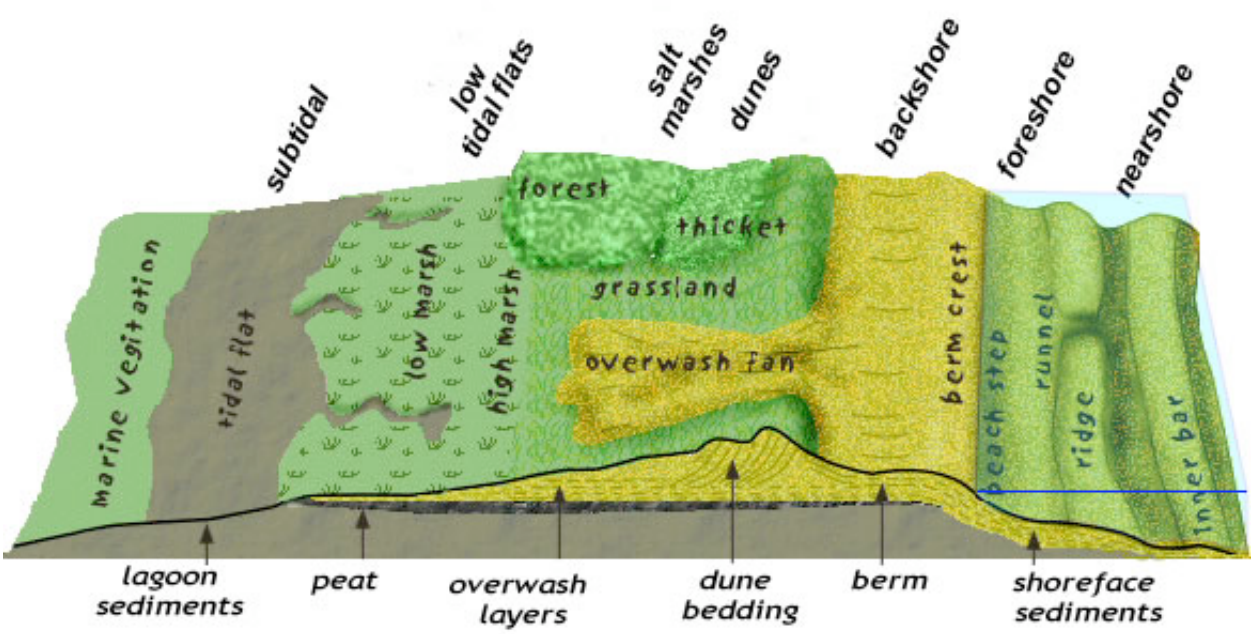

Figure 3. Barrier island morphology. Redrawn from Godfrey 1971.

Instructions:

You will be working with an assigned partner. Write your observations and answers to questions on pages of this lab. Write your answer on pages 5-7. Be prepared to explain and discuss your answer in class.

Step 1: Select the coastal lab KMZ file to open and load onto Google Earth.

Step 2: Uncheck the primary database to remove the clutter from your map interface. (See Appendix.)

Step 3: Familiarize yourself with the measuring tool (ruler) and Google Maps tools. You will use the ruler to determine the dimensions of shoreline features. The Google Maps Tool is invaluable for getting details relating to the geographic location of your image. (See Appendix.)

Step 4: **Part I** - Load the following KZM file and tour through the yellow info sites to become familiar with features presented in this lab.

Step 5: **Part II** - Visit each of the areas marked with the red tags and answer the questions.

Step 6: Compare your observations with another team and evaluate.

Step 7: Open Jtides and search for each location and approximate the mean tidal range from the data.

Step 8: Using the morphology and tidal range estimate where each location would plot on Figure 2.

Step 9: **Part III** – Locate an examples on your own and describe.

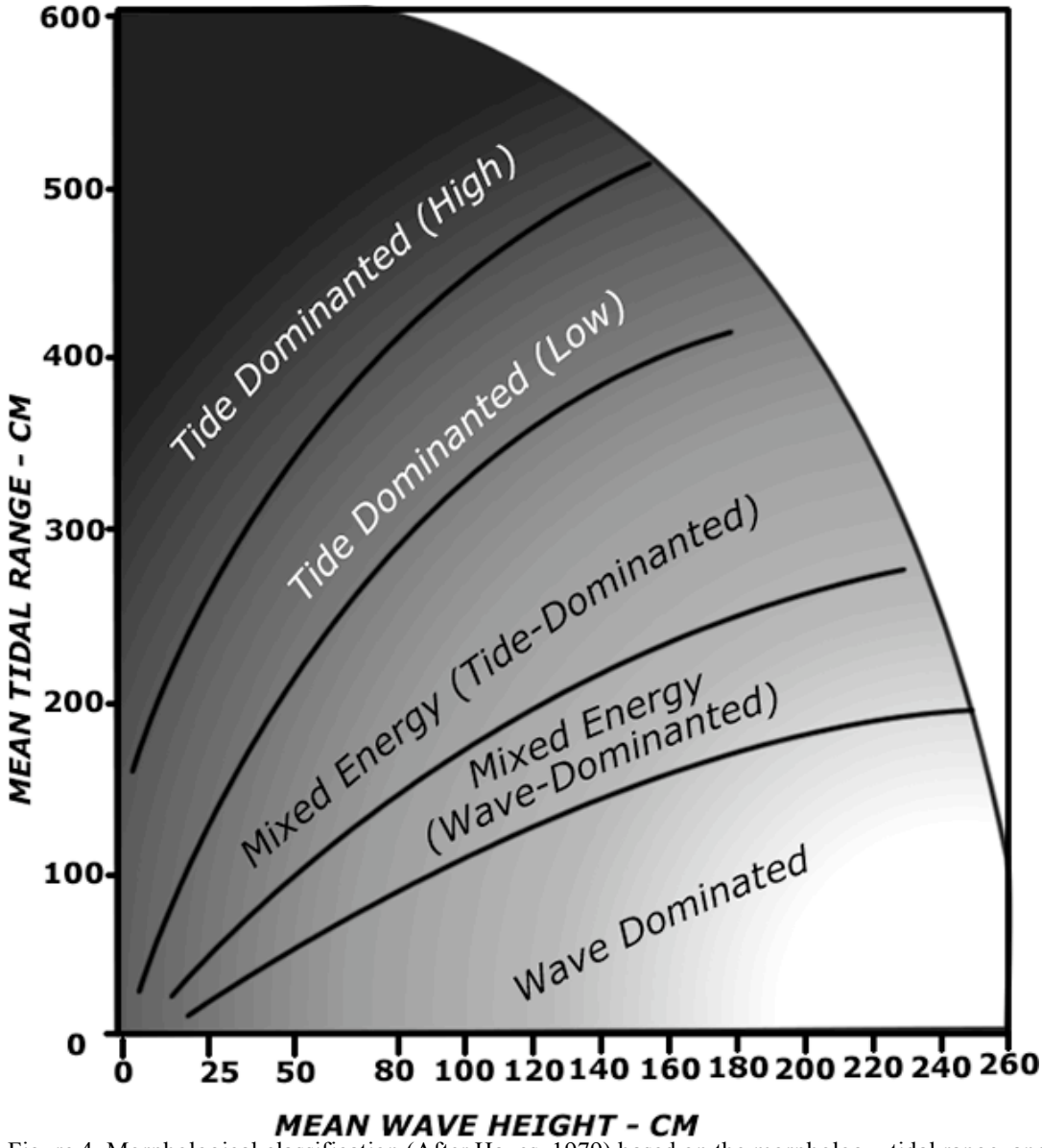

Figure 4. Morphological classification (After Hayes, 1979) based on the morphology, tidal range, and mean wave height of 21 coastal plain shorelines (not plotted).

Exercise

Part I: Introductory exploration

1. Matagorda, Texas
2. Nile River Delta, Egypt
3. Barnegat Light, New Jersey
4. Kiawah Island, South Carolina
5. The Ganges-Brahmaputra Delta

Part II: Identification and interpretation

A. Long Island, SC

1. Describe the island and identify the environment behind the barrier.
Barrier is short and stubby and contains numerous beach ridges and swales. . Down-drift offset indicates that the dominant direction of longshore transport is southwesterly. Recurved spits curve around the south end.

Back barrier region is occupied by vegetated marsh and tidal creek system.

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.
length 8.35 km, width: .66 – 1.2 km wide

3. Are there any ebb or flood tidal deltas? *yes* Describe their size and shape.
Ebb tidal deltas and inlets (5-3 km wide) are large relative to the size of the inlands. Deltas are an irregular fan shape and quite long. No room for flood tidal delta—back barrier region is filled.

4. Discuss the occurrence of washovers. Do they exist? *no* How numerous are they? *no*
Note: a substantial dune ridge, which would inhibit overwash, backs the beach.

5. Based on the above what would you conclude about the hydrographic regime?
Circle one: microtidal, mesotidal, macrotidal

6. What is the approximate tidal range in meters? (Use Jtides.) *1.8 meters*

7. Plot this shore on Figure 4. (Use mean wave height = 50 cm)

B. Mississippi Delta

1.Explore the delta and nearby areas. What clues are there to its hydrographic regime?
The complete lack of tide oriented sand bodies, funnel-shaped estuaries indicates low tidal influence. The delta also shows little wave modification

2. Based on the above what would you conclude about the hydrographic regime?
Circle one: microtidal, mesotidal, macrotidal

3. What is the approximate tidal range in meters? (Use Jtides.) *Tides are mixed ranging from .2-.6 meters (use Southwest Pass station)*

4. Plot this shore on Figure 4. (Use mean wave height = 30 cm)

C. Texas Barrier

1. Describe the island and identify the environment behind the barrier.

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.
length: *205 km*, width: *1-8 km, average approx. 4 km*

3. Are there any ebb or flood tidal deltas? *Natural inlets to the north contain small-vegetated flood tidal deltas and not ebb tidal deltas*. Why are there jetties along all of the inlets on this coast?
Tidal flow is to weak to maintain the inlets. They would otherwise be closed off by wave activity.

4. Discuss the occurrence of washovers. Do they exist? *They occur along the length of the barrier.* How numerous are they? *abundant*

5. Based on the above what would you conclude about the hydrographic regime?
Circle one: microtidal, mesotidal, macrotidal

6. Carefully look and the structures and incoming waves. What is the direction of longshore transport on the south end of the island? *south* On the north end? *north*

7. What is the approximate tidal range in meters? (Use Jtides.) Mixed tides ranging from .2 to .6 meters
8. Plot this shore on Figure 4. (Mean wave height = 30 cm)

D. Plum Island, MA

1. Identify the environment behind the barrier. *Marsh and tidal creek system and partially open estuary*

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.
length: *12 km*, width: *.5-1.3 km*

3. Are there any ebb or flood tidal deltas? Flood tidal deltas form small inner shoals. Ebb tidal deltas are arcuate except at the south end where it is deflected to the south. Describe their size and shape?

4. Discuss the occurrence of washovers. Do they exist? *None obvious*

5. Based on the above what would you conclude about the hydrographic regime?
Circle one: microtidal, *mesotidal,* macrotidal

6. What is the approximate tidal range in meters? (Use Jtides.) 2.2 – 2.9 Ave. around 2.6 (Use Merrimack data)

7. Observe the incoming waves. What is the direction of longshore transport? *South* Does this explain the orientation of the ebb tidal delta formed at the southern inlet? *yes*

8. Estimate where this shore would plot on Figure 4.

Additional notes: The southern end of the island is anchored to a drumlin. You might want to ask student, what direction of ice flow is indicate?. Offshore, just north of the drumlin is the lag deposit of an eroded drumlin. Shoreline features to point out: beach cusps, ridge and runnel systems, rip currents, and parabolic dunes. Morphological features relating to tidal deltas (flood ramp, ebb shield, ebb spits, channel marginal linear bars, etc) are clearly visible on the tidal deltas associated with Essex Bay inlet, 6 km south of Plum Island.

E. Outer Banks, North Carolina

1. Identify the environment behind the barrier. *Open bay*

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.
length: from *inlet to inlet aprox. 81.4 km*, width: *ave. < 1km*
3. Are there any ebb or flood tidal deltas? *Both are present.* Can you describe their size and shape? *1.4 x 1.7 km arcuate and elongate ebb tidal delta; 9 x 12 km large flaring flood tidal delta*

4. Discuss the occurrence of washovers. Do they exist? *yes* How numerous are they? *not too abundant--obscured by development. Best seen along back barrier fringe.*

5. Based on the above what would you conclude about the hydrographic regime?
Circle one: *microtidal,* mesotidal, macrotidal

6. What is the approximate tidal range in meters? (Use Jtides.) *.4 to1 m; mean is around .65m (use Hatteras Inlet, NC)*

7. Estimate where this shore would plot on Figure 4. (Mean wave height = 115 cm)

F. Sanibel Island, FL

1. Identify the environment behind the barrier. *Large bay*

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.

length: *27.4 km*, width: *.5 – 3.7 km*

3. Are there any ebb or flood tidal deltas?

4. Discuss the occurrence of washovers. Do they exist? *Few on Sanibel, several on Captiva Island to the north where the island is thinnest.*
5. Based on the above what would you conclude about the hydrographic regime?

Circle one: microtidal, mesotidal, macrotidal

6. What is the approximate tidal range in meters? (Use Jtides.) .) *mixed .1 - .5 (Use Fort Meyers.) Inlets are formed during hurricanes and soon closed.*

7. Plot where this shore would plot on Figure 4. (Mean wave height = 30 cm)

G. Mouth of the Colorado River, Gulf of California

1. Based on the coastal morphology, would you classify this as microtidal, mesotidal, or macrotidal? (circle one)

2. Describe the features from which you based your conclusion
All tide oriented features. Funnel-shaped estuary

3. What is the approximate tidal range in meters? (Use Jtides.) *.5 - 6 meters (Use El Golfo de Santa Clara, Sonora Mexico)*

4. Estimate where this shore would plot on Figure 4. (Mean wave height = not data, but probably <50 cm)

H. Penobscott Bay

1. Describe the coast.

2. What can you infer about the hydrographic regime? *Appears to be macrotidal – everything is oriented perpendicular to the coast.*

3. How does is this estuary different from the Colorado River Estuary? *No visible sedimentary deposits*

4. Observe and discuss any other factors that influence morphology of this coast. *This is a glaciated coast. The digitate morphology is an artifact of glacial scouring of folded metasedimentary rocks that strike perpendicular to the coast. This is an erosional coast. Sediment supply is low because the last glacier*

removed all coastal plain sediments from this region and dumped on the continental shelf. There is no local sediment suppy. Hayes' classification does not apply in this instance.

4. What is the approximate tidal range in meters? (Use Jtides.) *1- 2.5 m*

Part III: Exploring coasts

A. Using Google Earth explore the coast around the world. Fine one example for each of the following and cite your evidence:

1. Macrotidal coast:
   Evidence:

2. Mesotidal coast:
   Evidence:

3. Microtidal coast:
   Evidence:

B. Evaluate the conditions where this classification may not apply. Using Google Earth, find and locate two examples.

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