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' three 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.)

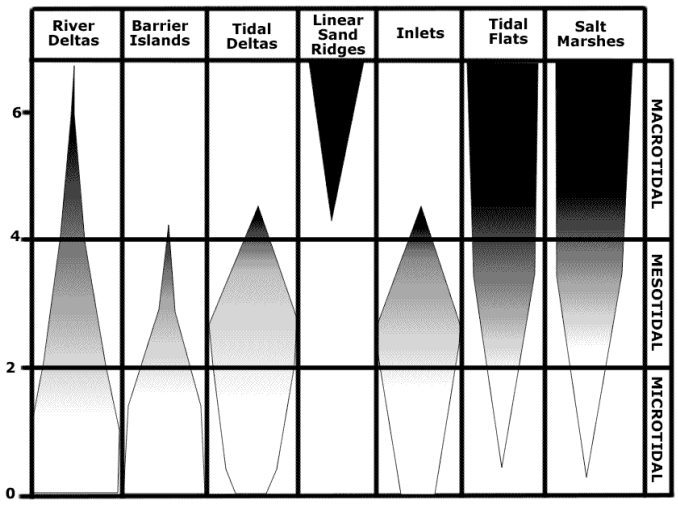

Figure 1. Distribution and frequency of shoreline features with respect to tidal range (after Hayes, 1975).

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

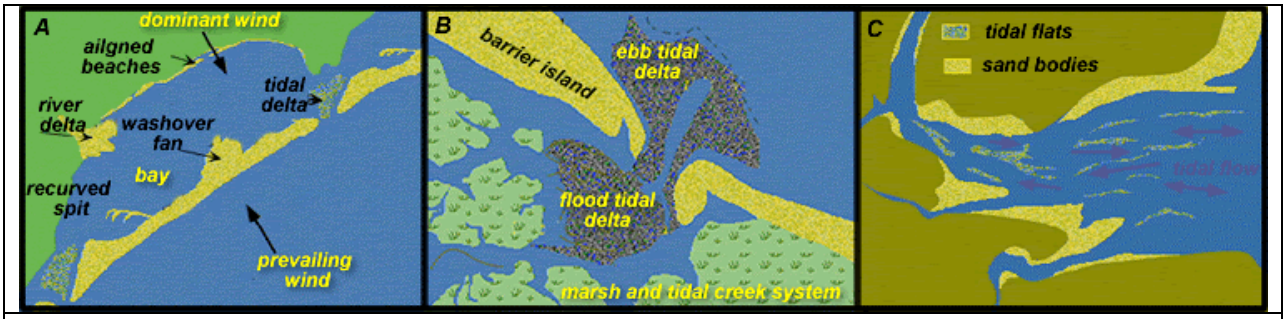

Figure 2. Microtidal (A), mesotidal (B) and macrotidal (C) estuary models. Redrawn from Hayes and Kana (1979)

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 five 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.

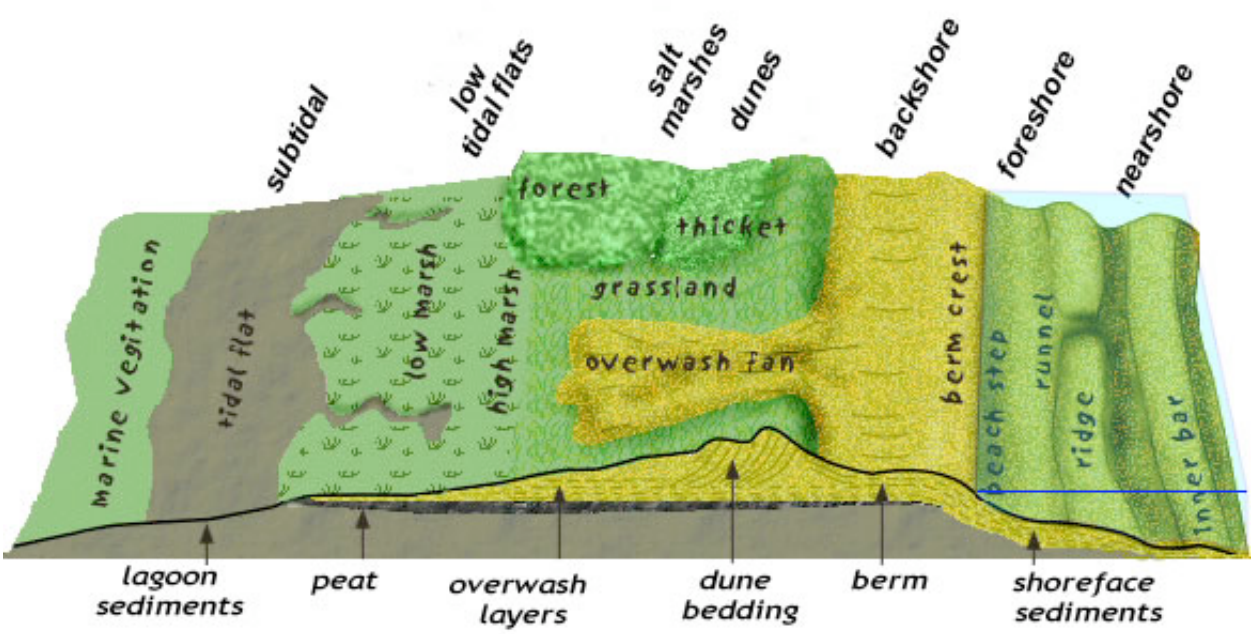

Figure 3. Barrier island morphology. Redrawn from Godfrey 1971.

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.

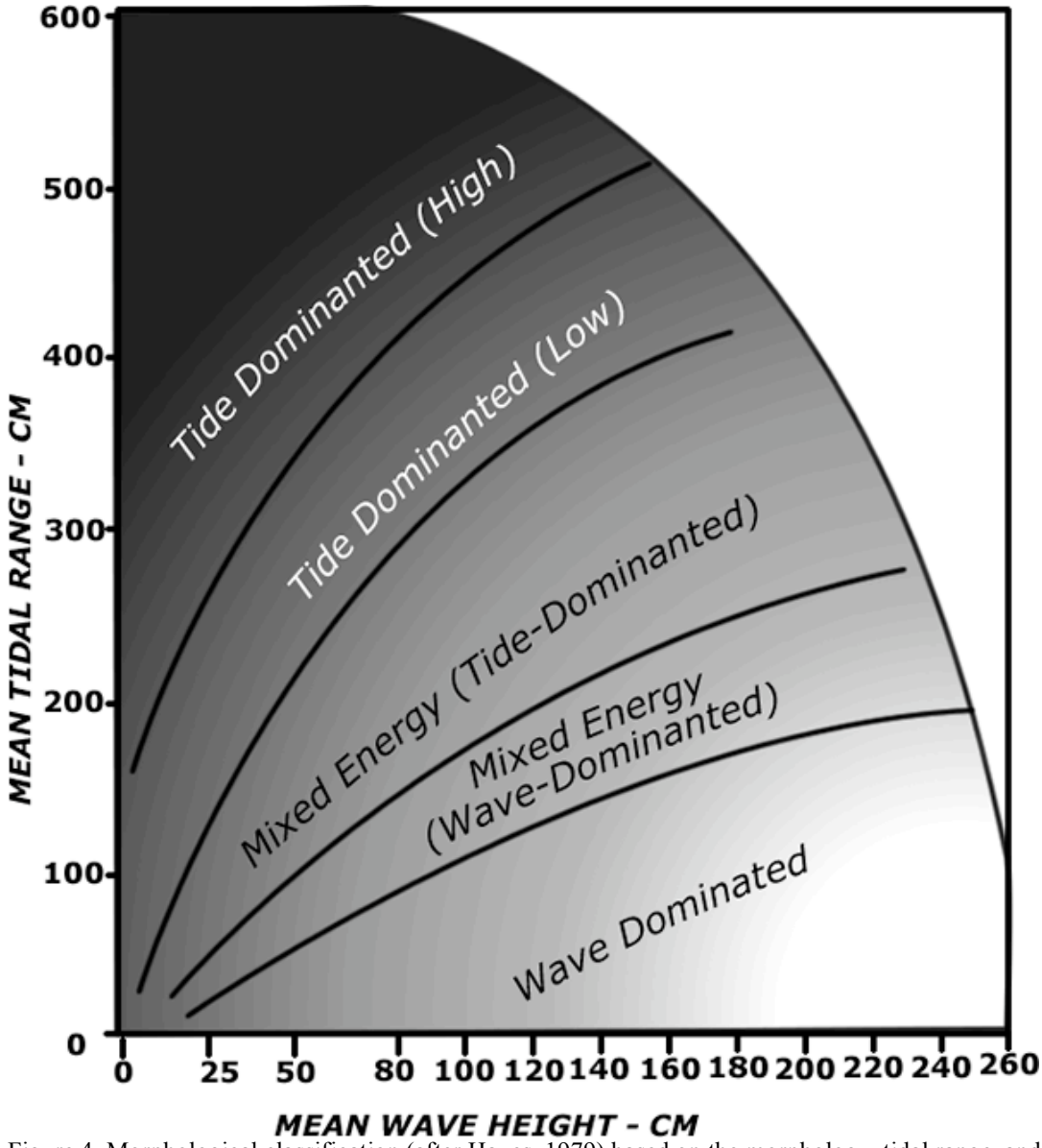

Figure 4. Morphological classification (after Hayes, 1979) based on the morphology, tidal range, and mean wave height of 21 coastal plain shorelines (not plotted).

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..

2. Use the ruler to determine the average length and width of the barrier islands along this section of the coast.
   length: _____, width: _____
3. Are there any ebb or flood tidal deltas? _____ Describe their size and shape.

4. Discuss the occurrence of washovers. Do they exist? ____ How numerous are they?

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.) _____

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?

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.) _____

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: _____, width: _____

3. Are there any ebb or flood tidal deltas? _____ Describe their size and shape? Why are there jetties along all of the inlets on this coast?

4. Discuss the occurrence of washovers. Do they exist? ____ How numerous are they?

6. Carefully look and the structures and incoming waves. What is the direction of longshore transport on the south end of the island? _____ On the north end? (See Appendix C.)

7. What is the approximate tidal range in meters? (Use Jtides.)

8. Plot this shore on Figure 4. (Mean wave height = 30 cm)

D. Plum Island, MA

1. 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: _____, width: _____

3. Are there any ebb or flood tidal deltas? Describe their size and shape?

4. Discuss the occurrence of washovers. Do they exist? _____ How numerous are they?

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 Jtides7. Observe the incoming waves. What is the direction of longshore transport? Does this explain the orientation of the ebb tidal delta formed at the southern inlet?

8. Plot this shore on Figure 4. (Mean wave height = 150 cm)

E. Outer Banks, North Carolina

1. 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: _____, width: _____

3. Are there any ebb or flood tidal deltas? _____ Can you describe their size and shape?

4. Discuss the occurrence of washovers. Do they exist?_____ How numerous are they?

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.) _____

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.

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

length: _____, width: _____

3. Are there any ebb or flood tidal deltas? _____ Can you describe their size and shape?

4. Discuss the occurrence of washovers. Do they exist? _____ How numerous are they?

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.) _____

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.

3. What is the approximate tidal range in meters? (Use Jtides.) _____

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? _____

3. How does is this estuary different from the Colorado River Estuary?

4. Observe and discuss any other factors that influence morphology of this coast.

5. What is the approximate tidal range in meters? (Use Jtides.) _____

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.

References Cited

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Godfrey, P. J., 1976, Barrier beaches of the east coast: Oceanus, v. 19, n. 5, p. 27-40.

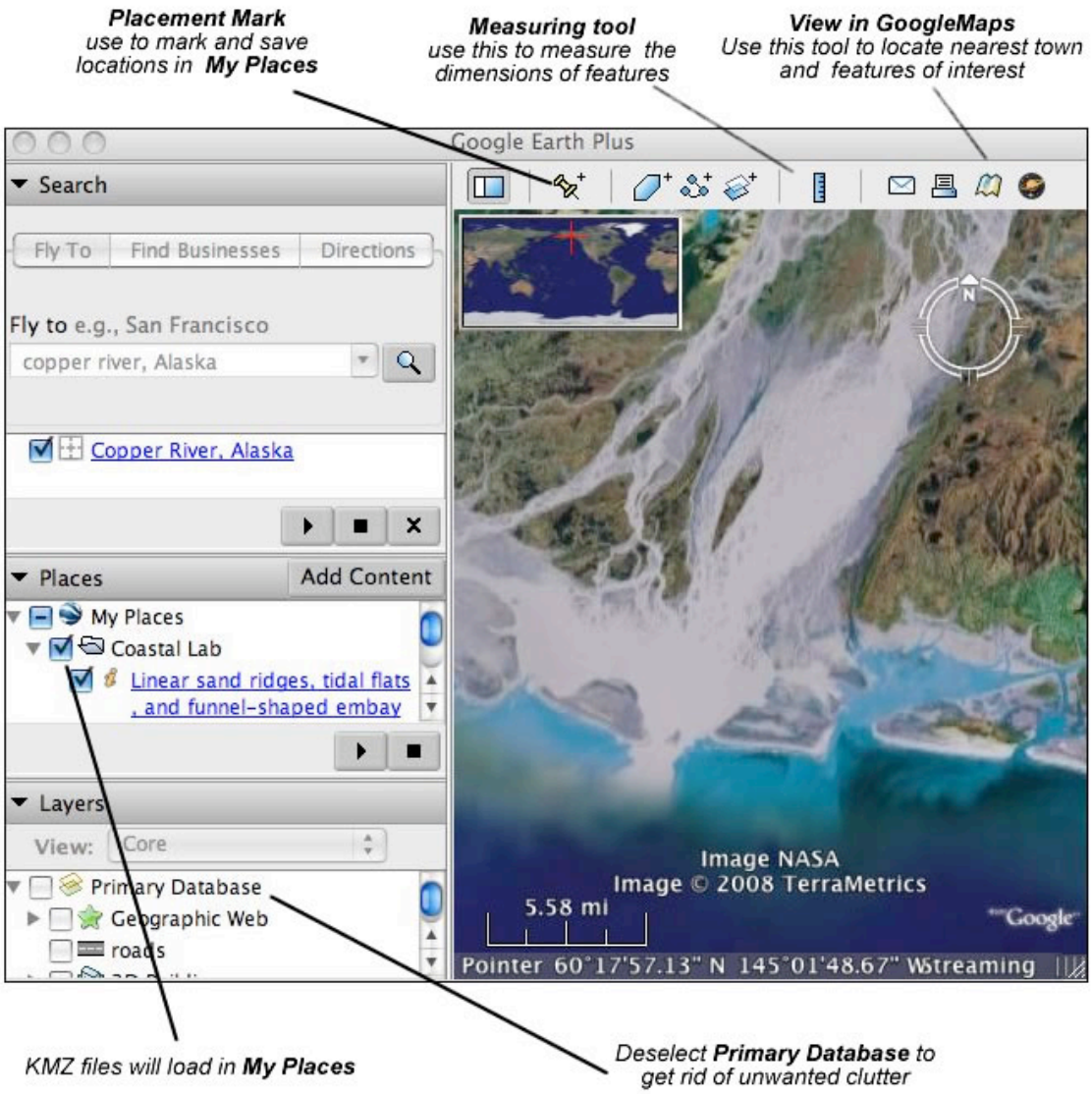
Hayes, M.O., 1975, Morphology of sand accumulations in estuaries, in L.E. Cronin, ed., Estuarine Research: v. 2, p. 3-22. Academic Press, New York.

Hayes, M. O., 1979, Barrier island morphology as a function of wave and tide regime, in Leatherman, S. P. ed., Barrier islands from the Gulf of St. Lawrence to the Gulf of Mexico: Academic Press, New York, NY, pp 1-29.

Appendix

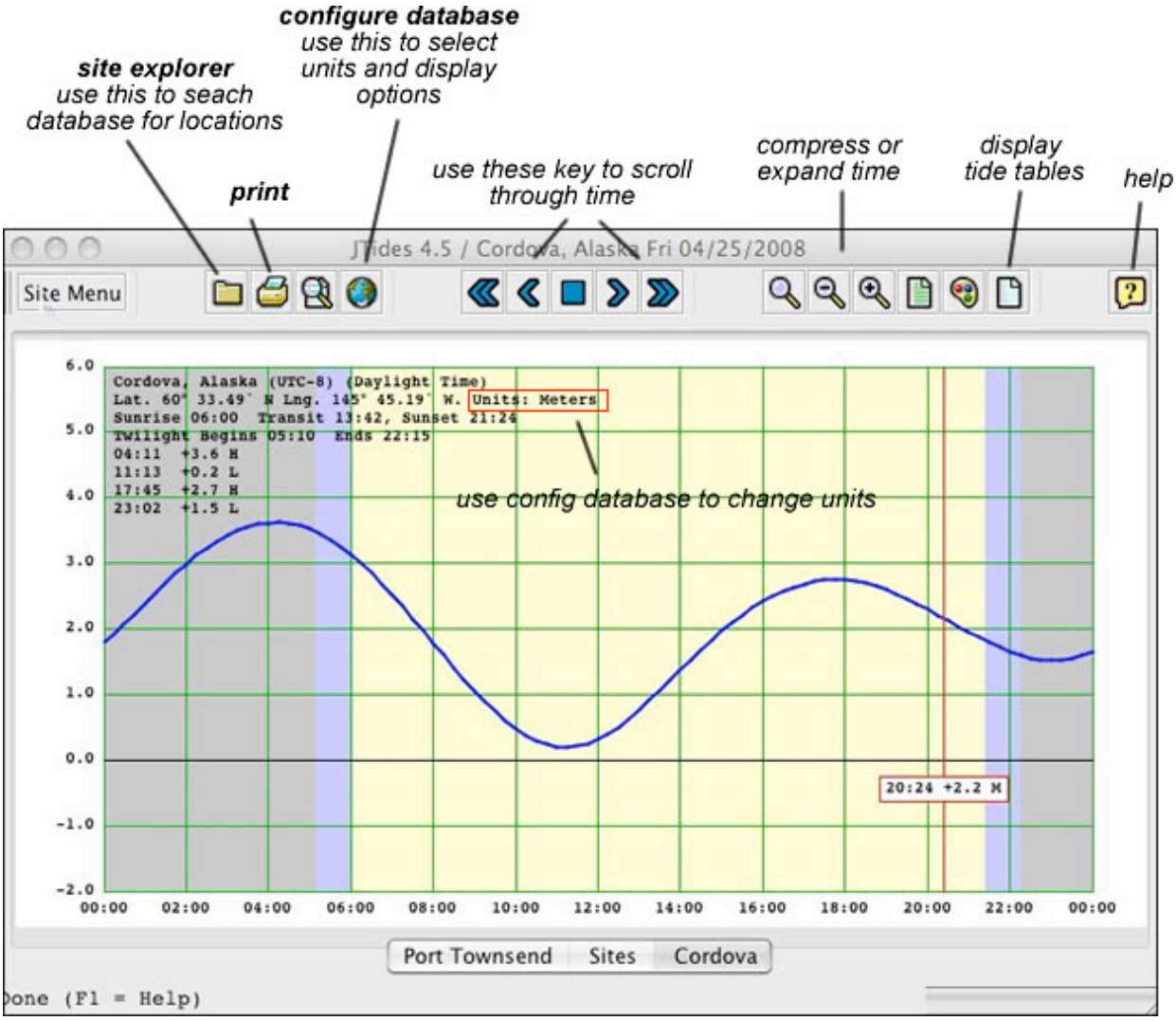
A. Google Earth (homepage URL: http://earth.google.com/index.html)

GoogleEarth is a free earth visualizaton program that is both mac and pc compatible. Click on the KMZ file after you have downloaded and installed Google Earth. Google Earth will automatically open and place the files in the ***Places*** window.



B. Jtides (homepage URL: http://www.arachnoid.com/JTides/)

Jtides is a free mac and pc compatible java program with a worldwide database of tides and currents. The interface is easy to use. Once open you can search the database for locations and look up data that can be displayed in Table or graphic format.



C. Determining the direction of longshore transport.
Sediment is transported onshore by swash and offshore by backwash produced when waves break. When wave approach is oblique to the shore, sediment carried by the backwash is captured by the on-coming wave and deflected down shore. The prevailing direction of longshore transport can be identified by accumulations of sediment on the up shore side of groins and the direction of spit accretion.

Where strong ebb tidal deltas are present, waves will refract around the ebb shield resulting in sediment deposition on the barrier tip just down drift of the inlet. Subsequently, mesotidal barriers are widest and often protrude seaward (exhibiting a down-drift offset), down drift of inlets. (See Table 2.