

## **SOLUTION SET FOR FINAL EXAM**

**NAME:**

December 10, 2004

### **EAS-4300 Oceanography FINAL Exam**

**There are 6 questions and you have up to 2 hours and 50 minutes.  
However you should be done earlier!**

**Remember: this exam is not to test your ability to memorize things. Use the concepts you learned in the class to give answers and reasonable explanations to the questions. The questions may have more than one answer so it is important that you explain when asked to do so.**

**If you have questions during the exam, ask me.**

Figure 1 shows a map of SST anomalies.

a) Label the El Nino and La Nina condition.

**Check figure.**

b) Draw the winds anomalies in the equatorial region for case A and B.

**Check figure.**

c) In panel C draw the thermocline along the equator associated with the SST anomalies in case B. Also indicate the approximate depth of the Ekman spiral.

**Ekman Spiral can be 100-200 m deep.**

d) If you were located along the equator at Longitude -120, where would you expect higher sea level (A or B)? Why?

**I would expect higher sea level at A during El Nino condition because the upper ocean is warmer and the divergence due to upwelling has decreased.**

e) Label three major upwelling systems in map B (UP1, UP2, UP3). Below list how these upwelling systems experience changes during El Nino and La Nina conditions. M = more upwelling. L= less upwelling. U = unchanged.

	During El Nino conditions	During La Nina conditions
UPW1	<b>L</b>	<b>U</b>
UPW2	<b>L</b>	<b>M</b>
UPW3	<b>L</b>	<b>M</b>

h) Draw the Kuroshio Current on map B.

**Check figure**

g) When do you expect the California Current to be stronger, during case A or case B? Explain and don't be scared of being wrong, just give some reasoning!

**In case A. Warmer temperature leads to a higher than usual sea level, which reduces the cross-shore gradient and therefore the strength of the equatorward currents (in this case the California Current).**

Assume the frequency of your waves is defined as:

$$\omega = -\frac{df}{dy} \frac{gd}{f^2} k$$

where  $d$  is the depth of the thermocline,  $f$  the Coriolis parameter (rate of rotation of the planet),  $k$  the wave number,  $\omega$  the frequency of the wave,  $df/dy$  the south to north gradient in  $f$ . (This is in fact the frequency of Rossby waves).

a) Are these waves dispersive? (note: a wave is said to be dispersive if the speed of propagation depends on the wavelength of the wave. If you know the frequency of the wave you can compute the phase speed...).

**NO.**

$$c = \frac{\omega}{k} \longrightarrow c = -\frac{df}{dy} \frac{gd}{f^2}$$

**The phase speed of these waves does not depend on wavelength (=not depend on  $k$ ).**

b) Do long waves or short waves travel faster, according to the relationship above?

**They travel at the same speed (since the phase speed does not depend on wavelength)**

**In figures 1 case B**

c) Do you expect these waves to travel faster at Pt.1 or Pt. 2? **Pt.2. It is closer to the equator,  $f$  is smaller**

d) In which direction will they travel at Pt. 1 (east or west)? **West ( $c$  is negative)**

e) In which direction will they travel at Pt. 3 (east or west)? **West ( $c$  is still negative)**

f) Can these waves exist right at the equator? Explain.

**No because  $f=0$  and the frequency goes to infinity**

g) Would you expect to see Kelvin Waves at Pt. 1 or Pt. 3? Why?

**At Pt.3. Kelvin waves travel along a coastal boundary (or at the equator because of the change in sign in the rotation rate.)**

h) What is a TSUNAMI? Who generates them? If you are in the middle of the Pacific Ocean and a TSUNAMI is being forecast to travel where you are at, would you be scared? Explain why you should or should not be scared.

**Huge tidal waves generated by submerged earthquakes. In the open ocean TSUNAMI travel like shallow water waves (like the tides) and the surface elevation is unnoticeable. Only when they reach coastal region where the depth becomes smaller, there amplitude grows and become devastating.**

Figure 2 shows a map of global amphidromic systems associated with the lunar tide.

a) Label one amphidromic point. Clearly label one cotidal lines.

**Check figure**

b) What is a Corange Line in tidal charts? Draw one corange line for the amphidromic system in the North Atlantic.

**It is a line connecting points that experience equal tidal range. Check figure**

c) Do wave crest travel faster at Pt. 1 or Pt. 2 in Figure 2?

**Pt. 1 the cotidal lines (the crest of the tides moving from hour to hour) are further apart.**

d) Where are the tidal elevations expected to be higher at Pt. 1 or Pt. 2?

**Pt. 2 the cotidal lines are closer together.**

f) Draw the direction of propagation of the tide at Pt. 2?

**Check figure. You can tell the propagation from the hours indicated on the cotidal lines.**

g) How many high tides do you expect in 1 day? **2**

e) We have learned about the differences between the equilibrium and the dynamical model of tides. If the planet was not rotating and there were no continents, would you expect these two models to give the same answer. Explain.

**Not quite. You still need to account for the fact that once the tide is excited the propagation of tidal waves is set by the depth of the water (bathymetry) and the gravity. Therefore the tidal elevation would still not look like the shape of the forces that have generated them (which is the assumption of the equilibrium model).**

**Review on the book the concepts of equilibrium and the dynamical model of tides if you are still confused.**

f) Say you have a sailboat in a marina and you want to sink it to gain money from your insurance company. Here is your chance to use the power of tides to do so! Suddenly you are called as an engineer to decide if you want to do some dredging or replenishment of sand at the bottom of the marina. How could this help you make the wave condition very hostile in the marina? (hint: the waves in the marina travel at the speed of shallow waves  $c = \sqrt{gd}$ ).

**If possible would try to adjust the bottom of the marina so that the natural frequency of oscillation of shallow water gravity waves in the marina is close to the one of the tides leading to a resonance effect, which in turn will produce even higher amplitude waves!**

a) On Figure 3, draw a schematic of nutrient cycling in the ocean. In the arrows you will draw indicate if the transfer of mass is associated with organic or inorganic matter.

**Check figure**

b) Discuss briefly the role of bacteria.

**Convert Dead Organic Matter into Nutrient Inorganic matter.**

**They are fundamental to the marine ecosystem ....see chapter 10 Bacteria as Decomposers.**

c) Also what special property makes bacteria vital in hydrothermal vents?

**They are autotrophs can use chemical energy from oxidation of inorganic compounds (this process is called chemosynthesis), producing food. Because of this ability they represent the first trophic level to support life in hydrothermal vents which exist deep in the ocean in anaerobic environments. These bacteria can also resist very high temperatures!**

d) Briefly sketch/describe how changes in availability of nutrients and sunlight in the regions listed in Figure 3b affect the primary productivity. **Please write your answer on the figure in the appropriate space.**

**Check figure**

a) Describe the direct and indirect effects that temperature can have on marine organisms. Also give one specific example for a direct and indirect effect associated with global warming (from reading assignments).

**Check text book, there is plenty.**

**For the global warming case a simple examples are CORALS, page. 35 of [Reading on Ecosystems and Climate article](#).**

b) Design a fish that would be reasonably adept at maneuvering through holes and crevices of a coral reef while also relying on a darting motion to catch prey. Explain each element of your model.

**Examining Figure 9-23 of textbook, a fish adapted to both a maneuvering and darting style would perhaps have a body form and caudal fin similar to a bluegill. The body would be flat for pushing against the water which would make it very maneuverable and the low aspect ratio of a truncated caudal fin (Figure 9-22) would provide ample acceleration for a darting motion.**

c) Figure 5 (Inter-tidal seas) is a schematic for a benthic banded community. List the adaptation strategies required for the organism to survive in each zone. You can also make references to what you have seen in the Blue Planet Video. If you can name some of the animals associated with the adaptation strategy that you are discussing you get an extra point. **Please write your answer on the side of the figure.**

**Check text book, Chapter 9, Benthic Communities (page 312 on my book).**

a) What are the main differences in the ecosystem in a lagoon and in an estuary? What adaptation would you expect from the organism living in these areas?

**Lagoons are generally calm and very salty due to evaporation, especially if not connected with the ocean. Estuaries are fresher due to river runoff. Biological adaptation includes osmoregulation...etc..**

**Read chapter 12 Biology at Estuary and Lagoon (page 405-411)**

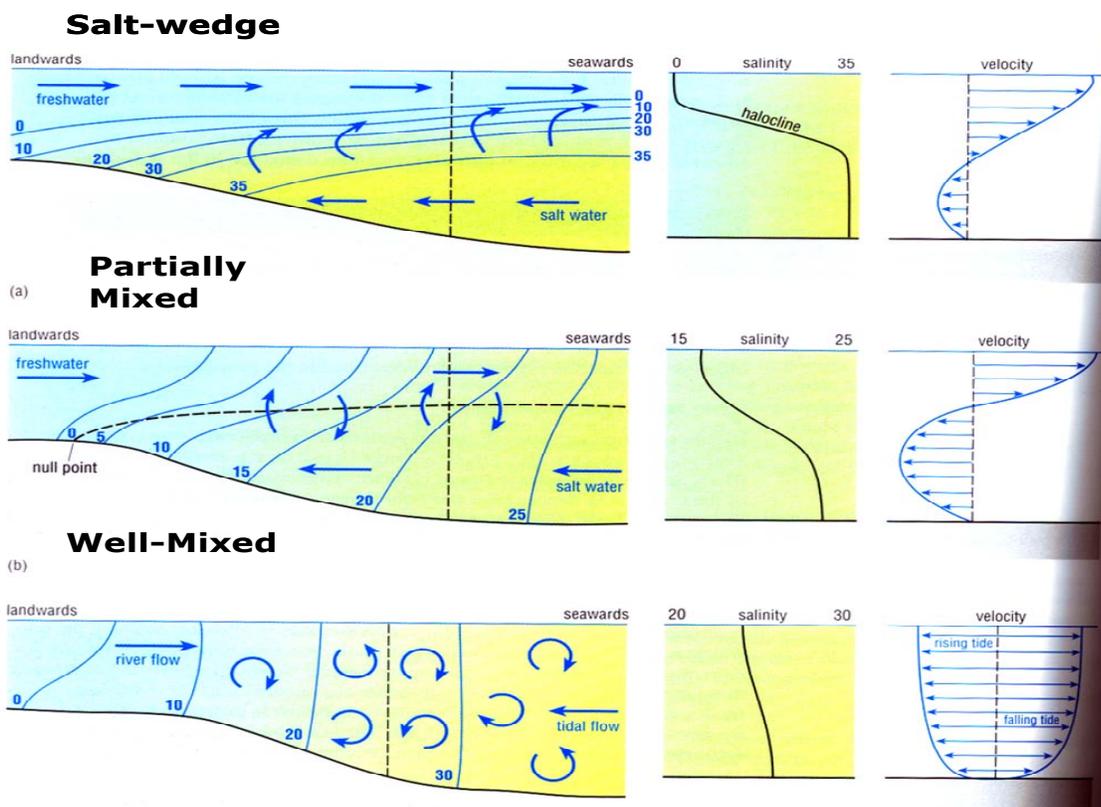
**Also remember the blue planet video – those tiny shrimps that can survive extremely salty environments!**

**Anything would have been fine for this answer**

b) List at least two mechanisms that would lead to the generation of Barrier Islands.

Check Figure 4 of solutions.

b) Draw the profile of the currents as a function of depth in a salt-wedge estuary, partially mixed and well mixed estuary.



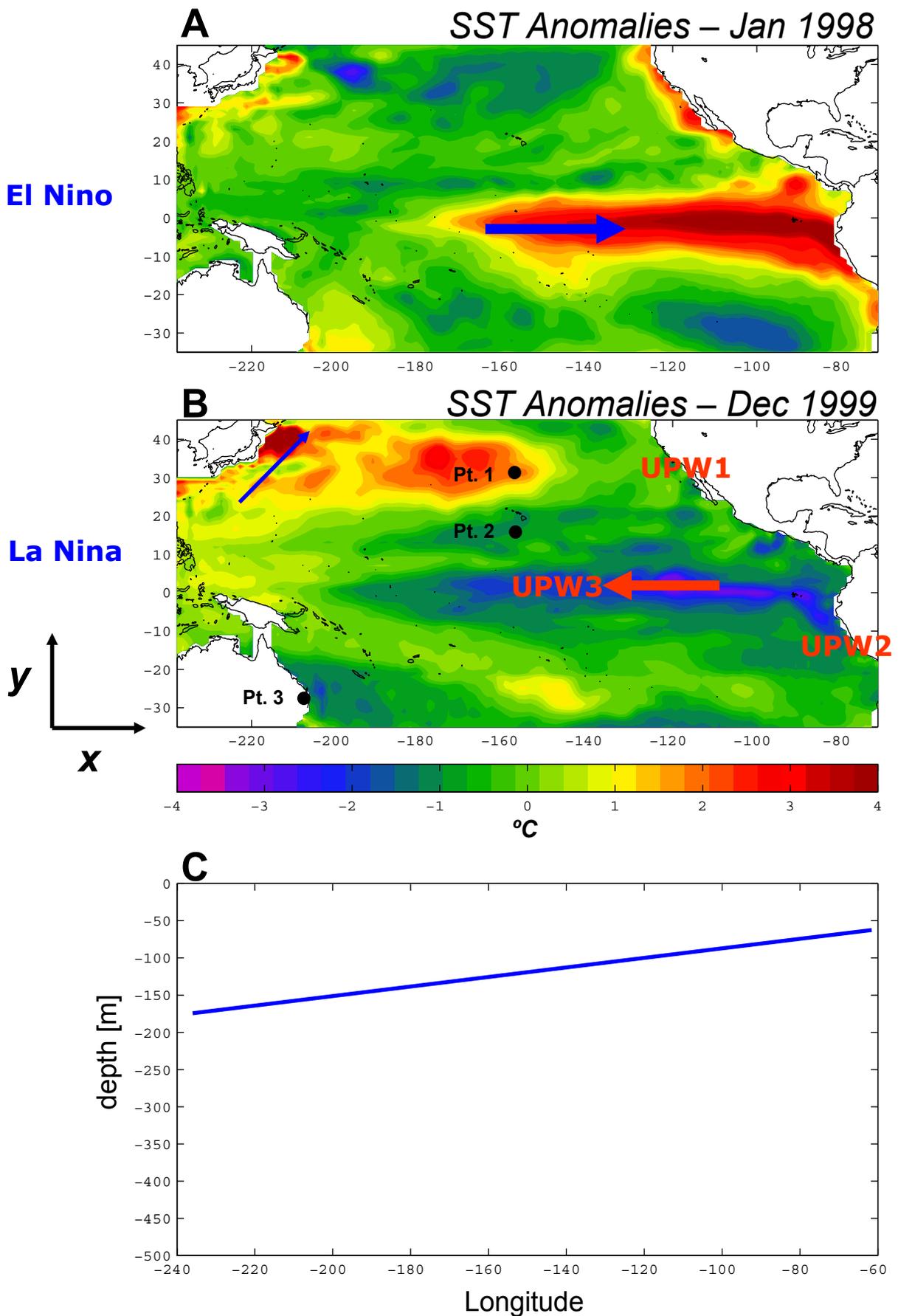
c) As a town counselor, you must vote on a proposal to allow a major hotel and seaside resort to expand its beach front by artificial replenishment (renourishment). The area of expansion is shown in Figure 4. The hotel proposes to dredge sand from deep water far offshore. Because the sand is clean, there will be no pollution. The hotel’s lawyer are arguing that the expansion wil have little impact on the shoreline. Study the figure and determine the possible long-term impact of the proposal. How would you vote on this measure? Justify your vote. **Write on the figure.**

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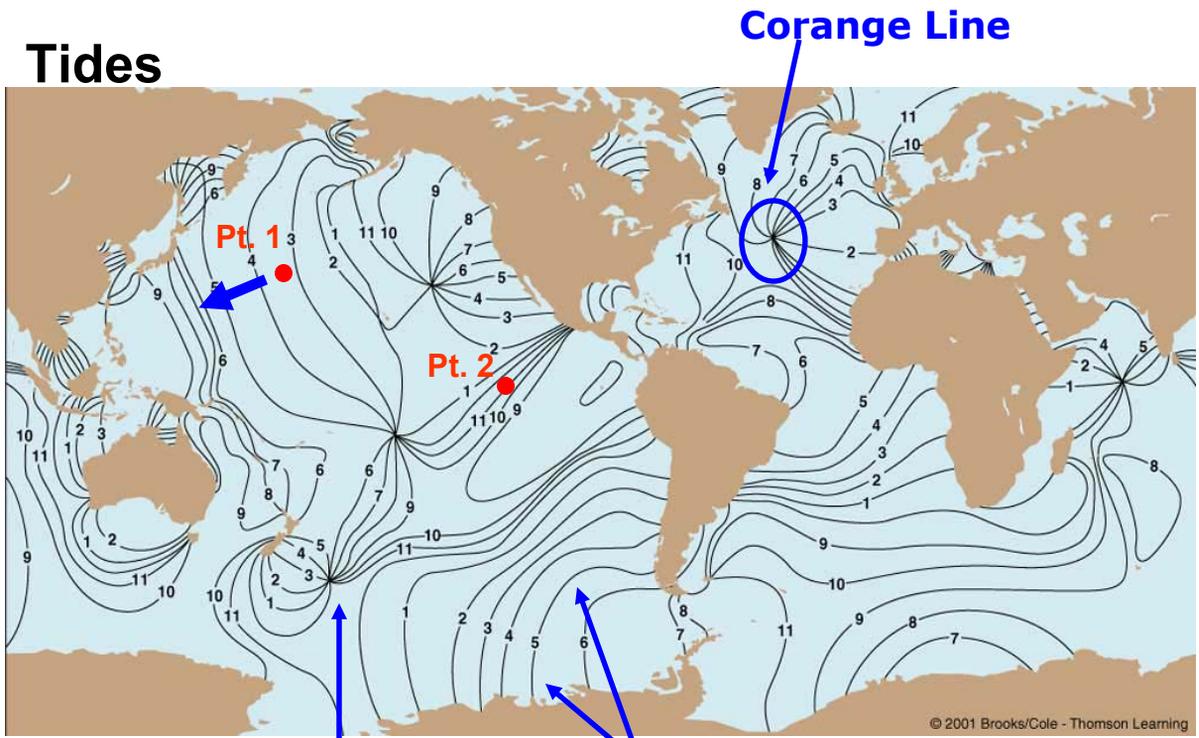
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**FIGURES**



**Figure 1**

# Tides



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**Figure 2**

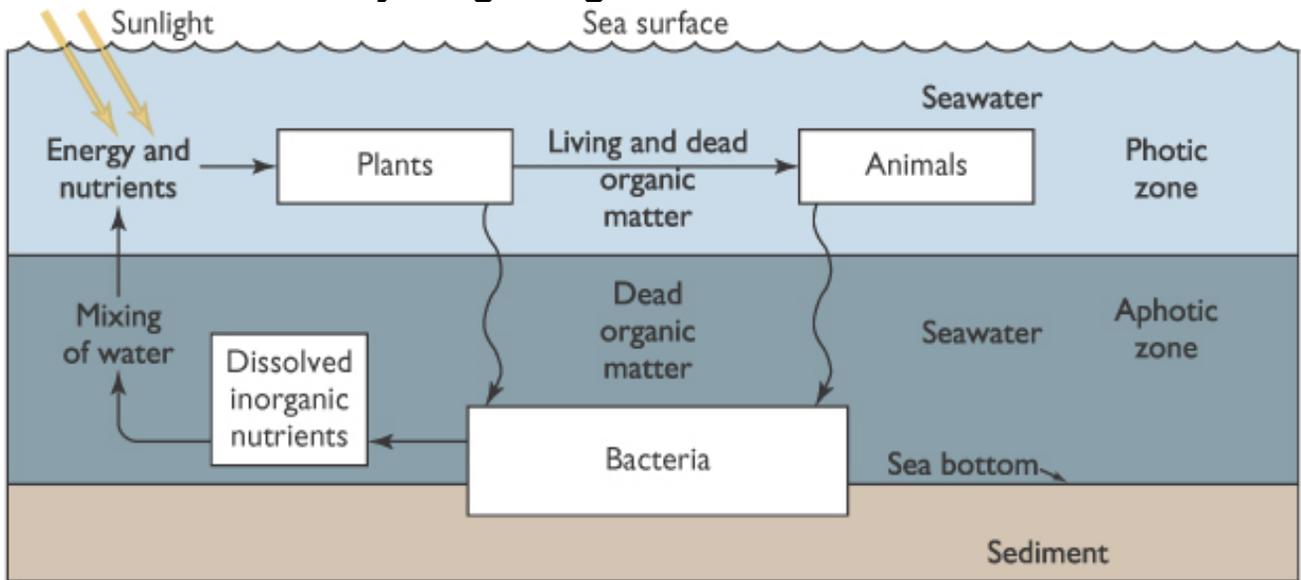
**Corange Line**

**Cotidal Line**

**Amphidromic point**

Figure 3a

## Draw Nutrient Cycling Diagram



(a) NUTRIENT CYCLING

## Tropics and Subtropics

Sunlight is abundant, but it generates a strong thermocline that restricts upwelling of nutrients and results in lower productivity

High productivity locally can occur in areas of coastal upwelling, in the tropical waters between the gyres and at coral reefs.

## Temperate regions

In temperate regions productivity is distinctly seasonal

In winter, the water column is isothermal and mixes easily, nutrients are abundant at the surface, but limited sunlight restricts productivity

In spring, sunlight becomes more abundant and there is a diatom bloom.

By summer, productivity declines as:

1. A thermocline develops and prevents vertical mixing and re-supply of nutrients.
2. Usage depletes the nutrients in the surface water.
3. Grazing by herbivores greatly reduces the population of phytoplankton.

In the fall, productivity initially increases as the water becomes isothermal and nutrients again become abundant, but then declines because the amount of sunlight decreases.

## Polar regions

Polar waters are nutrient-rich all year but productivity is only high in the summer when light is abundant.

Figure 3b

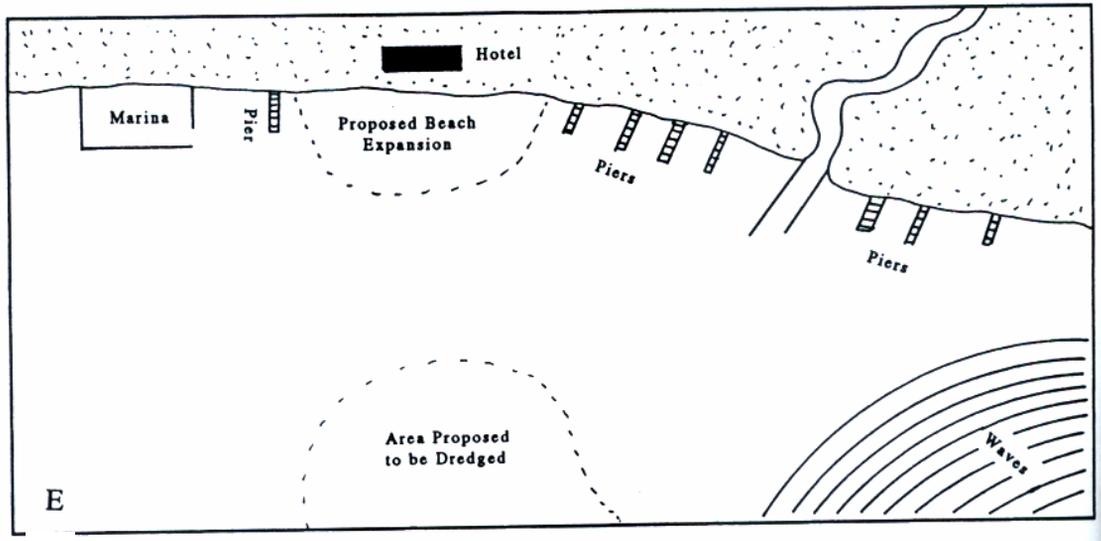
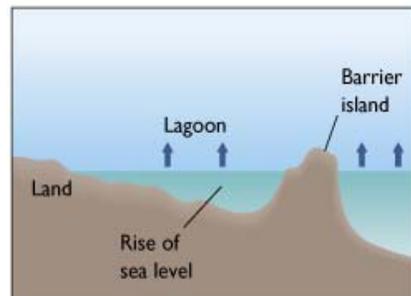
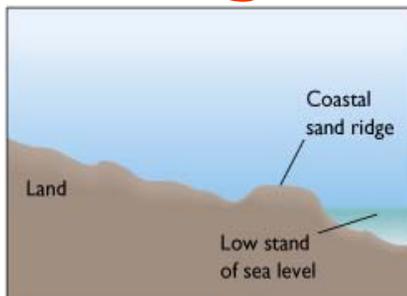


Figure 4

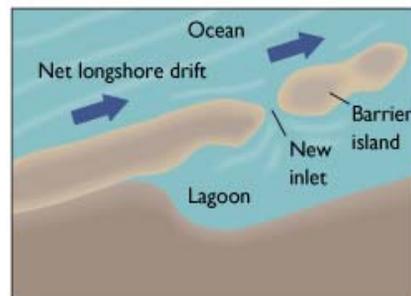
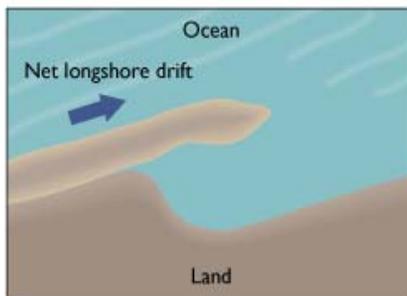
## Origin of Barrier Islands

1)



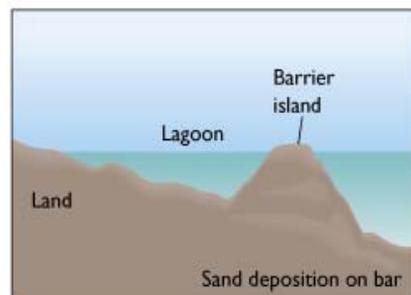
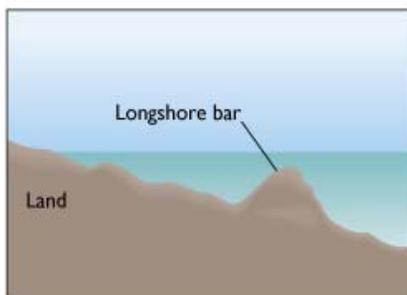
(a) SUBMERGENCE OF A COASTAL SAND RIDGE

2)



(b) SEGMENTATION OF A SAND SPIT

3)



(c) EMERGENCE OF A LONGSHORE BAR

# Inter-tidal Seas

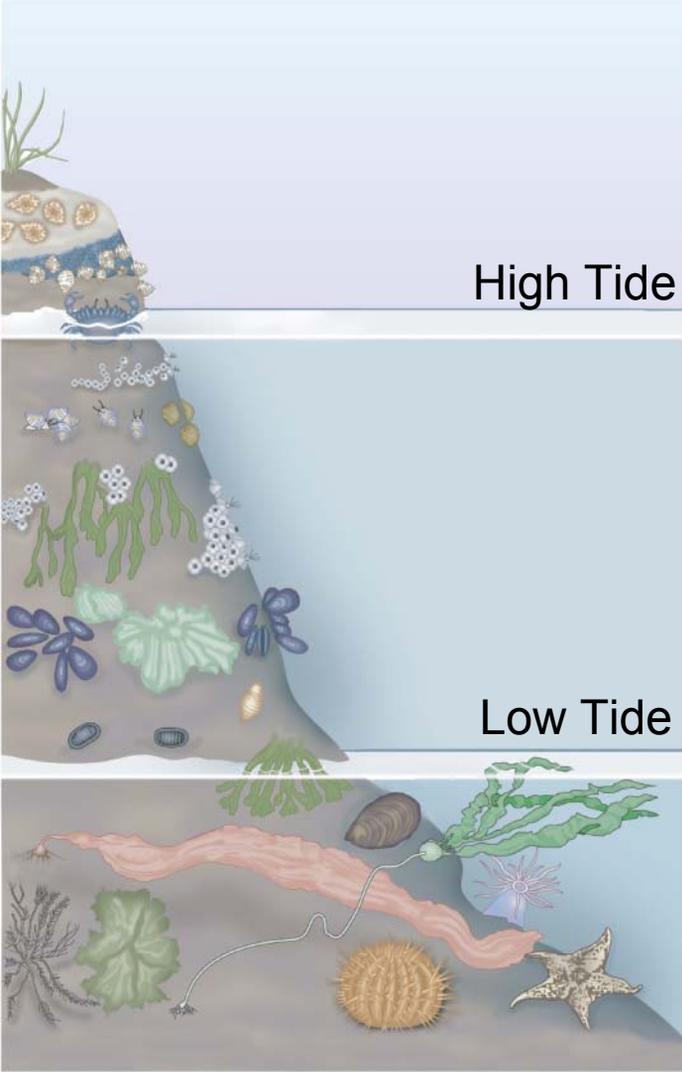


Figure 5