

**AP<sup>®</sup> ENVIRONMENTAL SCIENCE  
2010 SCORING GUIDELINES**

**Question 4**

- (a) **Based on the rate cited above, calculate the expected increase in sea level, in meters, during the next 50 years.**

One point can be earned for the correct setup, and 1 point can be earned for the correct answer.

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} = 150 \text{ mm} = 0.15 \text{ m}$$

OR

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} \times \frac{1 \text{ m}}{1,000 \text{ mm}} = 0.15 \text{ m}$$

- (b) **Identify TWO phenomena that result from an increase in global mean atmospheric temperature and that contribute to increases in sea level. For each phenomenon that you identify, explain how it causes sea level to increase.**

One point can be earned for each identification, and 1 point can be earned for each explanation. Only the first two answers will be considered.

<b>Phenomenon</b>	<b>Explanation</b>
Melting of glaciers, continental ice caps ( <i>"Ice caps" or "polar ice caps" are NOT acceptable answers by themselves.</i> )	As ice melts, the amount of water in the ocean increases.
Melting of ice sheets (Greenland and Antarctica)	As ice melts, the amount of water in the ocean increases.
Thermal expansion of the ocean	As water warms, water molecules move farther apart and the volume of the ocean increases.
Melting of Antarctic ice shelves	Ice shelves are attached to continental ice and do not displace liquid water; if they break off, they will displace water and raise sea level.

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**Question 4 (continued)**

**(c) Describe TWO environmental impacts that increasing sea level will have on an estuarine ecosystem such as those in the Mississippi Delta, Chesapeake Bay, and San Francisco Bay.**

One point can be earned for each description of an environmental impact. Only the first two impacts are considered.

<b>Impact</b>	<b>Description</b>
Loss/flooding/erosion of estuary habitat (conversion to open water)	<ul style="list-style-type: none"> <li>• Loss of wetlands, marshes, salt marshes, intertidal zone, riparian zone, mangroves.</li> <li>• May lead to changes in water depth, light levels and temperature, causing migration or local extinction of species that have specific requirements.</li> <li>• Inland migration of wetlands.</li> <li>• May lead to loss of species (fish, shellfish, birds) that rely on estuary as a nursery/breeding area. *</li> <li>• May lead to loss of species that rely on estuary for protection from predators.</li> <li>• May lead to loss of migratory species (birds) that rely on estuary as a stopover.</li> </ul>
Increased nutrient loads in the water	Estuaries filter out excess nutrients; without them, eutrophication may lead to algal blooms.
Increased storm destruction of areas adjacent to the estuary	<ul style="list-style-type: none"> <li>• Estuaries absorb excess water, reducing flooding.</li> <li>• Estuaries provide a physical barrier that protects the area from storm surges, preventing erosion.</li> <li>• Increased erosion of coastline leads to habitat loss.</li> </ul>
Change in salinity	<ul style="list-style-type: none"> <li>• Salinity may increase.</li> <li>• May lead to loss of species that have a small salinity-tolerance range.</li> </ul>
Waterlogged soils due to flooding	Loss of marsh plant species.

*\*Student response should show understanding of estuarine ecosystem.*

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**Question 4 (continued)**

Impact	Description
Spreading of oil spills that occur in ocean to inland areas	<ul style="list-style-type: none"> <li>• Oil may coat birds' feathers, reducing insulation and ability to fly.</li> <li>• Oil may coat mammals' coats; animals may ingest the oil during cleaning and die.</li> <li>• Oil may cause suffocation (organisms unable to perform gas exchange).</li> </ul>

**(d) Although sea level has been rising for over a century, human populations in coastal areas have increased dramatically during this period.**

**(i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.**

One point can be earned: only the first negative economic impact stated will be considered.

Impact	Description
Damage to private property	<ul style="list-style-type: none"> <li>• Cost of replacement, relocation, or improved construction to reduce storm damage.</li> <li>• Increased insurance premiums.</li> <li>• Decrease in property values (unable to sell).</li> </ul>
Loss of income/livelihood	<ul style="list-style-type: none"> <li>• Loss of commercial fishing.</li> <li>• Loss of income-producing agricultural lands.</li> <li>• Loss of tourism dollars.</li> </ul>
Loss of food supply	People who rely on fishing or agriculture in coastal areas will need to buy food.
Saltwater intrusion	Water supplies for drinking and irrigation may require expensive desalination treatment.

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### Question 4 (continued)

(ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

One point can be earned for each description; only the first two strategies will be considered.

- Raise premiums or refuse to insure in areas that repeatedly flood/are damaged by storms
- Raise property taxes in coastal areas
- Education campaigns, PSAs, advertising that discourage movement to the coast or encourage movement away from the coast
- Offer incentives to relocate inland, such as jobs, schools, reduced property taxes
- Designate the area as a preserve/reserve making it illegal to build
- Impose stricter penalties for infringements of regulations designed to protect the coastline
- Zone to restrict building in coastal areas, limit distance to coast
- Designate the beach as public property
- Remove or ban human structures designed to stabilize shoreline (seawalls, bulkheads)
- Ban the practice of beach nourishment
- Pass rolling easements in which property owners agree to abandon buildings when their properties become flooded
- Impose a tax to support beach-area protection
- Prevent the building of infrastructure/services (roads, power lines, water lines) that service coastal areas

4. Scientific evidence shows a direct relationship between sea level and the global mean atmospheric temperature at Earth's surface. Increases in the global mean atmospheric temperature during the past century have been accompanied by a gradual increase in sea level; currently the average rate of increase in sea level is 3.0 mm/yr. Additional increases in sea level are expected during the next century as global mean atmospheric temperatures continue to rise. These increases in sea level will affect coastal ecosystems as well as human activity along coastal margins.

- (a) Based on the rate cited above, calculate the expected increase in sea level, in meters, during the next 50 years.
- (b) Identify TWO phenomena that result from an increase in global mean atmospheric temperature and that contribute to increases in sea level. For each phenomenon that you identify, explain how it causes sea level to increase.
- (c) Describe TWO environmental impacts that increasing sea level will have on an estuarine ecosystem such as those in the Mississippi Delta, Chesapeake Bay, and San Francisco Bay.
- (d) Although sea level has been rising for over a century, human populations in coastal areas have increased dramatically during this period.
  - (i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.
  - (ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

a) 
$$\frac{(3.0 \text{ mm/yr})(50 \text{ years})}{(1,000 \text{ mm in a meter})} = \boxed{.150 \text{ m increase}}$$

b) Two phenomena that result in an increase of sea level from an increase in global atmosphere temperature is thermal expansion of the oceans, and the melting of land based glaciers. Thermal expansion occurs because as things get warmer they expand, and as the atmosphere gets warmer so does the oceans, which expand based on the thermal expansion coefficient of water. The melting of land based glaciers, such as Greenland contributes to a rise in sea level because as it gets warmer, more ice

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melts and flows into the sea, thus increasing the amount of water in the ocean.

c) ~~Two things that will result from a~~  
Two impacts that an increasing sea level will have on an estuarine ecosystem would be to increase the salinity levels further in as more ~~fresh~~ salt water mixes with the freshwater, which could cause some habitats to become unsuitable for various forms of life. Another effect would be to raise the level of the water, thus flooding once dry areas that may have been used as homes or resting grounds for various species.

d) A negative economic impact rising sea levels will have along the coast line would be to flood large areas of ~~land~~ land used for both real estate and commercial uses.

vi) The government could limit the amount of new development along the coast line, and could also offer incentives to live away from the coast, such as tax breaks or cheaper land than what can be found along the coast.

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  - (i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.
  - (ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

a.  $50 \times 3.0 \text{ mm/yr} = 150 \text{ mm}$  ~~mm~~  $\left(\frac{150 \text{ mm}}{1}\right) \left(\frac{1 \text{ m}}{1000 \text{ mm}}\right) = .150 \text{ m}$  ~~m~~  
 khdbdcm

b. One phenomena caused by increased temperature is glaciers melting, which raises sea level because the melted water is being added to the ocean. Another is increased evaporation, which would lead to sea level rising because more water being evaporated would cause more rain which would add water to the ocean.

c. Rising sea level will impact ~~the~~ estuarine ecosystems by making them farther inland as coastal areas flood. It could also add more toxins from coastal areas as they are flooded.

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do i. People who live on the coast will be impacted economically because they will need to move from ~~their~~ their homes when they are flooded, so they will need to pay for a new house as well as pay to move all of their belongings.

ii. Governments could discourage people from moving to coastal areas by charging them extra money in taxes to live on the coast. They could also build more businesses and jobs inland to provide an incentive to move away from the coastline.

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  - (ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

a) 
$$\begin{array}{r} 50 \text{ years} \\ \times 3.0 \text{ mm/yr} \\ \hline 150 \text{ mm} \end{array} \xrightarrow{\text{50}} 2.4 \text{ m/50 years}$$

b) 1) When global mean atmospheric temperatures rise it causes glaciers and ice caps to melt. When they melt the water enters oceans, increasing sea levels.

2) Increases in temperature increase annual precipitation and climate events such as hurricanes. The increase in precipitation results in increase in sea level because more H<sub>2</sub>O is entering the ocean than usual.

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c) i) Rising sea levels will cause the level of salinity in estuaries to increase because there is more salt water (ocean water) entering.

2) The increase in salinity will result in a decrease in aquatic life due to the abnormal amount of salt in the water. Organisms will ~~be~~ <sup>not be</sup> able to the levels of salinity and will not be able to survive.

d) i) An increase in sea level will destroy coastlines. It will lead to increased flooding. Homes, ~~and~~ buildings, ~~at~~ and streets will flood and be ruined.

ii) 1) Governments could raise taxes on homes near coast lines in order to discourage people from living here.

2) Government could create laws to regulate the development of coastlines, restricting houses from being built.

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## 2010 SCORING COMMENTARY

### Question 4

#### Overview

The intent of this question was to have students demonstrate their knowledge of the phenomena that cause sea level rise, what the impacts of sea level rise are on estuarine ecosystems, what negative economic impacts may result from sea level rise, and how governments could discourage movement of populations into coastal areas.

#### Sample: 4A

**Score: 11**

This is an excellent response. In part (a) the student correctly sets up the calculation, including the conversion factor from millimeters to meters, and calculates the correct answer, earning the maximum 2 points.

In part (b) the response earned 1 point for identifying "thermal expansion of the oceans" as a cause of sea level rise and 1 point for specifically stating that "the melting of land based glaciers" is a cause of sea level rise. The student also clearly explains that as the ocean gets warmer it expands, earning 1 point; and the response earned a second point for explaining that as land-based glaciers, such as Greenland, melt, the amount of water in the ocean increases.

The response earned both points in part (c): 1 point for explaining that salinity levels increase "further in as more salt water mixes with freshwater" and 1 point for stating that the raised level of water may flood areas that have been used as "nesting grounds for various species."

The student earned 1 point in part (d)(i) for stating that commercial areas, which are where economic activity occurs, will be flooded with rising sea levels. In part (d)(ii) the response earned 1 point for stating that "[t]he government could limit the amount of new development along the coastline" and 1 point for suggesting that the government could offer specific incentives, "such as tax breaks [*sic*]," to encourage people to live away from the coast.

#### Sample: 4B

**Score: 8**

This response earned points in all sections. In part (a) the student correctly sets up the equation, earning 1 point, and shows the conversion from millimeters to meters to arrive at the correct answer, 0.15m, earning 1 point.

In part (b) the student earned 1 point for a description of glaciers melting and 1 point for saying that "melted water is ... added to the ocean." A stronger response would have described how only the melting of continental ice contributes to the rise in sea level; however, this answer still earned full credit. The second phenomenon given, increased evaporation, did not earn any points because it is not a cause of sea level rise.

The response earned 1 point in part (c) for stating that estuary ecosystems move "farther inland" as they flood (wetland migration); however, the second answer did not earn credit because the term "toxins" implies human activity.

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### Question 4 (continued)

In part (d)(i) the student clearly describes an economic impact — that people on the coast “will need to pay for a new house” and new belongings if their house floods — and earned 1 point. The response earned 1 point in part (d)(ii) for describing how governments can charge extra taxes if people live on the coast and 1 point for stating that governments can “build more businesses and jobs inland to provide an incentive to move away from the coastline.”

#### **Sample: 4C**

#### **Score: 6**

The response earned points in every section; however, the answers were often too general to earn full credit. In part (a) 1 point was earned for correct setup of the calculation. The student incorrectly converts millimeters to meters in a way that demonstrates inadequate knowledge of the metric system.

The response earned 1 point in part (b) for stating that rising temperatures cause glaciers to melt and 1 point for stating that the water enters the oceans. A clearer answer would not have connected glaciers with ice caps or would have more specifically described the location of the ice caps described in the answer. The second phenomenon cited, that an increase in precipitation and hurricanes will cause a rise in sea level, is incorrect and did not earn credit.

The student states clearly in part (c) that “[r]ising sea levels will cause the level of salinity ... to increase” as more saltwater from the ocean enters the estuary, earning 1 point.

In part (d)(i) the answer given, “[h]omes, building[s], and streets will flood and be ruined,” is not linked directly to an economic impact and did not earn points. The response in part (d)(ii) is succinct, stating that governments “could raise taxes on homes near coast lines,” earning 1 point; and the suggestion that “[g]overnment could create laws to regulate the development of coast lines, restricting house[s] from being built,” earned 1 point.