2020 Camas Invite Water Quality

Answer Key

This test is fairly long, so be efficient with your time (I would suggest having each person start from opposite ends of the test to ensure complete coverage). It will be helpful to have a scientific calculator (non-graphing) for a few problems, but answers will not require significant figures. Please round answers as requested in each question. Show work the best you can for any math questions by writing out key equations used.

For subscripts and superscripts, denote with "_" and "^" respectively. Example: if you want to write CO_3^{2-} write CO_3^(2-).

Notes from the Test Writer/Grader:

- In addition to answers, I provided some common mistakes made by students
- In the coral reef species identification, I was a little lenient with answers even though I specified in the question to use the name provided in the Water Quality Rules
    - Example: humpback grouper instead of barramundi cod, all the different kinds of parrot fish etc.
    - Please answer questions as asked, especially since the names all came directly out of the rules and should have been the most likely answer.
- I also noticed that many students who correctly answered the math questions didn't show work which resulted in a substantial loss of points for work that they had already done. I clearly stated at the beginning of the test that work was necessary. In the future, remember that it is beneficial to read the instructions at the beginning of a test.
- There were also many students who incorrectly answered the math questions and didn't show work. Had they shown work, partial credit may have been earned.

Disclaimer: Many of the questions on this test have several correct answers, so you may have noticed you received points for an answer not specifically listed in the answer key

Properties of Water:

Explain following properties of water and their importance to life on Earth. (2 pts each)
Many students correctly identified how the property of water affected life, but didn't describe what the property of water meant.

1. Large heat capacity

Means that a lot of heat is required to raise the temperature of water (1). Temperatures don't change as drastically as they could, climate is more stable, more time for life to adjust to different temperatures, ex. Temperature of water doesn't change much from day to night (1 pt for reason similar to this)

2. Large heat of vaporization

Means that a lot of heat is required to evaporate water (1). The reason why sweating works, when sweat evaporates, it takes a lot of excess heat with it (temperature regulation for some animals) (1)

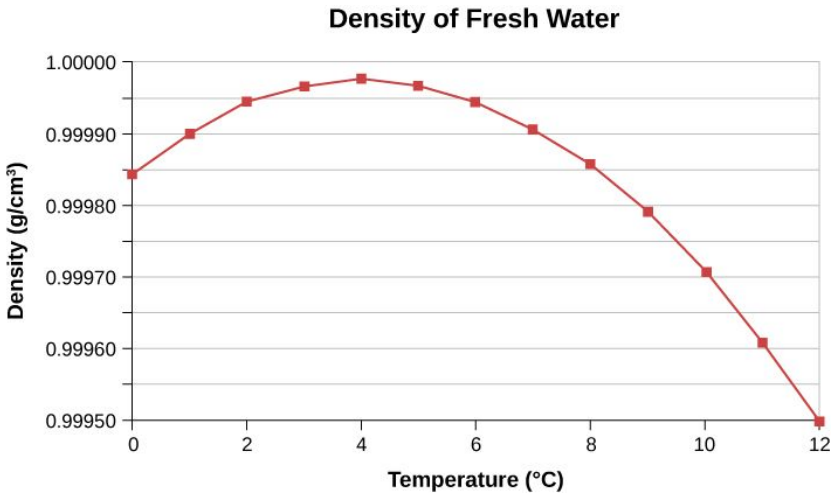
3. Hydrogen bonding

Dipole dipole attraction between hydrogen atom covalently bonded to an electronegative atom and some other electronegative atom (ex. H in H_2O with O in a different H_2O), allows for cohesion and adhesion, the reason for surface tension, allows for fluid transport in plants (capillary action), also for DNA and protein structure, other answers included that it's the reason for the differences in density of ice and water (creates the lattice structure in ice)

4. Polar (i.e. good solvent)

Since water can dissolve a lot of polar and ionic molecules (1), it can carry a lot of nutrients through the water cycle to different locations (spreads nutrients so life can exist in many different places) (1)

Use the following graph to answer questions 5-8:



5. At what temperature (to the nearest degree C) is the density of freshwater the largest? (1)

4 degrees Celsius

6. For temperatures above this maximum, _____ water rises and _____ water descends (1)

a. Warm, cool
b. Cool, warm

7. For temperatures below this maximum, _____ water rises and _____ water descends (1)

a. Warm, cool
b. Cool, warm

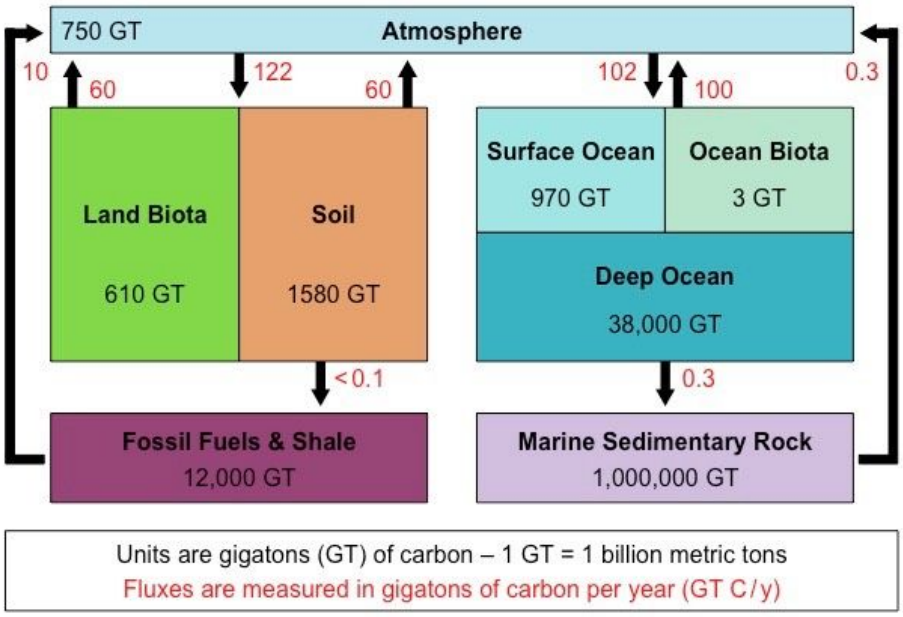
8. What two implications does this property of water have on the formation of ice? How did these impact life on Earth? (3)
1. Ice forms starting at the top of a body of water (1) (This was definitely the harder one to figure out, but equally important)
2. Ice floats (1)
This allows life to persist in regions where water freezes every year. If ice started forming at the bottom of a lake or didn't float, the entire body of water would end up freezing and wouldn't leave a layer of water underneath for life (1)

Nutrient Cycling:

9. Of the following options, which is the largest carbon reservoir? (1)
   a. Atmosphere
   b. Vegetation
   c. Soils and Detritus
   d. Surface ocean
   e. Deep ocean

10. What percent of the atmosphere is carbon dioxide? (1)
   a. 40%
   b. 4%
   c. 0.4%
   d. 0.04%
   e. 0.004%

Use the following diagram of carbon reservoirs and annual fluxes to answer questions 11-15:



Note: the arrow on the far left represents fossil fuel burning by humans, the arrow on the far right represents CO_2 emissions by volcanoes and other geologically active regions.

11. What is the largest carbon reservoir in this diagram? (1)
Marine Sedimentary Rock

12. Compared to human emissions of CO_2 from burning fossil fuels, volcanoes and other geological sources of CO_2 emit what percent of human emissions? (2)
Volcanoes etc.: 0.3 GT/yr
Fossil fuels: 10 GT/yr
0.3/10 = 0.03 (1 for correct equation)
3% (1 for correct answer)

13. What is the net increase in GT of carbon in the atmosphere each year (nearest tenth)? (2)
Add up the fluxes entering and subtract the fluxes exiting the atmosphere:
10 + 60 + 60 + 100 + 0.3 - 122 - 102 = 6.3 (1 for correct set up)
6.3 GT/yr (1)

14. How many GT of carbon from human fossil fuel burning end up in the land per year (to the nearest GT)? (2)
Note: if we remove the human impact, interactions between the atmosphere and land are roughly equal
Add fluxes entering land and subtract fluxes exiting:
122-60-60-(a number less than 0.1) = 2 GT rounded (1 pt for correct set up)
2 GT/yr (1)

15. How many GT of carbon from human fossil fuel burning end up in the oceans per year (nearest tenth)? (2)
Note: if we remove the human impact, interactions between the atmosphere and oceans are roughly equal
Add fluxes entering and subtract fluxes exiting the oceans:
102 - 100 - 0.3 = 1.7 GT (1 pt for correct set up)
1.7 GT/yr (1)

We can check the answers to parts d and e by remembering that 6.3 is the net increase in GT of carbon for the atmosphere. Adding the answers from c, d, and e returns the value 10 GT that we started with for human impact. A lot of teams put answers greater than 10 GT for questions 13 and 14 which should have immediately not made sense.

16. What is the largest source of **accessible** nitrogen? (1)
Atmosphere (note, rocks and sediments deep in the Earth are technically the largest nitrogen reservoir, but they are too deep to be accessible)

I would like to apologize for this question. I had originally written accessible to prevent the answer written in the parenthesis above, but a couple of teams seemed to interpret it as directly accessible to plants and animals (by answering nitrite/nitrate in soil, for example) while I meant that it was readily cycled through the nitrogen cycle.

17. Define the term, limiting nutrient. (2)
The nutrient that is the most scarce meaning that it will run out first. Therefore, it will determine the maximum possible population of various organisms.

A lot of people understood the part that the limiting nutrient is scarce, but many didn't get the important aspect that it is the MOST scarce of the necessary nutrients meaning that it will be the determining factor in the size of the population.

18. Despite the large amount of nitrogen on Earth, why is nitrogen often the limiting nutrient in many ecosystems? (2)
Most nitrogen that is accessible is diatomic nitrogen in the atmosphere (1) which is relatively unreactive and metabolically unusable to most life (1)

19. What is one way human activity affects the nitrogen cycle in marine ecosystems? (2)
Fertilizer runoff adds extra nitrogen to the oceans (1) which can cause large algae blooms, and consequently, hypoxia (dead zones, eutrophication) (1).
Another example of a two point answer:
Fossil fuel combustion releases nitrogen oxides (1) and leads to acid rain which lowers the pH of water (1).

20. Unlike most of the other nutrient cycles, phosphorus doesn't have a significant presence in which 'sphere'? (1)
Atmosphere

21. What is one natural way that phosphorus can enter marine ecosystems? (1)
Dissolved in freshwater as runoff from weathered rocks, leaching, aerosols, volcanic ash (1 pt for any of the above)

Some people didn't read the "natural" part and wrote about human sources of phosphorus.

22. Phosphorus is more commonly the limiting nutrient in: (1)
    a. Freshwater ecosystems
    b. Saltwater ecosystems

Implications of Ocean Circulation and Garbage Patches:

23. Which direction do gyres rotate in the northern hemisphere? (1)
    a. Clockwise
    b. Counterclockwise
    c. It depends on the gyre

24. How does the global oceanic circulation affect garbage patches? (2)
The global oceanic circulation determines where the world's garbage patches are (1). The movement of oceanic currents in relatively circular manners in the oceans allows for the accumulation of "garbage" in the centers of gyres. (1)

25. The largest garbage patch is located in which gyre? (1)
North Pacific Gyre

26. **TB1**: Explain the difference between bioaccumulation and biomagnification in terms of microplastics found in garbage patches. (4)
Bioaccumulation is the growing abundance of a substance within an organism (1) while biomagnification is the increasing abundance of a substance moving up trophic levels due to the fact that organisms higher up eat organisms with smaller amounts of the substance at lower levels (1). In terms of microplastics in garbage patches, bioaccumulation is common in zooplankton and other filter feeders (1). Biomagnification occurs when fish then eat those filter feeders so that the concentration of microplastics is larger in the fish. This continues up the trophic levels so that the top predators end up with the most microplastics in them. (1) (The key difference is that bioaccumulation occurs at each trophic level individually while biomagnification describes the trend across trophic levels)

27. What are two negative impacts of the five ocean garbage patches on ocean life? (2)
Organisms eat plastic/other garbage thinking it's food which causes them to stop eating real food because they feel full. Lost fishing nets can "catch" organisms (ghost fishing), garbage can entangle organisms. Garbage can carry organisms from different regions to new places which can be detrimental to the native population (1 pt each for any of the above, max 2)

Estuaries:

The Mississippi River watershed drains nearly 3 million square kilometers of North America and is both ecologically and economically important. The estuary at the mouth of the river hosts a wide diversity of different ecosystems as well as several large cities.

28. **TB4**: What is the term for plants and animals that can tolerate both saltwater and freshwater? (1)
Euryhaline

29. Given that the Mississippi River is large and has a high volumetric flow rate, what would its estuary be classified by water circulation? (2)
salt wedge or highly stratified (2 pts for either answer)

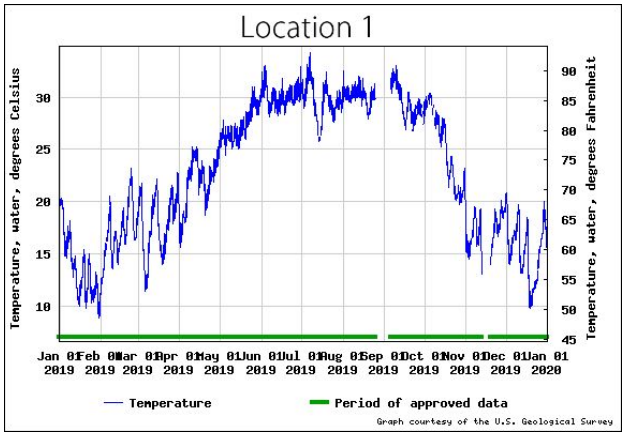
30. What is one consequence of the above to life in the estuary? (1)
Organisms either need to be tolerant of two very different salinities or live in regions that are completely within one region or the other. A different answer could be that the stratification can be a natural cause of hypoxia since the different density waters don't mix as well. (1 pt for either answer above or a different valid answer)

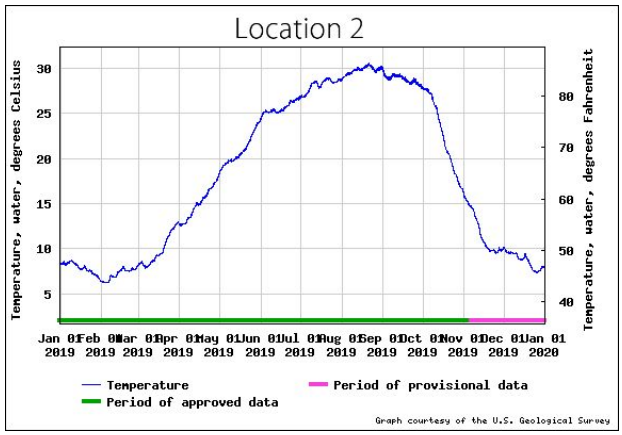
31. Name two ecosystem services provided by this estuary. (2)
Natural filtration of water (this is probably the biggest one) examples include excess nutrients, heavy metals, herbicides, pesticides, buffer zone, protection from storms, flooding, erosion (1 pt each for any of the above, max 2)

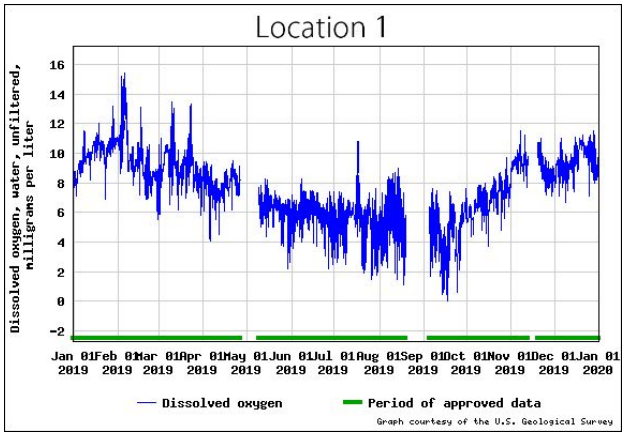
32. Given that the OH- concentration in the estuary is 1.5E-6, calculate the pH of the estuary. (round to the nearest tenth) (2)
pOH = -log(1.5E-6) = 5.8, pH = 14 - pOH, pH = 14 - 5.8 = 8.2 (1 pt for correct equations used, 1 pt for correct answer)

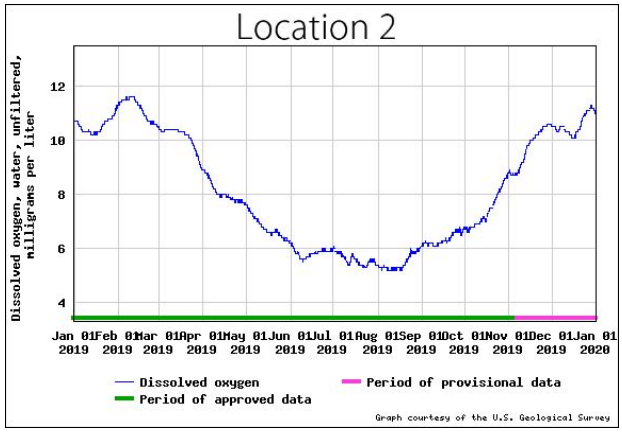
Several teams missed out on a free point by not showing their work.

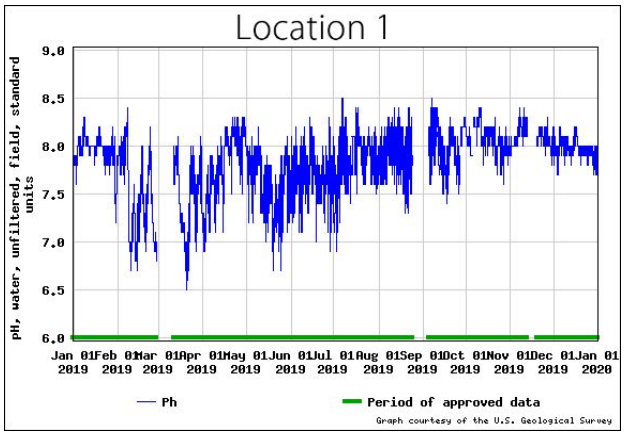
The following graphs are of two different locations around the estuary: Use them to help answer questions 33-36

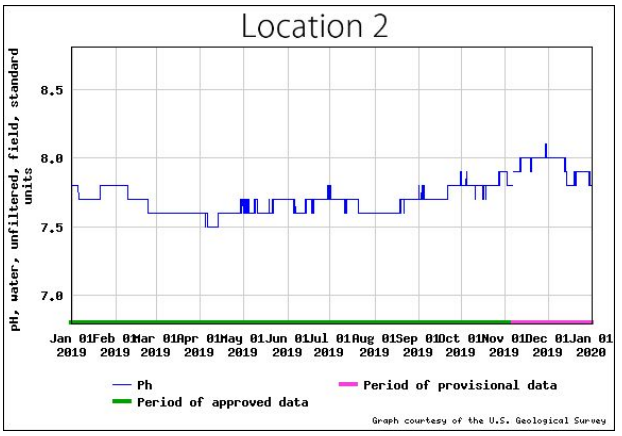


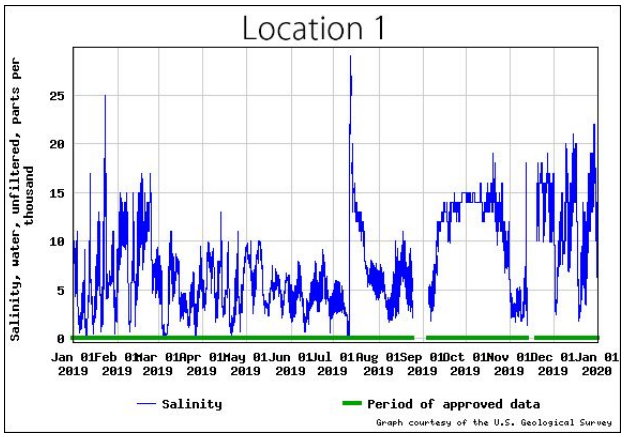


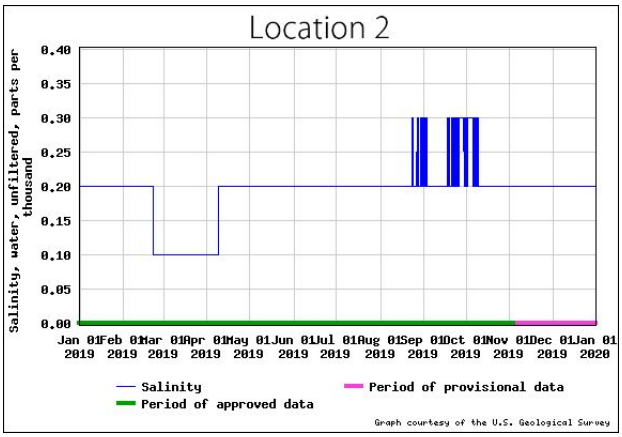

Location 1
Dissolved oxygen, water, unfiltered, milligrams per liter
16
14
12
10
8
6
4
2
0
-2
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Dissolved oxygen
Period of approved data
Graph courtesy of the U.S. Geological Survey

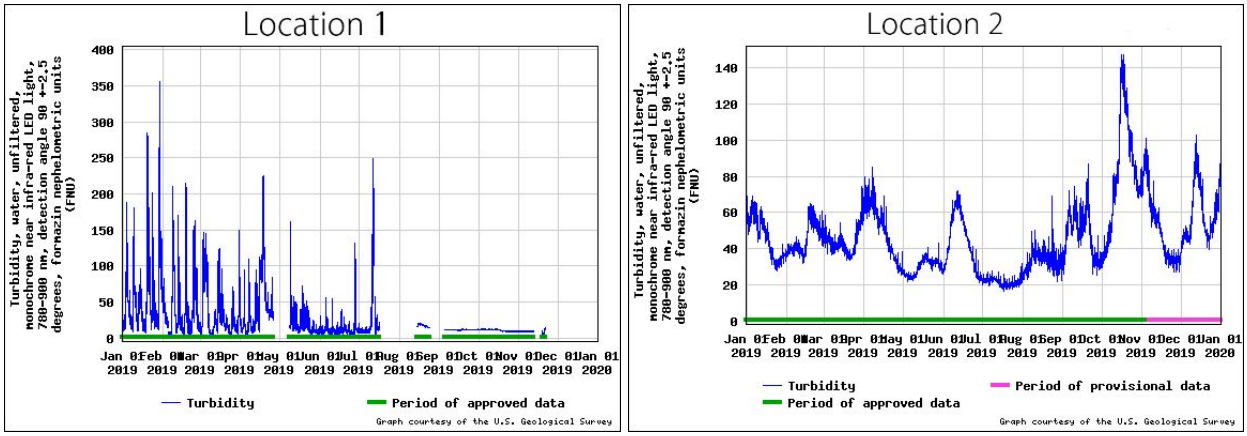

Location 2
Dissolved oxygen, water, unfiltered, milligrams per liter
12
10
8
6
4
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Dissolved oxygen
Period of provisional data
Period of approved data
Graph courtesy of the U.S. Geological Survey


Location 1
pH, water, unfiltered, field, standard units
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Ph
Period of approved data
Graph courtesy of the U.S. Geological Survey


Location 2
pH, water, unfiltered, field, standard units
8.5
8.0
7.5
7.0
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Ph
Period of provisional data
Period of approved data
Graph courtesy of the U.S. Geological Survey


Location 1
Salinity, water, unfiltered, parts per thousand
25
20
15
10
5
0
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Salinity
Period of approved data
Graph courtesy of the U.S. Geological Survey


Location 2
Salinity, water, unfiltered, parts per thousand
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan 01 2019
Feb 01 2019
Mar 01 2019
Apr 01 2019
May 01 2019
Jun 01 2019
Jul 01 2019
Aug 01 2019
Sep 01 2019
Oct 01 2019
Nov 01 2019
Dec 01 2019
Jan 01 2020
Salinity
Period of provisional data
Period of approved data
Graph courtesy of the U.S. Geological Survey



33. Judging from the graphs, which location is closer to the mouth of the estuary? Explain using the graphs. (2)

Location 1 (1)

Higher salinity is the main reason, pH closer to that of seawater could also be a reason, though the Mississippi does have a relatively high pH as well in the region. (1 pt for a reason)

34. What is one possible cause of the unusually high turbidity at location 1 near the beginning of the year? (1)

Lots of rain or runoff, perhaps some industrial activity occurred like dredging, mining, oil drilling, logging, fertilizer runoff, sedimentation pollution etc. (1 pt for any of these)

35. Using the graphs, explain the relationship between temperature and dissolved oxygen. How does this explain the yearly changes of the two? (3)

Higher temperatures correlate to low dissolved oxygen in the graphs (1), increasing the temperature of water decreases its ability to hold oxygen (1), water temperatures are highest in late summer/early fall which means that dissolved oxygen levels are lowest in late summer/early fall (1)

36. Which is more likely to be near a wastewater treatment plant? Explain using the graphs. (2)

Location 1 (1)

Larger range in DO/ overall lower DO (look carefully at the scales of the two graphs), higher turbidity/larger variation in turbidity (1)

Note: Even though waste treatment plants do reduce the turbidity of the water they treat, the ending result typically still has a higher turbidity than the water it is dumping into. Just the fact that a large volume of water is being released into the stream can be enough to stir up the sediment already in the stream which increases turbidity.

37. Explain what happens in primary, secondary, and tertiary treatment of wastewater. (3)

Primary treatment: removes physical contaminants by settling sludge secondary treatment: removes biological contaminants tertiary treatment: can include filtration, nitrogen/phosphorus removal, or disinfection by UV or chlorination (1 pt for each stage)

One of the largest dead zones exists just beyond the mouth of the Mississippi River. A major cause of this dead zone is harmful algae blooms.

38. Explain how harmful algae blooms can cause dead zones. (2)
When algae die, the bacteria that decompose them use up oxygen in the water which can result in hypoxia (1). This depletion in oxygen can kill fish and other organisms in the water which results in “dead zones” without very much life. (1)
Another acceptable answer could be that the algae block sunlight from reaching lower depths which prevents photosynthesis among plants lower down, though the primary cause is listed above.

I was fairly lenient with this question, though there was a common misconception that I would like to clear up:
Many teams wrote something along the lines of “the algae use up the oxygen so there isn’t enough for other marine life,” which should sound a little odd immediately because algae are photosynthetic organisms (they might use some oxygen for cellular respiration, but they also produce oxygen through photosynthesis). What really depletes the oxygen is when the algae die, they fall to the sea floor where bacteria decompose them. The excessive growth of this bacteria uses a lot of oxygen which greatly decreases the oxygen level near the sea floor (That’s why the dead zone is at the bottom of lakes, oceans etc. If it was because of the algae, the dead zone would be near the surface of the body of water).

39. What is a possible cause of these algae blooms in the context of this estuary? (1)
Excess nitrogen and phosphorus from fertilizer runoff into the Mississippi

40. Below what dissolved oxygen concentration in mg/L is water considered hypoxic? (1)
2 mg/L

41. How will rising sea temperatures affect the size of this dead zone? (2)
Increase (1), because warmer water can’t hold as much O2 as colder water (1).

42. How would an increase in the frequency, length and size of this dead zone affect the economy of the region? (2)
The dead zone would greatly affect fishing, recreation, and tourism since there would be large die offs of organisms that have no method of leaving the region when the dead zone appears. (2 for mentioning a relevant effect)

Marine Ecology Case Study: The Deep Ocean

The deep ocean is one of the last relatively unexplored regions on Earth. While originally thought to be mostly devoid of life due to the lack of sunlight, and extreme pressure and temperatures, the deep ocean hosts a surprising amount of biodiversity and complex communities.

43. Aside from hydrothermal vents, what are the two other major sources of nutrients and energy for deep ocean communities? (2)
Whale falls (1), marine snow (1)

I was actually surprised that many people got this one right, but I assume it's crossover knowledge from Oceanography.

44. Due to the scarcity of nutrients and energy in the deep ocean, most organisms are: (1)
    a. Producers
    b. Herbivores
    c. Predators
    d. Scavengers

45. Due to the lack of light, many bacteria near hydrothermal vents have developed a different method to generate usable energy called chemosynthesis. The following **unbalanced** equation is an example of one such reaction:
$H_2S + CO_2 + O_2 \rightarrow C_6H_{12}O_6 + H_2O + S$
Balance the equation and determine how many moles of H_2S would be required to create 4 mol of glucose assuming H_2S is the limiting factor. (3)

$14\mathbf{H_2S} + 6CO_2 + \mathbf{O_2} \rightarrow C_6\mathbf{H_{12}}O_6 + 8\mathbf{H_2O} + 14\mathbf{S}$
Need 14 moles of H2S for every mole of glucose, so 14*4 moles of glucose equals 56 moles of H2S

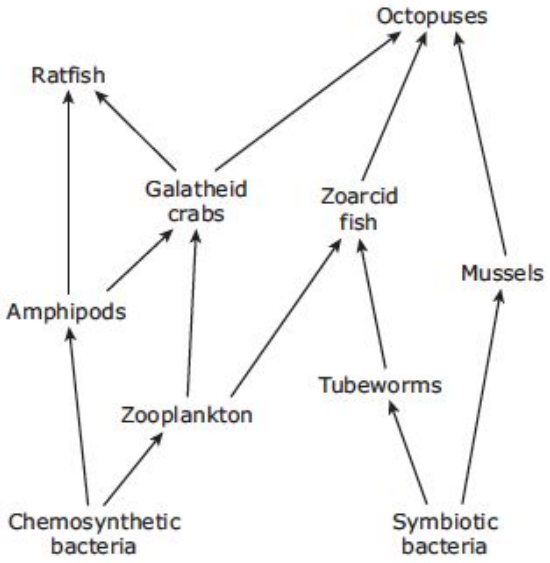
Checking the equation:
Hydrogen:
Left side: 14*2 = 28 Right side: 12 + 8*2 = 28
Sulfur:
Left side: 14 Right side: 14
Carbon:
Left side: 6 Right side: 6
Oxygen:
Left side: 6*2 + 2 = 14 Right side: 6 + 8 = 14

I only accepted the most reduced balanced equation for consistency. I did notice that Wikipedia has a less reduced version of this equation, but as much as I usually love Wikipedia, I could not figure out where their equation came from, so I will stay with this result.

46. The relationship that giant tube worms have with chemosynthetic bacteria is MOST similar to which of the following? (1)

a. Anemone and clownfish
b. Banded coral shrimp and most fish
c. Coral polyps and zooxanthellae
d. Sharks and remora

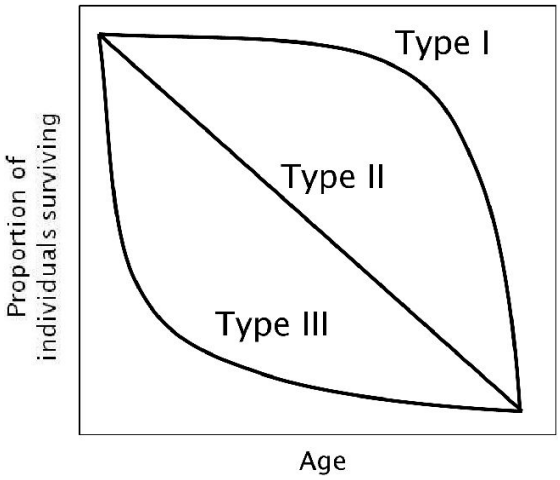
The following is a simple food web of a hydrothermal vent community:



47. Identify one secondary consumer in the food web above. (1)
Galatheid crabs, zoarcid fish (only need to name one of these for the point)
(These organisms are two arrows above the bottom)

48. How would a sudden decrease in the population of octopuses affect the rest of the food web? (2)
There would be an increase in the population of the octopuses' prey, in this case galatheid crabs, zoarcid fish, and mussels. This in turn would result in a decrease in the prey of those organisms (zooplankton, tubeworms, amphipods). There could also be an increase in the number of ratfish since they would have less competition for prey.

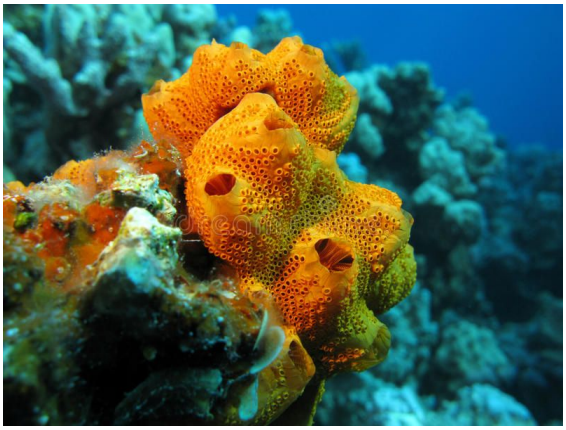
49. Judging by the survivorship curves shown below, the large majority of the organisms in food web should be classified as: (1)



a. Type I
b. Type II
c. Type III

Coral Reef Organism Identification and Ecology:

Identify the common name of the following organisms and explain their role in a coral reef: (2 pts each, 1 for common name, 1 for correct role)
Please use the common name listed in the Water Quality Rules

50. 

Sponge (1)
Filter water, process various nutrients like carbon, nitrogen, phosphorus helping to drive productivity, acts as a buffer to changes in the environment (1)

51. 

Gorgonia (1)

A type of soft coral that is food for some organisms and provides shelter for others. (1)

52. 

Barramundi cod (1)

An lone ambush predator that feeds on small fish and crustaceans (1)

53. 

Parrotfish (1)

Eat algae off of coral, create new surfaces for coral to grow on, break down coral bits to make sand (contribute to bioerosion) (1)

54. Identify the following organism: (1)

Banded Coral Shrimp (1)

55. What kind of relationship does this organism have with the fish pictured above? (1)

a. Mutualism
b. Commensalism
c. Amensalism
d. Parasitism

56. Identify the following organism: (1)

Long-spined black sea urchin (1)

57. What is this the main diet of the above organism? (1)

They eat algae covering coral

58. How would a large decrease in their population affect the health of a coral reef? (2)

There would be an increase in algae (1) in the reef which would limit coral growth (1)

Coral Reefs Ecology:

59. Identify two ways the loss of coral reefs affects humans. (2)
Loss of food source, loss of shore protection, reduced fishing/fishing nurseries, decrease in tourism, etc. (1 pt each for any of the above, 2 pts max, this is not an exhaustive list)

60. Name two conditions necessary for coral reefs. (2)
Clear water, warm temperatures, high pH, sunlight, stable environment (1 pt each, any two of the above or other correct answer)

61. Between what latitudes do most coral reefs occur? (1)
30 N and 30 S

62. Explain the process of coral bleaching (2)
Under poor conditions, coral polyps will either consume or expel zooxanthellae to ensure short term survival (this is what causes the coral to look white or "bleached") (1). However, if left for too long, the polyps will starve because the zooxanthellae provide most of their energy. (1)

63. What are two possible triggers of coral bleaching? (2)
Drastic change in water temperature (increase or decrease), low oxygen level, increase in turbidity, change in salinity, pollutants, ocean acidification, disease, exposure to air, (basically any large change in the environment) (1 pt each for any of the above, 2 pts max)

Coral Reef Case Study: The Great Barrier Reef

The Great Barrier Reef located off the northeast coast of Australia is facing an increasing problem related to the organism shown below.

64. Identify the common name of the organism. (1)
Crown of Thorns starfish

65. Is the organism above considered an invasive species to the Great Barrier Reef? (1)
   a. Yes
   b. no

The Crown of Thorns starfish is actually native to the Great Barrier Reef, though it is invasive in other regions.

66. How does an overabundance of this organism affect the Great Barrier Reef? (1)
Adults are natural predators of coral polyps, so too many can quickly decimate a coral reef, especially since they reproduce quickly

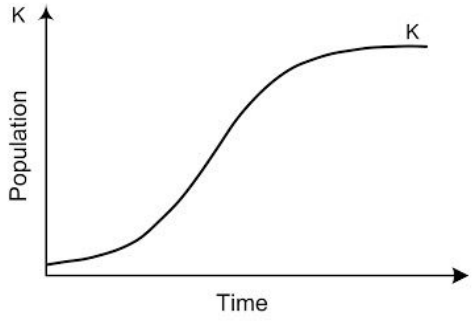
67. What are two reasons for the increasing number of outbreaks of these organisms? (2)
An increase in phytoplankton (perhaps from fertilizer runoff?) leads to a much higher survival rate for the starfish, overcollection of Tritons (a predator of the starfish), warmer temperatures enhance larvae development, overfishing of other predators of the starfish, other threats (coral bleaching, calcification, severe storms) to coral reefs weakening their resilience to starfish outbreaks (1 pt each for any of the above, 2 pts max)

68. What is the main method of dealing with an outbreak of these organisms in the Great Barrier Reef? (1)
Injecting individual starfish with poisons (accepted partial credit for manual removal)

69. Name two natural predators of the above organism from the list in Part 2. of the Water Quality Rules (2)
Triton, Humphead wrasse (1 pt each)

70. Explain the difference between an r and K selected species. Based on these descriptions, how would you classify the above organism and why? (4)
r-selected: more common in unstable environments, large number of offspring with little to no parental care, goal is that some will survive, (1)
K-selected: more common in stable environments, few offspring and a large amount of parental care, goal is that all will survive (1)
R-selected (1) because females can produce up to 50 million eggs a year which are released to fend for themselves with the hope that at least a few will survive (1 pt for something similar to this)

The following is a graph of the population of the above organism in its native region:



71. **TB 2**: What does the K represent? (1)
Carrying capacity
72. Name one density independent and one density dependent factor that could affect the population of the above organism. (2)
Density independent: temperature change, natural disasters like storms
Density dependent: availability of nutrients for larvae, availability of coral for adults, disease, number of predators
(1 pt for a correct density independent factor, 1 pt for a correct density dependent factor, not these lists are not exhaustive)

Biological Oxygen Demand:

73. Given the following reaction for the oxidation of glucose, calculate the theoretical biochemical oxygen demand in mg O_2/L for 3.0 E-3 mol glucose. (hint: the molar mass of O_2 is 32 g/mol) (3)

$$C_6H_{12}O_6+6O_2 \rightarrow 6CO_2+6H_2O$$

3.0E-3 mol glucose/L x 6 mol O_2/mol glucose x 32 g O_2/mol O_2 (1)
0.576 g O_2/L = 576 mg O_2/L (2, only 1 pt if left in g O_2/L)

74. We conducted a carbonaceous BOD test at 25°C in which 10 mL of a waste sample was diluted with water to 500 mL. Given the following, calculate the 5 day BOD in mg/L at 25°C. (round to the nearest tenth) (4)

Initial DO of diluted sample: 12.3 mg/L
Final DO of diluted sample after 5 days: 4.2 mg/L
Initial DO of seeded dilution water: 9.5 mg/L
Final DO of seeded dilution water: 6.6 mg/L

((D1 - D2) - (B1 - B2)*f)/P
where f = (500 -10)/500 = 0.98, P = 10/500 = 0.02 (1 pt for correct equation, 1 pt for correct f and P values)
((12.3 - 4.2) - (9.5 - 6.6)0.98)/0.02 = 262.9 mg/L 2 pt for correct answer

75. What does this tell us about the sample? (1)
There is definitely organic matter present since the BOD is so high

Note: this point is earned based on the calculated answer provided by the students. i.e. the point if for interpreting their calculated answer correctly. So if they got the previous answer wrong and found a low BOD, they could still earn this point by saying the BOD is low so there is probably little organic matter

76. Why do we generally calculate BOD on the fifth day? (2)
After 8-10 days nitrifying bacteria start using oxygen to convert ammonia to nitrites. Since we are only interested in calculating carbonaceous BOD, we need to stop before then. Also, technically takes an infinite time for oxidation to complete, though 99% is completed by 20 days. But 20 days is a long time to wait and by day 5 we have completed 60-70%. (1 pt for only carbonaceous BOD, 1 pt for long time to wait)

77. Why might we need to dilute the original sample? (2)
Most samples of wastewater require more oxygen than available in the BOD bottle, so dilution is necessary to obtain an actual BOD. We don't know BOD if all the oxygen is used!

78. The BOD test requires that the samples be kept in opaque bottles during the five day period. Why? (2)
We don't want the DO measured to be affected by photosynthesis (1). Without an opaque bottle, we won't know how much of the DO measured at the end was there to begin or was introduced from photosynthesis (i.e. the reason this method for measuring BOD works is because we assume the only reason for the change in DO from the start to the end is from cellular respiration) (1)

79. If we **didn't** use an opaque bottle, the calculated BOD would most likely be: (1)
    a. Higher than the actual value
    b. Lower than the actual value

This is because the DO at the end would be higher due to photosynthesis.

Salinity:

80. What is the average salinity of the ocean? (1)
    a. 0.35 ppt
    b. 3.5 ppt
    c. 35 ppt
    d. 350 ppt

What effect do each of the following have on seawater salinity? (5pts)

81. Precipitation:
    a. increase
    b. decrease

82. Runoff:
    a. increase
    b. decrease

83. icebergs melting:
    a. increase
    b. decrease

84. sea ice forming:
    a. increase
    b. decrease

85. Evaporation:
    a. increase
    b. decrease

Aragonite Saturation:

86. Why is it important for us to measure aragonite saturation? (2)
Coral calcification, Aragonite is produced by most mollusks and coral (1), so the higher the aragonite concentration, the more likely we'll find coral! (1)

87. **TB3**: How does the addition of CO2 to the atmosphere affect aragonite saturation in the oceans? Therefore, how is aragonite saturation related to pH? (2)
More CO2 means lower aragonite saturation (1). Similarly, more CO2 will lead to ocean acidification and result in lower pH. Both aragonite saturation and pH decrease with the addition of CO2 (1)

88. Given the precipitation dissolution reaction for aragonite, calculate the aragonite saturation state given K_{sp} of aragonite = 6.0E-9 at 25 degrees C, and the concentration of Ca^{2+} = 1.0E-4 M. (3)

$$Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3$$

($[Ca^{2+}] \times [CO_3^{2-}]$) / ($K_{sp}$ of aragonite) = Ω (saturation state of aragonite) 1 pt for equation
Since concentration of Ca^{2+} is 1.0E-4 M, the concentration of CO_3^{2-} is also 1.0E-4 since the molar ratio is 1:1 (1 pt)
(1.0E-4 x 1.0E-4)/6.0E-9 = 1.67 (1 pt for correct answer)

89. Is aragonite dissolving or precipitating in question 88? (1)
    a. Dissolving
    b. Precipitating

Precipitating because omega is greater than 1

90. What would happen to the above number if the CO2 levels in the atmosphere were to increase? Explain. (2)
Omega would decrease (1 pt) because there is relatively less CO_3^{2-} in the water (1 pt)

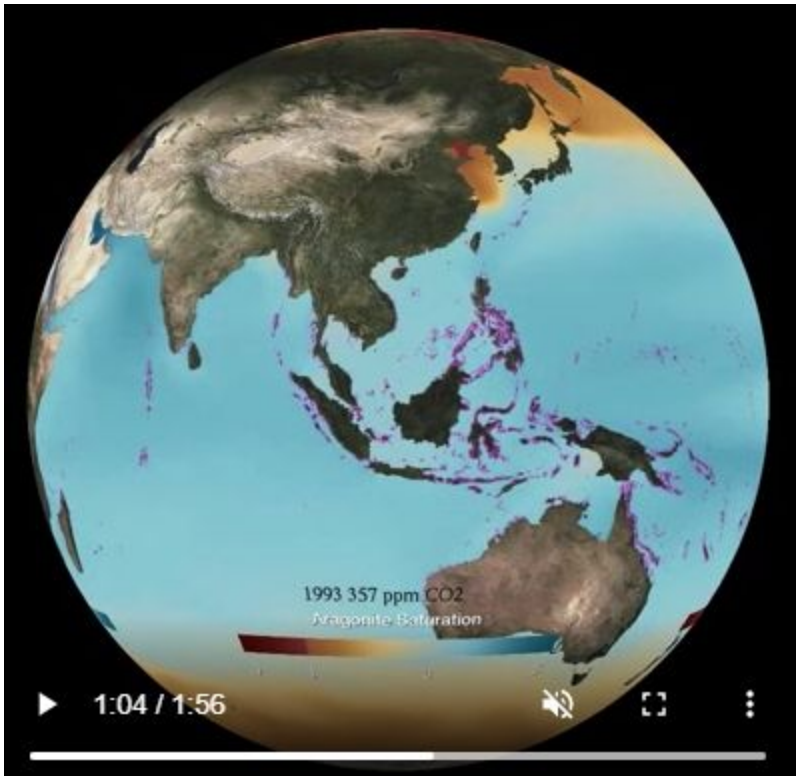
91. What would happen to the above number if the temperature of the water were to increase? Explain. (2)
Omega would increase (1) because a high temperature allows the water to become supersaturated (1)

92. Give an approximate cutoff for aragonite saturations that coral reefs can be found at. (1)
3

I noticed many teams put 4, and I'm fairly certain above 4 is ideal, but 3 is the cutoff. A couple of teams put 1 which would be the limit where coral and shells would start dissolving, but the coral would probably be dead before that happens.

93. Based on the answer to the previous question, is the aragonite saturation level found in question 88 adequate for coral reefs? (1)
no

94. Given the following simulation of aragonite saturation, explain the differences across latitude of aragonite saturation. (2)
There is higher aragonite saturation near the equator (1) because the temperature is higher which allows for supersaturation of water (1)



0 is dark red, 1 is between red and orange, 3 is between orange and blue, 6 is at the dark blue

This is a placeholder for the video in the Scilympiad version of this test.

95. According to this simulation, at around what year will most of the oceans not be able to support coral reefs? (2)

a. Around 2020-2030
b. Around 2060-2070
c. Around 2040-2050
d. Around 2090-2100