Water Quality - Division C Master Key

Boca Raton Placement Exam 2020

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Instructions and Clarifications:

- You have **50** minutes to finish this exam.
- This exam will be worth **95%** of your overall score. There will be a dry lab involving a salinometer instead of a wetlab. The dry lab will be worth **5%** of your overall score.
- Anything written on the exam will **not** be graded. Only the **answer sheet** will be graded.
- If you have any questions or comments about this exam, feel free to email me at velasco.scienceolympiad@gmail.com. **Happy testing!**

Part I: Marine and Estuary

Multiple Choice: Choose the most appropriate answer for each question below. Each question will be worth **one** point. **(30)**

1. Which of the following statements about salt marshes is correct?
    a. There is no mud in salt marshes.
    b. Peat, which is found in salt marshes, is known to have high oxygen levels.
    c. Salt marshes are not productive ecosystems.
    d. There are two main regions of salt marshes: high marsh and low marsh.
    e. All of the above
    f. None of the above

2. Which of the following statements about mangroves is correct?
    a. Mangroves are not found in subtropical latitudes.
    b. Mangrove ecosystems are very productive and connects the land and sea.
    c. The water near mangrove ecosystems is rich in oxygen.
    d. The global mangrove carbon storage is 68 million metric tons per year.
    e. All of the above
    f. None of the above

3. Which of the following statements about intertidal zones is correct?
    a. These areas are exposed to air during high tide and covered up by saltwater during low tide.
    b. The spray zone is submerged at high tide but remains dry for long periods of time between high tides.
    c. Thes high intertidal zone is a damp area that is usually only reached by ocean.
    d. The low intertidal zone is submerged nearly all the time except during the lowest tides
    e. All of the above
    f. None of the above

4. Which of the following statements about lagoons is correct?
    a. There is only one type of lagoon: coastal lagoons.
    b. An atoll lagoon is a body of water that is separated from the ocean by a physical barrier.
    c. Atoll lagoons are usually deeper than coastal lagoons.
    d. There are lagoons in Antarctica.
    e. All of the above
    f. None of the above

5. Which of the following nutrients is cycled by microbes in the ocean?
    a. Carbon
    b. Nitrogen
    c. Phosphorus
    d. Trace elements
    e. All of the above
    f. None of the above

6. Which of the following statements about marine habitats is correct?
    a. Marine habitats can be divided into coastal and open ocean habitats.
    b. Coastal habitats are found in the area that extends from the shoreline to the continental shelf edge.
    c. Open ocean habitats are also found in deep ocean beyond the continental shelf.
    d. Pelagic habitats are found near the surface or in the open water column
    e. All of the above
    f. None of the above

7. Which of the following statements about intertidal zones are correct?
    a. These areas are farthest to the shore.
    b. There are never exposed by tides.
    c. This region can never be underwater.
    d. Organisms in the intertidal zones bores and grinds exposed rock through bioerosion.
    e. All of the above
    f. None of the above

8. What is the acronym for the regions of the world's oceans encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margins of the major ocean current system?
    a. ACEs
    b. LCEs
    c. LMEs
    d. DEEs
    e. All the above
    f. None of the above

9. What is the main primary producer at the bottom of the marine food chain?
    a. Phytoplankton
    b. Zooplankton
    c. Predatory zooplankton
    d. Filter feeders
    e. All of the above
    f. None of the above

10. What organism is usually found in the second level of the marine food chain?
    a. Small crustaceans
    b. Copepods
    c. Krill
    d. Lobster larvae
    e. All of the above
    f. None of the above

11. Which of the following regions has the highest biomass productivity?
    a. Algal beds
    b. Open ocean
    c. Coral reefs
    d. Swamps and marshes
    e. All of the above
    f. None of the above

12. Which of the following statements about the hydrologic cycle is correct?
    a. Evapotranspiration is the process when water transpired from ice and evaporated.
    b. Ice caps can only store frozen water for 500 years.
    c. Buoyancy drives humid air lower.
    d. As altitude increases, air pressure increases and temperature increases.
    e. All of the above
    f. None of the above

13. What process in the hydrologic cycle involves precipitation that is intercepted by plant foliage that eventually evaporates back into the atmosphere?
    a. Infiltration
    b. Subsurface flow
    c. Canopy interception
    d. Evaporation
    e. All of the above
    f. None of the above

14. Which of the following reservoirs has the highest average residence time?
    a. Deep groundwater
    b. Antarctica
    c. Seasonal snow cover
    d. Glaciers
    e. All of the above
    f. None of the above

15. Which of the following is involved in the carbon cycle?
    a. Biosphere
    b. Pedosphere
    c. Geosphere
    d. Hydrosphere
    e. All of the above
    f. None of the above

16. Which of the following statements about the carbon cycle is correct?
    a. Carbon in the atmosphere only exists in the form of carbon dioxide.
    b. Photosynthesis is the main process that returns carbon dioxide into the atmosphere.
    c. The carbon cycle will most likely increase the rate of carbon dioxide absorption by the soil from carbonate-silicate cycle in the future.
    d. Carbon dioxide cannot dissolve in lakes.
    e. All of the above
    f. None of the above

17. Which of the following statements about the role of the ocean in the carbon cycle is correct?
    a. The DIC in the surface layer is exchanged rapidly with the atmosphere.
    b. The DIC in the surface layer is 30% higher than the deep layer.
    c. Oceans are acidic because of carbon dioxide dissolving into the ocean.
    d. The increase of ocean acidity increases the biological precipitation of calcium carbonates.
    e. All of the above
    f. None of the above

18. Which of the following is a step in the sulfur cycle?
    a. Mineralization of organic sulfur into organic forms.
    b. Reduction of hydrogen sulfide to sulfate.
    c. Oxidation of sulfate to sulfide.
    d. Incorporation of sulfide into inorganic compounds.
    e. All of the above
    f. None of the above

19. What is the term for the process that produces elemental sulfur with an oxidation state of zero?
    a. Assimilative sulfate reduction
    b. Desulfurization
    c. Oxidation of hydrogen sulfide
    d. Oxidation in elemental sulfur
    e. All of the above
    f. None of the above

20. Which of the following statements about the marine sulfur cycle is correct?
    a. The modern global oceans have a sulfur storage of 2.6×10^{21} g.
    b. The overall input flux is 1.0×10^{14} g/year with the sulfur isotope composition of ~3‰.
    c. There is one major output of sulfur from the oceans.
    d. The residence time of sulfur in modern global oceans is 20,000,000 years.
    e. All of the above
    f. None of the above

21. What is the percent composition of nitrogen in the atmosphere?
    a. < 1%
    b. 40
    c. 78%
    d. 99%
    e. All of the above
    f. None of the above

22. Which of the following statements about the nitrogen cycle is correct?
    a. Most fixation is done by free-living or symbiotic bacteria known as diazotrophs.
    b. About 30% of the total fixed nitrogen is produced by the Haber-Bosch process.
    c. In the process of assimilation, plants absorb nitrate or ammonium from the soil by their root hairs.
    d. Bacteria or fungi convert organic nitrogen into ammonium in the process of ammonification.
    e. All of the above
    f. None of the above

23. Which of the following statements about the marine nitrogen cycle is correct?
    a. Nitrogen enters the ocean through precipitation, runoff, or nitrogen gas from the atmosphere.
    b. Nitrification can convert ammonium to nitrite and nitrate.
    c. Ammonium is believed to be the preferred source of fixed nitrogen for phytoplankton.
    d. The nutrients in the ocean are not uniformly distributed.
    e. All of the above
    f. None of the above

24. Which of the following statements about the phosphorus cycling is correct?
    a. Phosphates move slowly through plants and animals.
    b. There are four major processes in the phosphorus cycle.
    c. Soil phosphorus can never be buried in lake sediments.
    d. Phytoplankton in the ocean does not assimilate orthophosphate.
    e. All of the above
    f. None of the above

25. Which of the pairs of constituent and unit processes correctly match each other?
    a. Major dissolved inorganics - adsorption
    b. Minor dissolved inorganics - coagulation
    c. Pathogens - flocculation
    d. Turbidity - granular filtration
    e. All of the above
    f. None of the above

26. Which of the statements about water treatment processes is correct?
    a. Aeration is used in the removal of dissolved iron when present with small amounts of manganese.
    b. Disinfection is used to kill pathogens.
    c. Filtration is used to remove particles from the water.
    d. Sedimentation is the process used for the separation of solids.
    e. All of the above
    f. None of the above

27. Which of the following is considered a major watershed management issue?
    a. Keeping the watershed healthy while simultaneously growing it.
    b. Improved water quality while balancing the act of cleaning-up urban wastewater and controlling rural sources of pollution.
    c. Conserving heritage and a sense of place.
    d. Conserving the natural environment and biodiversity.
    e. All of the above
    f. None of the above

28. Which of the following statements about potable water treatment is correct?
    a. According to the WHO, 72% of the world's population had access to an improved drinking-water source in 2015.
    b. Coagulation is not needed in the process of potable water treatment.
    c. Flocculation is not needed in the process of potable water treatment.
    d. Clarification is needed in the process of potable water treatment.
    e. All of the above
    f. None of the above

29. Which of the following statements about sedimentation pollution is correct?
    a. Only coarse suspended particles cause turbidity in waterways.
    b. Decreased light due to particles can impede the growth of aquatic plants.
    c. Sessile invertebrates cannot be buried by sediment.
    d. Fine particles cannot be transported into coastal zones.
    e. All of the above
    f. None of the above

30. What is intraspecific competition?
    a. Competition between members of the same species.
    b. Competition between members of different species.
    c. Evolution of corresponding traits in the predator species when the prey species evolves.
    d. Members of one species consume members of other species.
    e. All of the above
    f. None of the above

Identification: Identify the harmful organisms shown below using their common name. Each organism is worth **one** point. **(6)**

1. 

European green crab

2. 

Zebra mussels

3. 

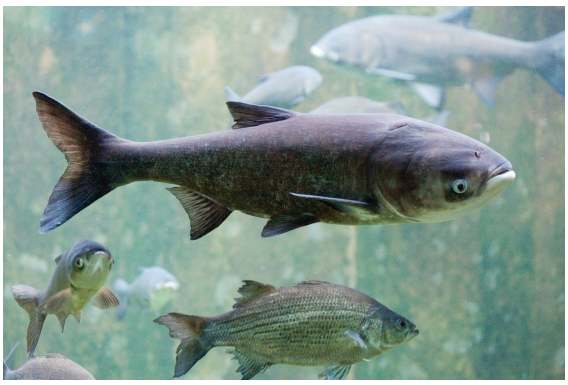
Northern snakehead

4. 

Lionfish (Pterois volitans)

5. 

Sea lamprey

6. 

Asian carp

Short Answer: Answer the following questions regarding water chemistry in the ocean. The point values for each question will be denoted. Be as concise and specific as possible.

1. List **four** different factors that can be affected by water temperature. **(4)**
    a. **Amount of dissolved gas: cold water can hold more dissolved gas.**
    b. **Rate of photosynthesis by algae and aquatic plants**
    c. **Metabolic rates of aquatic organisms (increased respiration, digestion, etc.)**
    d. **Organisms becoming more sensitive (increased levels of stress, increased vulnerability to disease, parasites, pollution, etc.)**

2. What are the two main sources of DO on Earth? **(2)**
    a. **Atmosphere**
    b. **Photosynthesis by algae and plants**

3. Describe the diel oxygen fluctuation. **(7)**

    Diel is the 24-hour period that includes a day and adjoining night. (1) Photosynthesis stops and respiration continues when the sun sets. (1) Because of this, DO levels drop naturally overnight (1), reaching their lowest level just before dawn (1), when the sun rises and photosynthesis adds more DO into the water (1). Extensive algal growth could lead to large oxygen fluctuations from late afternoon to early morning. (1). Really low DO levels can lead to aquatic animal death. (1)

4. What is the usual form of phosphorus in water? **(1)** **PO_4**

5. What is often the limiting nutrient for plant growth? **(2)** Explain your answer. **Phosphorus; it is less prevalent in surface water than nitrogen.**

6. List two examples of sources of phosphorus in streams. (2)
    Give two points for any two of the following examples below.
    a. **Septic systems**
    b. **Wastewater from sewage treatment plants**
    c. **Runoff from feedlots and from the application of animal wastes on fields**
    d. **Runoff of commercial fertilizer from crop fields, lawns, golf courses or parks.**

7. List and describe two ways that humans can change DO. **(4)**
   Give 1 point for example. Give 1 point for description. There should be a maximum of 4 points in this question. Do not give credit for more than two examples and descriptions.

   a. **Organic waste: includes human, animal, and plate waste. Comes from sewage treatment plants, malfunctioning septum systems, or manure runoff from animal operations. Organic wastes stimulate aquatic plant and algal growth. These plants and algae die eventually, contributing to more organic waste.**
   b. **Urban runoff: rain carries heat, salt, sediments and other pollutants into streams. As a result, water temperatures increases and the amount of total solids in the water increases. The amount of DO that the water can hold decreases.**
   c. **Dams: deceases oxygen level in water at damms. When water is released from the top of a dam or spillway, there can be an excessive air uptake from the atmosphere and result in water that has too much atmospheric gas.**
   d. **Removal of vegetation in the riparian corridor: Less shade leads to increased water temperature and a decreased protection from erosion. This also leads to increased suspended solids that contribute to decreased DO levels in the body of water affected.**

8. What are the two usable forms of nitrogen? **(2)** **NH_3 and NO_3 (ammonia and nitrate)**

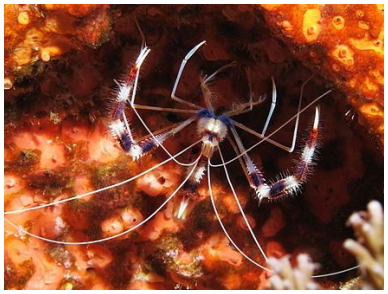
9. Write down the chemical formula for the oxidation of ammonia. **(5)**
   Give two points for the correct reactants. Give two points for the correct products. Glve one point for the arrow pointing to the right.

$$NH_3 + O_2 \rightarrow NO_2 + O_2 = NO_3$$

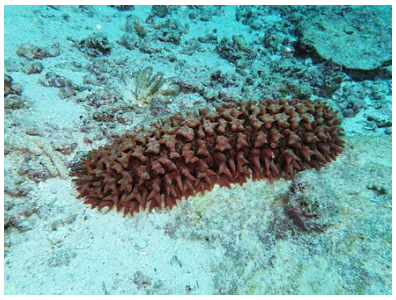
10. List two examples of sources of excess nitrates. **(2)**
    Give two points for any two of the following examples below.
    a. **Poorly functioning septic systems**
    b. **Inadequately treated wastewater from sewage treatment plants**
    c. **Storm drains**
    d. **Runoff from feedlots**
    e. **Runoff from crop fields, parks, and lawns**

Part II: Microflora and Fauna Identification

Identification: Provide the **scientific name** for the coral reef indicator species below and determine which ocean they are located in. Each name will be worth one point. The ocean where the species belong to is worth one point. In short, each question is worth **two** points. **Hint:** Some species are located globally. **(24)**

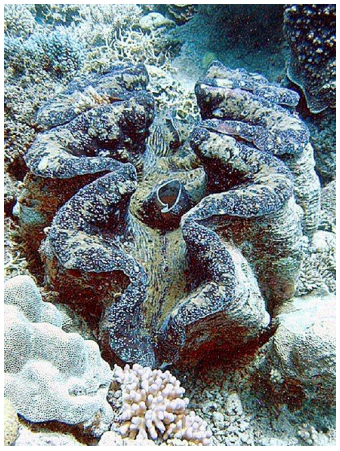
1.  ***Stenopus hispidus.*** **Global**

2.  ***Diadema setosum.*** **Global**

3.  ***Thelenota ananas.*** **Indo-Pacific**

4.  ***Epinephelus striatus.*** **Atlantic**

5.  ***Cyphoma gibbosum.*** **Atlantic**

6.  ***Tridacna gigas.*** **Indo-Pacific**

7. 

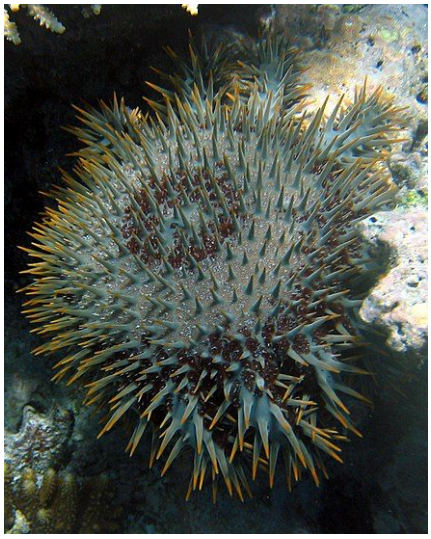
***Lutjanidae*. Global**

8. 

***Scarus frenatus*. Global**

9. 

***Charonia tritonis*. Global**

10. 

***Acanthaster planci*. Global**

11. 

***Haemulidae*. Global**

12. 

***Lates calcarifer*. Indo-Pacific.**

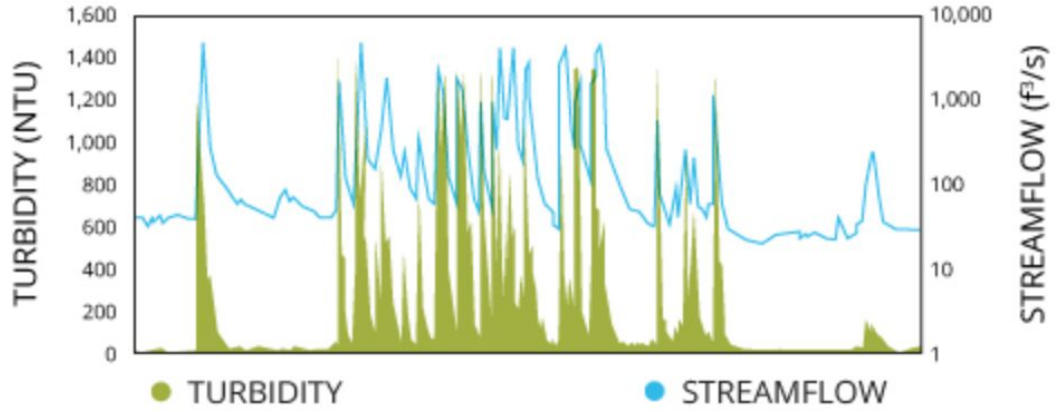
Part III: Water Monitoring and Analysis

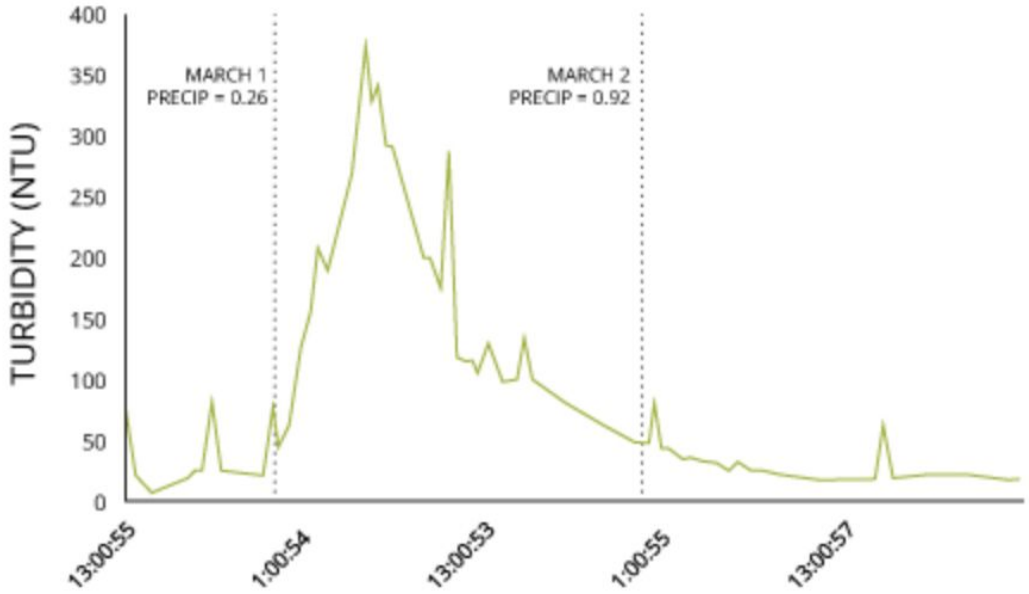
1. Describe your salinometer blueprint (steps in making a salinometer) using a soda straw, modeling clay, fine-tipped permanent marker, calibration fluid, salt, and water. Then, explain how you would calibrate your device. (I understand that some teams have access to 3D printed salinometers but teams should still understand how to make one with these materials). **This is the dry lab section! (18)**

   Give two points for each sentence answered. The maximum points in this section is 18 points. This section is the dry lab section of the exam, so when calculating the overall mark, use the formula listed to consider the weight of this section: 0.05 x points earned. After that, add this to the rest of the test: .95 x points earned in the rest of the exam. Add the points together for the adjusted overall score.

   1. **Create a ball of modeling clay around one end of the straw.**
   2. **Make sure that the clay prevents water from leaking inside the straw.**
   3. **Do not form pits or voids inside the clay that can trap air.**
   4. **Fill the container with water and then place the straw (clay covered end submerged first).**
   5. **Add or remove clay until the straw floats at the maximum depth you wish.**
   6. **Use the permanent marker to mark the depth where the salinometer floats in the water (0% salt solution).**
   7. **Mix a saltwater solution to use for calibration (10% for example).**
   8. **Place the salinometer inside the saltwater solution and mark the level where it floats.**
   9. **Repeat this process for other concentrations to improve the accuracy of your salinometer.**

2. Based on the graphs below, answer the following questions about turbidity. **(6)**





A. What is the relationship between streamflow and turbidity? **(2)** **As water flow increases, turbidity levels increase.**
B. Would high flow rates keep particles suspended or settled? **(1)** **Suspended**
C. Rainfall can increase stream volume and stream flow. Would sediments be suspended or settled. **(1)** **Suspended**
D. What is the relationship between rainfall and turbidity? **(2)** **Increase in rainfall will cause an increase in turbidity due to increased water flow and increased sediment from runoff.**

3. Biochemical Oxygen Demand, also known as BOD, is the amount of dissolved oxygen needed by aerobic organisms to break down organic material present in a water sample with a given temperature over a specific amount of time. The following questions below refer to BOD. **(14)**
    a. Most pristine rivers will have a 5-day carbonaceous BOD below what value in mg/L? **(1) 1**
    b. Municipal sewage treated with a three-stage process efficiently would have what 5-day carbonaceous BOD value in mg/L? **(1) 20 or less**
    c. What are two commonly recognized methods for measurement of BOD? **(2) Dilution method (1) and manometric method (1)**
    d. What are the two formulas for BOD_5 (unseeded or seeded)? **(8) Give four points for each equation. No partial credit will be given.**

- Unseeded: $\mathrm{BOD}_5 = \dfrac{(D_0 - D_5)}{P}$
- Seeded: $\mathrm{BOD}_5 = \dfrac{(D_0 - D_5) - (B_0 - B_5)f}{P}$

    e. List one pure culture that has been used for the construction of BOD biosensor. **(2) Give two points for any of the following: *Trichosporon cutaneum, Bacillus cereus, Klebsiella oxytoca, Pseudomonas sp*.**