

Name \_\_\_\_\_

Bio 362  
Marine Biology  
Dr. J. W. White  
Spring 2017

## Exam 1 -KEY

Total points:

Multiple choice \_\_\_\_\_/40

Matching \_\_\_\_\_/13

Definitions \_\_\_\_\_/10

Short answer \_\_\_\_\_/20

Long answer \_\_\_\_\_/10

Subtotal \_\_\_\_\_/93

Curve \_\_\_\_\_

Bonus \_\_\_\_\_/3

Total \_\_\_\_\_/93

Part I - Multiple Choice: Answer ALL 20 questions.  
Use Scantron. **Bubble in your name!!!**  
(2 pts each = 40 pts total)

- 1) On a warm summer day, a mussel living in the rocky intertidal zone opens its shell slightly to cool its body temperature. The mussel is taking advantage of what property of water?
  - a) Heat capacity
  - b) The latent heat of vaporization**
  - c) Potential energy
  - d) The latent heat of fusion
  
- 2) Coca-Cola has a pH of 3, while seawater has a pH of 8. This indicates that Coke has \_\_\_\_\_ hydrogen ions than seawater.
  - a) 0.375 times less
  - b) 5 times more
  - c) 100,000 times more**
  - d) 1000 times less
  
- 3) Which of the following marine mammal taxa consists entirely of species that feed on plankton rather than nekton?
  - a) Odontocetes
  - b) Phocidae
  - c) Otariidae
  - d) Procyonidae
  - e) Mysticetes**
  
- 4) The anterior portion (head and main body) of a calanoid copepod is the
  - a) prosome**
  - b) urosome
  - c) pleosome
  - d) pereosome
  
- 5) Which of the following taxa of birds are least likely to see on a beach near Wilmington?
  - a) Charadriiformes
  - b) Pelecaniformes
  - c) Procellariiformes**
  - d) All are equally unlikely

6) During phytoplankton blooms, ammonia is typically in very low concentrations in the mixed layer. This is best explained by

- a) ammonia undergoes rapid denitrification and reenters the atmosphere
- b) most epipelagic grazers release urea instead of ammonia as a waste product
- c) ammonia undergoes rapid nitrification by bacteria
- d) phytoplankton rapidly uptake ammonia as soon as it enters the water column**

7) Planktonic viruses (virioplankton) fall primarily into what size class?

- a) megaplankton
- b) microplankton
- c) nanoplankton
- d) femtoplankton**

8) Assuming all else is equal, an organism living in seawater at 5° C is likely to experience what conditions compared to one living in water with a temperature of 25° C?

- a) greater osmotic stress
- b) decreased viscosity
- c) increased buoyancy (it will float more)**
- d) higher Reynolds numbers

9) All of the following except \_\_\_\_\_ are considered **minor** ions in seawater.

- a) Sodium (Na<sup>+</sup>)**
- b) Bicarbonate (HCO<sub>3</sub><sup>-</sup>)
- c) Strontium (Sr<sup>2+</sup>)
- d) Bromide (Br<sup>-</sup>)

Use the information below to answer the following two questions. (Values are approximate)

Property	Tropical Water	Polar Water
Density ( $\rho$ ) ( $\text{g cm}^{-3}$ )	1.02	1.03
Viscosity ( $\mu$ ) ( $\text{g cm}^{-1} \text{s}^{-1}$ )	0.01	0.02

$$\text{Re} = \frac{\rho l U}{\mu}$$

- 10) If natural selection favors copepods with a Reynolds number greater than 100 (e.g. because of the operation of their feeding appendages), which species (tropical vs polar) can have a smaller maximum size, assuming that they swim at the same speed?

- a) **Tropical**
- b) Polar
- c) They will be the same size
- d) Impossible to determine

- 11) Two species of clams, one tropical and one polar, feed by filtering water that is transported through a tube-like siphon. Filtration is most efficient when flow within the siphon is laminar (i.e.  $\text{Re} < 1000$ ). If both species have siphons that are 1 cm in diameter and maintain laminar flow, which one can filter more water per unit time (assuming all else is equal).

- a) Tropical
- b) **Polar**
- c) They will be the same size
- d) Impossible to determine

- 12) The amount of light available for photosynthesis \_\_\_\_\_ as one moves toward the equator and \_\_\_\_\_ with increasing depth.

- a) increases, increases
- b) **increases, decreases**
- c) decreases, increases
- d) decreases, decreases

13) Because of the Coriolis effect, a water current moving from the equator towards the south pole in the southern hemisphere will tend to \_\_\_\_\_ as it moves along its course.

- a) **bend to the east**
- b) bend to the west
- c) continue in a straight path
- d) sink

14) Which of the following groups of plankton is nonmotile?

- a) **diatoms**
- b) dinoflagellates
- c) coccolithophores
- d) heterokonts

15) Which of the following is a preferred form of nitrogen that diatoms and other large phytoplankton preferentially uptake?

- a) dinitrogen ( $N_2$ )
- b) **nitrate**
- c) nitrite
- d) urea

16) The light bottle / dark bottle method measures primary productivity via changes in \_\_\_\_\_ concentrations, while the radiocarbon method technique measures changes in concentration of labeled \_\_\_\_\_.

- a) **oxygen; carbon-14**
- b) oxygen; carbon-12
- c) ammonia; carbon-14
- d) nitrate; carbon-12

17) The light bottle method typically measures higher rates of primary productivity than the radiocarbon method. This is likely because the radiocarbon method only measures fixed carbon that can be trapped on a filter, so it may not measure fixed carbon that is exuded by phytoplankton in the form of

- a) **DOC**
- b) DIC
- c) POC
- d) marine snow

- 18) Equatorial upwelling zones are characterized by:
- a) low primary productivity, low nutrient concentrations, and warm surface waters relative to adjacent subtropical gyres.
  - b) divergence of surface currents due to Ekman transport that brings nitrogen-rich water from deep layers to the surface.**
  - c) convergence of surface currents due to Ekman transport that causes nitrogen-rich surface water to sink toward the seafloor.
  - d) convergence of surface currents due to Ekman transport that brings warm water to the surface.
- 19) The Gulf Stream forms the western portion of the:
- a) South Atlantic subtropical gyre
  - b) North Atlantic subtropical gyre**
  - c) North Pacific subtropical gyre
  - d) North Atlantic subpolar gyre
- 20) Which statement accurately describes the relationship between the thermocline, nutrient availability, and phytoplankton production?
- a) The thermocline is a barrier that traps nutrients in the surface layer, thereby increasing primary production.
  - b) Tropical oceans never exhibit a strong thermocline so that phytoplankton rapidly sink out of the euphotic zone.
  - c) The permanent thermocline in the polar seas traps nutrients in the euphotic zone causing increased production at the poles.
  - d) Disruption of the thermocline by fall storms allows the recharging of nutrients in the surface mixed layer of temperate oceans.**

Part II - Matching: Match the following groups with their identifying characteristics. (1 Pt each = 13 Pts Total). Each question has a single correct match, but not every letter will be used.

- |                                  |                               |
|----------------------------------|-------------------------------|
| a) Diatoms (Bacillariophyceae)   | j) Choreotrich ciliate        |
| b) Dinoflagellates (Dinophyceae) | k) Chaetognatha (Arrow worms) |
| c) Cyanophyta                    | l) Pteropods                  |
| d) Prochlorophyta                | m) Hydrozoa                   |
| e) Coccolithophore               | n) Acanthopterygii            |
| f) Euphausia                     | o) Clupeidae                  |
| g) Ctenophora                    |                               |
| h) Copepoda                      |                               |
| i) Salpidae (Salps)              |                               |

- \_\_\_d\_\_\_ 1) Common in oligotrophic tropical waters, divinyl chlorophyll, no phycobilliproteins.
- \_\_\_o\_\_\_ 2) Group that includes herrings.
- \_\_\_m\_\_\_ 3) Has two life stages: medusa and polyp
- \_\_\_a\_\_\_ 4) Nonmotile, silica frustule, accessory pigment is fucoxanthin.
- \_\_\_b\_\_\_ 5) Two flagella, one transverse and one longitudinal; accessory pigment is peridinin, often mixotrophic .
- \_\_\_e\_\_\_ 6) Motile phytoplankton with calcium carbonate plates.
- \_\_\_i\_\_\_ 7) Filter feeding chordate zooplankton
- \_\_\_k\_\_\_ 8) Active predators of copepods and other zooplankton
- \_\_\_l\_\_\_ 9) Planktonic gastropods, many are filter feeders
- \_\_\_h\_\_\_ 10) Most abundant planktonic crustacean, important diatom grazers
- \_\_\_j\_\_\_ 11) Important grazer of planktonic microbes
- \_\_\_n\_\_\_ 12) Group that includes tunas and most coral reef fishes
- \_\_\_f\_\_\_ 13) Shrimplike crustacean zooplankton

Part III - Definitions: Provide a complete definition in 1-2 sentences of ALL of the following terms. (2.5 pts each = 10 pts total). You may include a sketch if that helps you define the term

1) Photoheterotrophic bacteria

Planktonic bacteria that utilize solar energy to generate ATP but cannot fix CO<sub>2</sub> into organic carbon. They rely on DOC to obtain fixed organic carbon.

*Most common error was giving the definition of mixotrophic plankton instead (-2 points). Other common misconceptions are that these organisms perform photosynthesis – they do not, because photosynthesis involves fixing carbon (-1.5 points). The process these species use is not technically photosynthesis. Some of you also suggested that these bacteria are “ingesting other organisms.” Remember that these are bacteria! They are too small to actually ingest anything else – instead they absorb DOC directly from their environment.*

2) Meroplankton

*Organisms that spend only part of their life in the plankton, such as nekton with a planktonic larval stage. Note that this does not mean that **half** of their life is spent in the plankton, as many of you wrote. Merely **part**.*

3) Mixotrophy

*A mixotrophic organism can perform photosynthesis or chemosynthesis (autotrophy) and also ingest prey (heterotrophy).*

4) Redfield ratio

*This is the ratio of C:N:P water column concentrations that is optimal for phytoplankton growth. It is 106:16:1, a ratio that is due to the physiological requirements for each element in biomolecules. This ratio is also found in deep waters because of the decomposition of sinking phytoplankton biomass.*

*Full credit required giving the actual ratio, correctly identifying which element corresponded to which number, explaining **where** these concentrations would be measured, and **why** it was important. Many just wrote that this is the C:N:P ratio in phytoplankton, which is true, but this is more commonly used to describe the ratio of elements in the water column, in order to determine what nutrient might be limiting.*

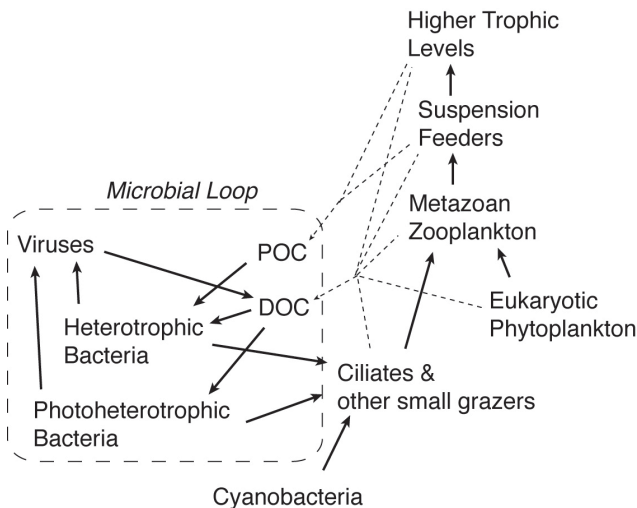
Part IV - Short Answer: Answer ALL of the following questions.  
Please be as brief and concise as possible. (5 pts each = 20 pts total)

1) Explain what TEP is. Why is it produced by phytoplankton? What happens to it, and what role does it play in the planktonic food web?

*TEP is transparent extracellular polysaccharide. It is a long-chain carbohydrate produced and extruded by phytoplankton in nutrient-limiting conditions: when they are N-limited and cannot synthesize new proteins or reproduce, they continue to photosynthesize in order to avoid being damaged by solar radiation. After extrusion, TEP typically adheres to other DOC particles, eventually clumping up into larger POC particles that form marine snow. It then serves as the base of the detrital food web and microbial loop as it decomposes while sinking to the benthos.*

*The most common error here (aside from having no idea what TEP is, or not actually explaining what the acronym stood for) was to fail to explain why the phytoplankton make it. Note that the phytoplankton do not make it in order to supply the food web. Phytoplankton don't care about the food web – it is only evolutionarily adaptive if it benefits the phytoplankton themselves.*

2) Draw a sketch of an epipelagic food web, including all of the major players in the microbial loop. Use arrows to indicate the flow of carbon, including DOC.



*Something approximating the above received full credit. Notice that it includes the microbial loop, as requested, and shows the formation and flow of DOC. Credit was lost for not including the microbial loop (-3 points), or not including a key link in the food web (e.g., phytoplankton), or not distinguishing the two different size classes of zooplankton (those that feed on microbes in the*

*microbial loop, e.g., ciliates, and those that feed on larger phytoplankton, e.g., copepods; -1 point), or for including benthic organisms (e.g., corals) in a drawing of an **epipelagic** food web.*

3) Many zooplankton undergo diurnal vertical migration (DVM). Explain what DVM is, and one hypothesis that seems to explain why DVM occurs.

*DVM is movement of zooplankton and fishes from below the photic zone and mixed layer (down in the mesopelagic) up to the surface at dusk, and then returning at dawn. While at the surface, the zooplankton feed on phytoplankton.*

*Two hypotheses that do explain the pattern are predation avoidance (avoid daytime surface waters and thus visual predators) and a metabolic advantage (spending time in the deeper cold waters improves metabolic efficiency). Other hypotheses have also been offered (e.g., avoiding UV damage) but they do not actually explain the pattern (e.g., UV damage can be avoided with only a few meter's depth, not 200 m). Those answers did not receive full credit.*

*Some students suggested that the zooplankton themselves needed sunlight. Zooplankton are not photosynthetic, so that answer does not make sense.*

4) We often find that photosynthetic rates and chlorophyll concentrations (i.e. phytoplankton biomass) are highest at intermediate depths (i.e. not at the surface nor in the deep sea). Why?

*There are two factors at work here. The first is light: irradiance decreases with depth, but is so high at the surface that it may cause photoinhibition. So productivity could be highest just below the zone of photoinhibition, and is restricted to depths where there is enough PAR for photosynthesis to occur. The second factor is nutrients: nitrate and other forms of fixed nitrogen are typically depleted in the higher parts of the water column, and are typically highest near the thermocline and below (because dead organic matter is sinking and decomposing along the way).*

PART V Longer Answer – Answer ONLY ONE of these. (10 pts)  
(use back page if necessary)

1) Explain Critical Depth Theory.

- A) What are the critical depth, compensation point, and mixed layer? (Drawing a diagram will probably help)
- B) How is this theory used to predict the timing of the North Atlantic Spring Bloom?
- C) Explain a key criticism of the CDT, and an alternative explanation that has been proposed.

2) Explain iron limitation theory.

- A) What are HNLC zones? Why is productivity low in those places?
- B) Is there any planktonic productivity in HNLC regions? What type of organisms are photosynthesizing?
- C) What is the iron fertilization hypothesis? What problem is it intended to solve?
- D) If iron fertilization has the intended effect, what patterns of primary and secondary productivity would you expect to see in fertilized patches?
- E) Based on our discussions in class and your reading, is iron fertilization likely to be successful in solving the problem it is intended to address?

1) *The mixed layer is the water above the thermocline that experiences turbulent mixing by wind. The compensation point is the depth at which the rate of photosynthesis balances the rate of respiration (so net production is zero). The critical depth is the depth of the mixed layer at which the total amount of photosynthesis in the mixed layer is exactly balanced by the total amount of respiration. In other words, it is the depth at which the integral of the photosynthesis rate over depth is equal to the integral of the respiration rate over depth. When the mixed layer is deeper than the critical depth, phytoplankton experience net negative productivity and cannot increase in abundance. When the mixed layer is shallower than the critical depth, a bloom can occur.*

*This affects the NASB in the following way: at the end of winter, the mixed layer is quite deep because there is considerable wind (so lots of turbulent mixing) and cold air temperatures so very little water column stratification. This allows a lot of mixing, bringing N-rich water to the surface. Despite increased N availability, a bloom does not occur because the critical depth is quite shallow (due to low light intensity) relative to the deep mixed layer. As spring progresses, the critical depth deepens (longer days and higher light intensity) and the mixed layer becomes more shallow (less wind and higher air temps lead to a more stratified water column). Once the mixed layer becomes shallower than the critical depth, diatoms can utilize the N in the surface water and bloom.*

*A recent criticism of CDT is that it does not actually do a very good job of*

*predicting the timing of the spring bloom! This could be because the theory overlooks the importance of finer-scale spatial structure in the mixed layer. We discussed two alternative hypotheses. The dilution/recoupling hypothesis suggests that the bloom begins when the mixed layer is very deep because predators are too 'dilute' in the water column to effectively control phytoplankton growth, and then as the thermocline becomes shallower the predator-prey dynamics 'recouple', ending the bloom. The stratification-onset hypothesis suggests that the bloom really begins in a very shallow layer of stratified water at the surface, prior to the onset predicted by the critical depth theory.*

*(All three parts of the answer were needed for full credit, though part A was worth more than B and C. The most common errors in part A were confusing compensation depth with critical depth. Explaining how the mixed layer and critical depth change their relative depth in spring was essential to get credit for part B).*

*2. HNLC zones are high-nutrient, low chlorophyll. Basically they are places with high nitrate concentrations, but very low primary productivity. In most cases this appears to be because of a deficit of iron in the water column; iron is required for the enzymatic conversion of nitrate by phytoplankton. So the phytoplankton can't bloom despite the nitrate. There is typically a low level of production happening in these waters, typically by nanoplanktonic phytoplankton; these smaller cells are less nutrient-limited because of their high surface area to volume ratio, and can still photosynthesize effectively (though their overall productivity is collectively much less than what would happen in a eukaryote bloom).*

*The iron fertilization hypothesis states that if iron is added to the water column in HNLC zones, it will permit blooms of large iron-limited phytoplankton, drawing down atmospheric carbon dioxide. As the bloom dies and sinks it will pump carbon into the deep sea, sequestering it. This is intended to ameliorate anthropogenic climate change due to CO<sub>2</sub> accumulation in the atmosphere.*

*If successful, you would expect to see a rapid increase in primary productivity after fertilization. You would not necessarily expect a subsequent bloom in secondary productivity, because the majority of zooplankton in the area are specialized for feeding on the smaller nanoplankton, and may not be able to effectively graze on the larger plankton. Plus if there were a large burst of secondary production, that would defeat the purpose of the fertilization, because the carbon would be retained in the mixed layer and transferred to higher trophic levels rather than being pumped to the deep sea.*

*Currently iron fertilization is not thought to be an effective approach to climate mediation. Reducing atmospheric CO<sub>2</sub> concentrations would require fertilization*

*on a massive scale, and would require considerable fossil fuel consumption to execute. Additionally, the ramifications of large scale fertilization for oceanic foodwebs is unknown, and the precautionary principle suggests restraint.*

*Full credit for part C required mentioning atmospheric CO<sub>2</sub> levels and climate change. Full credit for E required an explanation (not just “yes” or “no”).*

PART VI: Bonus! (3 pts total)

1) What is the name of the western boundary current in the north Pacific ocean?

*Kuroshio*

2) What dinoflagellate toxin explains odd behaviors in a 1963 Alfred Hitchcock film?

*Domoic Acid ("The Birds" got half credit)*

3) Is a Gulf Stream cold core ring spinning clockwise or counterclockwise?

*counterclockwise*