This final exam consists of four parts: Multiple Choice, Definition, Short Answer, and Quantitative. Calculators are permitted, but no other electronic devices. Please leave all bags at the front of the room. You will have until 7:00 pm to complete this exam.

Please answer all questions on the page provided, including your name as well as the name of your TA on each page.

For the definitions, please choose any 5 of the words provided, and fill in your definitions (using sketches if desired) in the space provided.

Cheating will not be tolerated. Please sign your name under the statement below:

I understand that cheating on this final (including but not limited to, copying from others’ work or referring to pre-prepared notes during the exam) is not acceptable and will be subject to disciplinary action. I understand that I may fail the final, and that anyone I knowingly let cheat from my exam may also fail the final exam.

Signed

Printed

Multiple choice. Circle the one best answer for each question. 2 points each.

1. All photosynthetic primary producers
   A. are unicellular.
   B. have leaves.
   C. use chlorophyll a.
   D. have roots.
   E. have zooxanthellae.

2. What effect do El Niño conditions in the Pacific have on upwelling on the coast of Peru?
   A. El Niño shuts off upwelling of cold water by a shallowing of the thermocline in the eastern Pacific.
   B. El Niño enhances upwelling by a shallowing of the thermocline in the eastern Pacific.
   C. El Niño shuts off upwelling of cold water by deepening the thermocline in the eastern Pacific.
   D. El Niño enhances upwelling by deepening of the thermocline in the eastern Pacific.
3. Hydrothermal vent communities are mostly supported by autotrophs that are
A. photosynthetic.
B. chemosynthetic.
C. heterotrophic.
D. mixotrophic.

4. What is the speed of a deep-water wave whose wavelength is 1000 feet and whose period is 10 seconds?
A. 1000 feet
B. 1000 feet per second
C. 100 feet
D. 100 feet per second
E. There is not enough information to answer the question.

5. Which of the following is not a factor that affects the control of phytoplankton biomass by zooplankton?
A. light availability
B. temperature
C. life history of the zooplankton
D. grazing on zooplankton
E. abundance of zooplankton

6. The most common color of bioluminescence is
A. blue.
B. green.
C. red.
D. infrared.
E. yellow.

7. The practice of fishing at ever-lower trophic levels is called
A. fishing until the cows come home.
B. fishing up the food web.
C. fishing off the top.
D. fishing down the food web.
E. bottom fishing.

8. The breakdown of organic matter in the presence of oxygen is called
A. photosynthesis.
B. lithification.
C. respiration.
D. remineralization.
E. carbon reduction.
9. Which of the following represents the Redfield ratio for carbon, nitrogen and phosphorus?
A. 106:16:138
B. 138:106:122
C. 106:16:1
D. 122:16:1
E. 106:122:16

10. A sample of seawater has a dissolved oxygen (DO) concentration of 8 mg/L. After 24 hours, a clear bottle of the sample incubated at the surface has a DO concentration of 9 mg/L and a dark bottle of the sample incubated at the same depth has a DO concentration of 7 mg/L. What is the rate of gross primary production?
A. 8 mg/L/day
B. 20 mg/L/day
C. 14 mg/L/day
D. 2 mg/L/day
E. 12 mg/L/day

11. Biologically produced light is called
A. phosphorescence.
B. the green flash.
C. the Aurora Borealis.
D. bioluminescence.
E. red tide.

12. If fifteen people are in line at Starbucks and a new person is served every two minutes, what is the turnover time of the line?
A. forever
B. forty-five minutes
C. fifteen minutes
D. thirty minutes
E. sixty minutes

13. Most organisms in mid-water food webs depend primarily upon
A. bacteria growing on DOM.
B. primary productivity by non-photosynthetic autotrophs.
C. a rain of food from above.
D. vertical migration into the euphotic zone to graze.

14. Organisms living upon, within or attached to the sea floor are classified as
A. pelagic.
B. nektonic.
C. planktonic.
D. benthic.
E. epipelagic.
15. Which of the following is not a domain of life?
A. Bacteria
B. Animalia
C. Archaea
D. Eukaryotes

16. What is the position of the moon-Earth-sun system during neap tides?
A. the moon-Earth-sun are 90 degrees relative to each other
B. moon-Earth-sun are furthest away from each other
C. the moon-Earth-sun are closest to each other
D. the moon-Earth-sun are in a direct line with each other
E. the moon-Earth-sun are 45 degrees to each other

17. Toothed whales belong to a taxon called
A. Cetacea.
B. Flipper.
C. Odontocetes.
D. Mirabilis.
E. Mysticetes.

18. A region of the water column where the concentration of nutrients changes rapidly is called
A. the nutricline.
B. the halocline.
C. the lysocline.
D. the thermocline.
E. the pycnocline.

19. How many tons of top predator can a 3-level food web support annually if the primary producers manufacture 1,000,000 tons annually? Assume a trophic efficiency of 10%.
A. 10 tons
B. 100 tons
C. 1 ton
D. 10,000 tons
E. 1000 tons

20. Organisms that can swim under their own power through the ocean are classified as
A. pelagic.
B. nektonic.
C. planktonic.
D. epipelagic.
E. benthic.

21. From 1950 to 2000, the global fisheries catch has
A. trended towards species at lower trophic levels.
B. trended towards species at higher trophic levels.
C. fished the same trophic level at a constant level.
22. Harmful algal blooms
A. are becoming less frequent.
B. pose no threat to marine life.
C. pose no threat to humans.
D. are on the rise worldwide.

23. The restoring force for wind waves is
A. wind.
B. hydrostatic pressure.
C. surface tension.
D. None of the choices are correct.
E. gravity.

24. The earliest forms of life were likely
A. chemotrophs.
B. None of the choices are correct.
C. anoxygenic autotrophs.
D. oxygenic autotrophs.
E. photoautotrophs.

25. A key component of the microbial loop is
A. particulate organic matter.
B. inorganic matter.
C. dissolved organic matter.
D. marine snow.
E. regenerated nutrients.

26. The arrangement of organisms according to who eats whom defines the ___ of a community of organisms.
A. All of the choices are correct.
B. food chain
C. trophic structure
D. food web

27. Primary productivity in the world ocean contributes approximately ___ of the oxygen in the atmosphere.
A. 75%
B. 50%
C. 10%
D. 25%
E. 100%
Section TA: ________________________________

28. The epipelagic zone includes
A. oceanic ridges.
B. submarine trenches.
C. the abyss.
D. the euphotic zone.
E. All of the choices are correct.

29. Biogenic coasts are formed
A. along active continental margins.
B. from the erosion of volcanic platforms.
C. by the activities of organisms, namely, corals and reef-building algae.
D. during sea level rise.

30. Estuarine waters may include all of the following except
A. ice melt.
B. river water.
C. snow melt.
D. rainwater.
E. hydrothermal vent water.

31. Several field experiments in the world ocean have shown that addition of iron to iron-poor waters
A. increases the concentration of phytoplankton.
B. decreases the concentration of phytoplankton.
C. has no effect on the concentration of phytoplankton.

32. To which domain do humans belong?
A. Animalia
B. Eukaryotes
C. Archaea
D. Bacteria

Part 2: Definitions (8 pts). Choose any 4 of the following 8 words or terms listed on this page and give a brief but complete definition in the space below. Sketches are OK.

Chemotroph

Wave Period

Tsunami
Food Web

Redfield Ratio

Archaea

Fishing down the food chain

Harmful Algal Bloom

Part 3. SHORT ANSWERS

(3 pts) Draw the seasonal cycle of the North Atlantic, with time on the x-axis (Winter, Spring, Summer, Fall) and the following variables on the y-axis: temperature, light, nutrients, phytoplankton, and zooplankton. You can use more than one graph if that is easier.
(3 pts) In the oceans, a rule of thumb is that each trophic step results in 90% loss of energy. This helps to explain the relationship we see between size and abundance. Draw a graph of size versus abundance in the ocean, showing the relationship between bacteria, whales, and a third organism (you can choose any organism you want). Make sure to label the axes.

Japan recently started hunting whales again for human consumption. How many kilos of phytoplankton would be required for a human to gain 1 kilo if they were eating blue whales? How many kilos of phytoplankton would be needed to achieve the same goal if the human was eating sharks? (blue whales are at the 3rd trophic level, sharks are at the 5th. Assume a 10% transfer efficiency at each trophic level).

Think about the implications of this calculation. You are a top official with the United Nations. Should you promote a greater consumption of whales or sharks in the typical diet of citizens? Why or why not? What are the alternatives? Briefly explain why this is a difficult issue. (4 points)
Fill in the blanks 2 pts each.
(There's a list of words to use to fill in the short answers on the last page)

A polar bear is considered a marine mammal because it spends more than ________ of its time at sea.

Squid are considered to be ______________ because they are not transported by the currents; ______________ is an example of plankton because it cannot control its horizontal position.

The dinoflagellate genus *Alexandrium* causes paralytic shellfish poisoning because it produces the compound ________________

The 3 domains of life are ________________, ________________, and Archaea.

One adaptation that whales use to dive deeply is __________________________

Part 4. A little bit of math (you’re almost done!). 4 points—show your work.

The average concentration of dissolved inorganic carbon (DIC) in the ocean is 0.024 g per 1000 g of seawater. What is the total amount of carbon stored in the ocean as DIC? Give answer in units of kilograms. The mass of water in the ocean is $1.36 \times 10^{21}$ kg.
Extra Credit—2 points each.

Extra Credit #1: Lost at sea, we notice that our watch (set to the time at the Prime Meridian) says it’s 4:00 PM when the sun is directly overhead (local apparent noon). What is our approximate longitude?

Extra Credit #2: What will happen to the pH of the ocean if we continue to increase the amount of carbon dioxide in the atmosphere? Why do we care?

Extra Credit #3: What state in the US has the most coastline, and what country in the world has the most coastline?
WORDS FOR SHORT ANSWER, FILL-IN THE BLANKS:

active
Africa
amplitude
animalia
barrier island
bloom
centripetal force
cold
convergent
Coriolis effect
cove
deflection
delta
diffusion
dinoflagellate
divergent
Domoic acid
dry
eukaryota
efflux
Ekman transport
equatorial
equatorial flow
erosional
Europe
Flexible ribs
gradient transport
gravity
100 percent
headland
hypertonic
hypotonic