B - Dynamic Planet B - Pearl City Invitational - 12-12-2020

1. (1.00 pts) Which of the following is NOT true regarding seawater?

- (●) A) As salinity increases, heat capacity of seawater increases
- ( ) B) Seawater is nearly incompressible
- ( ) C) As temperature increases, thermal conductivity of seawater increases
- ( ) D) Sulfate is the third most common ion in seawater
- ( ) E) None of the above

2. (1.00 pts) Which of the following is most relevant to estimating the salinity of seawater?

- ( ) A) Reynold's Number
- ( ) B) Redfield Ratio
- ( ) C) Law of Lateral Continuity
- ( ) D) Residence Time
- (●) E) Forchhammer's Principle

3. (1.00 pts) Which of the following types of constituents is tied to biological, seasonal, or other short cycles?

- ( ) A) Organic
- ( ) B) Inorganic
- ( ) C) Conservative
- (●) D) Nonconservative
- ( ) E) None of the above

4. (1.00 pts) Which of the following is the most abundant gas dissolved in seawater?

- ( ) A) Carbon Dioxide
- ( ) B) Oxygen
- (●) C) Nitrogen
- ( ) D) Argon
- ( ) E) None of the above

5. (1.00 pts) Which of the following is NOT true regarding the SOFAR channel?

- ( ) A) SOFAR stands for sound fixing and ranging
- ( ) B) Sound waves exiting the SOFAR channel refract back into it
- ( ) C) The SOFAR channel is a minimum sound velocity layer of the ocean
- ( ) D) The SOFAR channel can be used to efficiently transmit sound waves in the ocean
- (●) E) None of the above

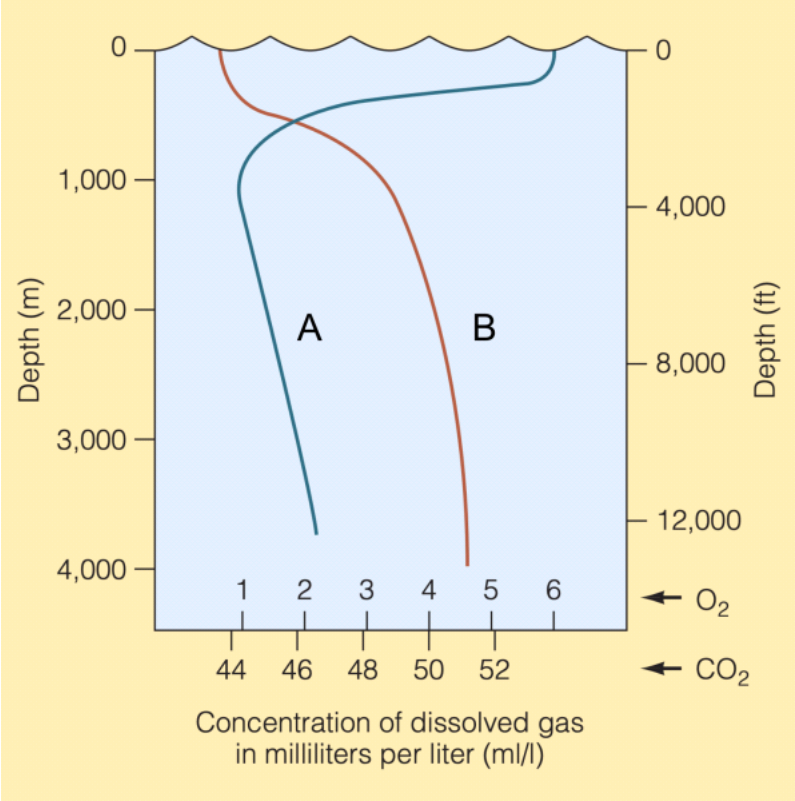
6. (1.00 pts) Which of the following is NOT true regarding the practical salinity scale?

- A) The scale uses conductivity to measure salinity
- B) Measurements on the practical salinity scale are reported with the units "grams per cubic centimeter"
- C) The practical salinity scale is based on a standard solution of potassium chloride
- D) Measurements adjusted for temperature when calculating PSU values

7. (1.00 pts) Which of the following terms describes the average time period an atom of a certain element stays in the ocean?

- A) Salinity
- B) Duration
- C) Age
- D) Half-life
- E) None of the above

Refer to the diagram below for the following two questions.



8. (1.00 pts) Curve A represents dissolved ___ concentration and Curve B represents dissolved ___ concentration.

- A) Oxygen, Carbon Dioxide
- B) Carbon Dioxide, Oxygen
- C) Carbon Dioxide, Carbon Dioxide

D) Oxygen, Oxygen

E) None of the above

9. (1.00 pts) Which of the processes influences the concentrations of both dissolved gases at the surface?

A) Upwelling

B) Downwelling

C) Photosynthesis

D) Volcanic outgassing

E) None of the above

10. (1.00 pts)

The chemical reaction above occurs when:

A) Seawater is too acidic

B) Seawater is too basic

C) Seawater is neutral

D) Seawater is unsaturated

E) Seawater is supersaturated

11. (1.00 pts) At which of the following depths is the rate of calcite dissolution closest to the rate of calcite accumulation?

A) 1500 m

B) 2500 m

C) 3500 m

D) 4500 m

E) 5500 m

12. (1.00 pts) Which of the following is NOT true regarding the Earth's ocean basins?

A) Continental shelves are wider at passive margins

B) On average, the continental slope is steeper than the continental shelf

C) On average, the continental shelf is steeper than the continental rise

D) Submarine canyons are commonly formed by the downcutting of rivers

13. (1.00 pts) Which of the following terms best describes the sediment found in an abyssal fan?

A) Cross-bedding

B) Graded bedding

C) Marine transgression

D) Marine regression

E) None of the above

14. (1.00 pts) Which of the following features is characteristic of a passive margin?

- A) Continental borderlands
- B) Accretionary wedge
- C) Dea-sea trench
- D) Andesitic volcanism
- E) None of the above

15. (1.00 pts) Who proposed the Theory of Continental Drift?

- A) Harry Hess
- B) Linus Pauling
- C) Robert Dietz
- D) Frederick Vine
- E) None of the above

For the following three questions, use the diagram below:

16. (1.00 pts) The figure above shows the _____ known as _____.

- A) Supercontinent, Ur
- B) Supercontinent, Rodinia

C) Tectonic Plate, Gaia
D) Tectonic Plate, Tethys
E) None of the above

17. (1.00 pts) The ocean around the landmass was known as:

A) Tethys
B) Pacific
C) Panthalassa
D) Gondwana
E) None of the above

18. (1.00 pts) When in geologic history did this landmass exist on Earth?

A) 4.45 Gya to 2.25 Gya
B) 3.35 Gya to 1.75 Gya
C) 445 Mya to 225 Mya
D) 335 Mya to 175 Mya

19. (1.00 pts) Which of the following was not a piece of evidence used to support continental drift?

A) Shoreline fit of continents
B) Matching fossils across oceans
C) Corresponding Rock types and geologic features
D) Ancient climates
E) None of the above

20. (1.00 pts) What was the important mineral component of ocean floor basalt that allowed for Harry Hess and others to understand seafloor spreading?

A) Neoproterozic garnet
B) Birefringent calcite
C) Conchoidal fracture quartz
D) Magnetic magnetite
E) None of the above

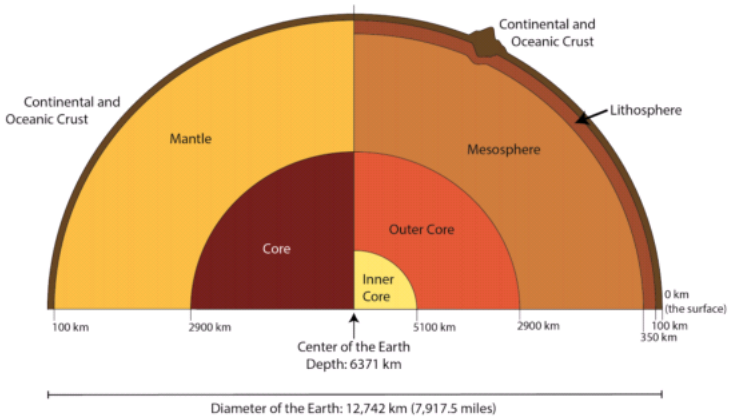
21. (1.00 pts) The lithosphere contains _____ while the asthenosphere contains _____.

A) the crust and upper mantle, the upper mantle
B) the upper crust, the lower crust and upper mantle
C) the upper crust, the lower crust
D) the crust, the mantle
E) None of the above

22. (1.00 pts) The Hawaiian islands were formed by:

- A) Subduction zone volcanism
- B) Oceanic basalt province
- C) Hydrothermal activity
- D) Isostatic equilibrium
- E) None of the above

23. (1.00 pts) Consider the diagram below:



The left side of the diagram divides the Earth into _____ layers and the right side of the diagram divides the Earth into _____ layers.

- A) rigid, molten
- B) molten, rigid
- C) chemical, physical
- D) physical, chemical
- E) None of the above

24. (1.00 pts) Following an earthquake, the transverse wave arrives _____, the surface waves arrive _____ and the longitudinal wave arrives _____.

- A) first, second, third
- B) second, first, third
- C) third, first, second
- D) third, second, first
- E) None of the above

25. (1.00 pts) What is the name given to the shower of organic material falling from upper waters to the deep ocean?

- A) Detritus
- B) Marine snow
- C) Precipitation
- D) Percolation
- E) None of the above

26. (1.00 pts) Where is oceanic crust destroyed?

- A) Continental shelf
- B) Continental slope
- C) Mid-ocean ridge
- D) Subduction zone
- E) None of the above

27. (1.00 pts) Oceanic crust farther from the mid-ocean ridges is:

- A) Older
- B) Saltier
- C) Younger
- D) Bluer
- E) None of the above

28. (1.00 pts) Chemosynthesis most commonly occurs where on the ocean floor?

- A) Continental shelves
- B) Hydrothermal vents
- C) Upwellings
- D) Coral reefs
- E) None of the above

29. (1.00 pts) What is the average salinity of ocean water?

- A) 20%
- B) 25%
- C) 30%
- D) 35%
- E) None of the above

30. (1.00 pts) Which of the following contains the least amount of water on Earth?

- A) Rivers
- B) Groundwater
- C) Lakes
- D) Soil
- E) Atmosphere

31. (1.00 pts) Which of the following is an example of a neritic biogenous sediment deposit?

- A) Abyssal clay

B) Siliceous ooze
C) Stromatolites
D) Phosphorite
E) Tektites
F) None of the above

32. (1.00 pts) Which of the following is an example of terrigenous sediment?

A) Abyssal clay
B) Siliceous ooze
C) Stromatolites
D) Phosphorite
E) Tektites
F) None of the above

33. (1.00 pts) Which of the following is the type of biogenous sediment that dominates in deposits below the CCD?

A) Abyssal clay
B) Siliceous ooze
C) Stromatolites
D) Phosphorite
E) Tektites
F) None of the above

34. (1.00 pts) Which of the following is an example of the least abundant sediment classification?

A) Abyssal clay
B) Siliceous ooze
C) Stromatolites
D) Phosphorite
E) Tektites
F) None of the above

35. (1.00 pts) Which of the following usually contains large proportions of foraminifera tests?

A) Abyssal clay
B) Siliceous ooze
C) Stromatolites
D) Phosphorite
E) Tektites
F) None of the above

36. (1.00 pts) Which of the following is made of layers of metal hydroxides?

- A) Abyssal clay
- B) Siliceous ooze
- C) Stromatolite
- D) Phosphorite
- E) Tektites
- F) None of the above

37. (2.00 pts) Which of the following is true regarding ocean acidification?

(Mark **ALL** correct answers)

- [ ] A) Ocean acidification has direct adverse effects on diatoms and radiolaria
- [x] B) Ocean acidification causes the ocean's pH to be closer to neutral
- [x] C) Human activity has a significant contribution to ocean acidification
- [ ] D) The ocean pH changes since the industrial revolution have had an insignificant on marine life so far
- [ ] E) Coral bleaching is a major cause of ocean acidification

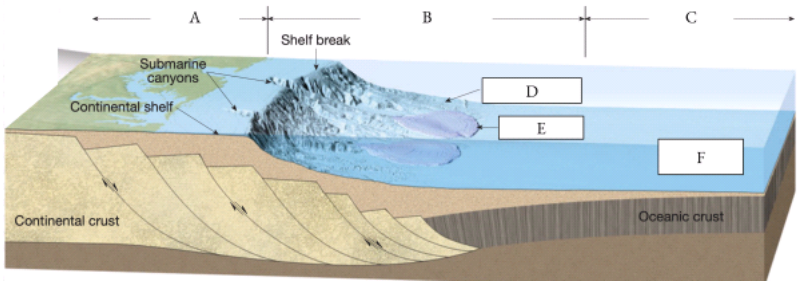
38. (1.00 pts) Which of the following statements is true? (select all that apply)

(Mark **ALL** correct answers)

- [ ] A) The poles receive more solar energy than the equator
- [x] B) The equator receives more solar energy than the poles
- [ ] C) Heat is transferred across latitudes only by ocean currents
- [ ] D) Heat is transferred across latitudes only by atmospheric winds
- [x] E) The surface mixed layer accounts for about 2% of the ocean

39. (1.00 pts) Which of the following statements is NOT true regarding the ocean floor?

- A) The average depth of the oceans is about 4.5 times greater than the average elevation of the continents
- B) Only about 5 percent of the seafloor has been mapped
- C) Radar altimeters measure subtle differences in seafloor features by bouncing microwaves off sea surface
- D) The youngest seafloor is found at mid-ocean ridges
- E) None of the above



Use the diagram below to answer the next four questions.

40. (1.00 pts) Which of the letters in the diagram above corresponds to the coastal plain?

- (●) A) A
- ( ) B) B
- ( ) C) C
- ( ) D) D
- ( ) E) E
- ( ) F) F

41. (1.00 pts) Which of the letters in the diagram above corresponds to the abyssal plain?

- ( ) A) A
- ( ) B) B
- ( ) C) C
- ( ) D) D
- ( ) E) E
- (●) F) F

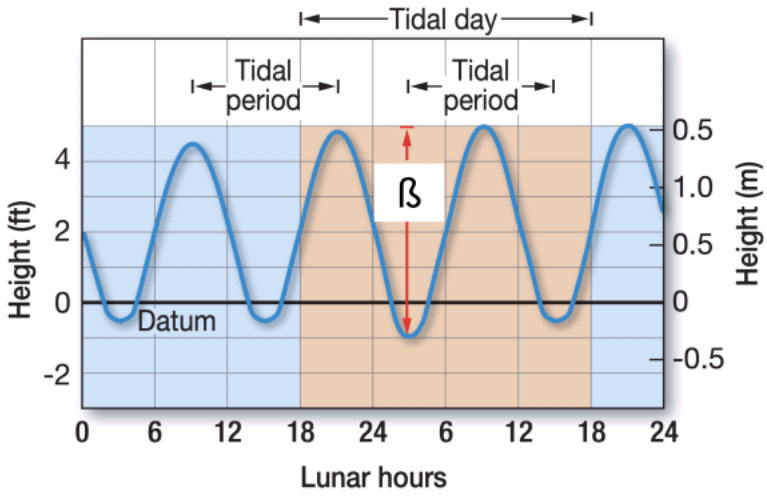
42. (1.00 pts) Which of the letters in the diagram above corresponds to the continental margin?

- ( ) A) A
- (●) B) B
- ( ) C) C
- ( ) D) D
- ( ) E) E
- ( ) F) F

43. (1.00 pts) Which of the letters in the diagram above corresponds to the deep-sea fan?

- ( ) A) A
- ( ) B) B
- ( ) C) C
- ( ) D) D
- (●) E) E
- ( ) F) F

Use the diagram below to answer the next two questions.



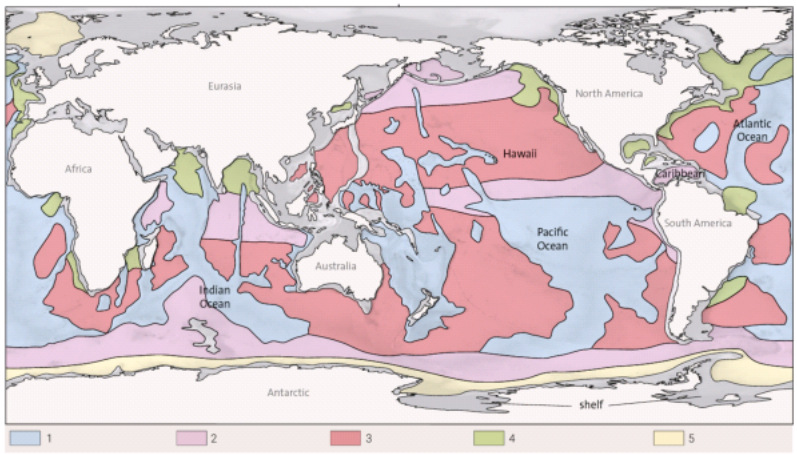
44. (1.00 pts) Which type of tidal pattern is depicted in the diagram above?

- A) Diurnal
- B) Semidiurnal
- C) Mixed
- D) None of the above

45. (2.00 pts) What is the term given to ß on the diagram above? (exactly two words)

tidal range

Use the diagram below for the following six questions.



The figure above shows a map of the distribution of various seafloor sediments. Choosing from the following list, assign each color to the correct sediment type. Not all options will be chosen.

a. Bare oceanic crust (no sediment)
b. Calcareous ooze
c. Siliceous ooze
d. Glacial deposits
e. Terrigenous sediments
f. Pelagic red clay
g. Cosmogenous tektites

46. (1.50 pts) 1 (blue): (answer ONLY with the lower case letter a-g corresponding to the correct sediment type)

b

47. (1.50 pts) 2 (pink): (answer ONLY with the lower case letter a-g corresponding to the correct sediment type)

c

48. (1.50 pts) 3 (red): (answer ONLY with the lower case letter a-g corresponding to the correct sediment type)

f

49. (1.50 pts) 4 (green): (answer ONLY with the lower case letter a-g corresponding to the correct sediment type)

e

50. (1.50 pts) 5 (yellow):

d

51. (5.00 pts) Justify why you assigned each of your answer choices.

Expected Answer: Accept any of the following justifications Calcareous ooze is present in large quantities near island chains like Hawaii Siliceous ooze is present in large quantities where there is high primary productivity and high diatom populations, like the equatorial Pacific Pelagic red clay is generally present in large areas of the deep ocean (e.g. across the Pacific) Terrigenous sediments are visibly located at the mouths of significant deltas (e.g. Mississippi, Ganges, Amazon) Glacial deposits are concentrated near the polar regions, at the edge of ice sheets

Salinity Distributions

52. (2.00 pts)

While surface currents in the North Atlantic tend to be more saline than the fresher water beneath it, the more saline water does not necessarily sink. What characteristic of the underlying water does this likely reflect?

Expected Answer: The underlying water is cold enough to be more dense than the overlying water despite being fresher.

53. (3.50 pts)

In the subtropical ocean there is a shallow salinity maximum that originates from water at the center of gyres. Name and describe the process that causes this movement of water.

Expected Answer: Ekman pumping; geostrophic flow in gyres leads to Ekman transport towards the center of the gyre, downwelling the saline surface water.

54. (2.00 pts) Compared to most of the Pacific ocean, describe the surface salinity in Southeast Asia. How is it likely to change in response to a strong El Niño phase?

Expected Answer: Lower salinity; salinity increases from less rainfall/drought.

55. (2.00 pts) Suggest why the southern regions of the Atlantic and Pacific have a similar salinity whereas the northern regions differ significantly.

Expected Answer: The southern regions of these two oceans include the Antarctic circumpolar current, which keeps those regions well mixed with each other. The northern region are separated by landmasses.

Wave Calculations

3 significant figures for all answers. Include units and show work! (4 pts each, 2 for answer, 2 for work)

56. (4.00 pts) Calculate the phase velocity of a wave with wavelength 110 meters traveling in water with depth 3.5 meters

Expected Answer: The wavelength > d * 20, so this is a shallow water wave: sqrt(gd) = sqrt(9.81*3.5) = 5.86 m/s

57. (4.00 pts) Calculate the group velocity of a wave train travelling in the open ocean with a period of 6.40 seconds.

Expected Answer: (g/4pi) T = (9.81/4pi) * 6.40 = 5.00 m/s

58. (4.00 pts) Calculate the phase velocity of a wave with wavelength 20.0 meters traveling in water with depth 150 meters.

Expected Answer: The wavelength < d * 2, so this is a deep water wave: 1.25*sqrt(λ) =1.25*sqrt(20.0) = 5.59 m/s

Heat Fluxes

Given the following constants (not all will be useful):

Albedo of Earth = 0.30

Solar constant S_0= 1370 W/m

Wein's constant b = 2.89 * 10^{-3} m * K

Stefan-Boltzmann constant = 5.67 * 10^{-3} W K^{-4} m-2

Luminosity of the sun: 3.83 * 10^{26} W

Radius of the Earth: 6.37 * 10^{6} m

59. (6.00 pts) Calculate the blackbody temperature of the Earth, in degrees Celsius. (6 pts)

Expected Answer: We can find the blackbody temperature by equating power into power out. (2 for energy balance) 4πr^2σT^4=(1-a)πr^2S0. Plugging in numbers, we find that T = -18.0 deg C (2). (2 for all work shown)

60. (6.00 pts)
Realistically, the Earth is not a perfect blackbody. The true radiant flux emitted by the Earth is, on average, about 226.56 W/m2. We can quantify the deviation from a blackbody by the emissivity ε, which is a dimensionless ratio between the true radiant flux to the ideal radiant flux of a blackbody. Given this, calculate the average emissivity of the Earth. (6 pts)

Expected Answer: Blackbody radiant flux of Earth: σT^4=239.74 W/m^2 (2). Then, we divide 226.56/239.74 = 0.9450 (2). (2 for all work shown)

61. (4.00 pts) Would you expect the emissivity of the ocean to be close to 1? Why or why not? (4 pts)

Expected Answer: Emissivity is essentially a measure of how well an object can radiate away thermal radiation. Given that the ocean is relatively dark, uniform, and smooth (2), we can expect the emissivity of the ocean to be close to 1 (2). Indeed, the emissivity of ocean water is usually given to be 0.96-0.97. (accept any reasonable explanation)

62. (4.00 pts)

When discussing the heat lost from the ocean, we frequently refer to both latent heat loss and sensible heat loss. Distinguish between these two terms and provide examples for th processes that drive each. (4 pts)

Expected Answer: Latent heat loss refers to heat loss during phase changes, e.g. evaporative cooling (2). Sensible heat loss refers to heat loss through direct heat transfers like conduction and convection/advection (2 for either).

Seawater chemistry

63. (2.00 pts) What is the dominant ion that buffers ocean pH?

Expected Answer: HCO3- (bicarbonate)

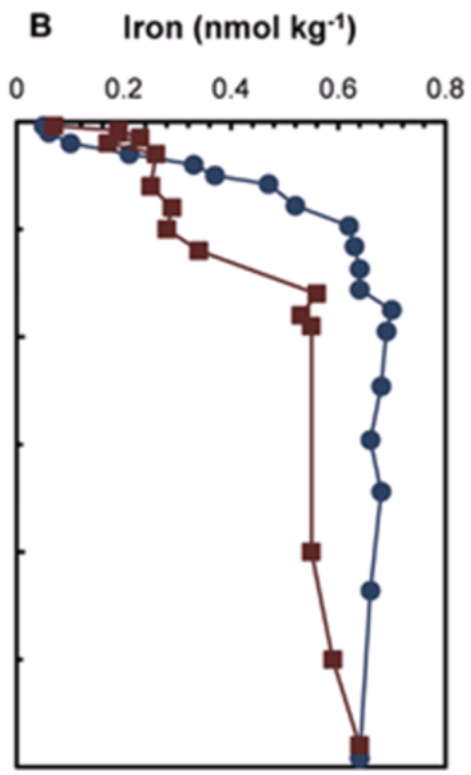
For the following two questions, identify where the CCD would be deeper, and justify why. (3 pts each)

64. (3.00 pts) The equator or 55 deg. N

Expected Answer: The equator has a significantly deeper CCD (1) because warmer waters decreases the solubility of CO2. Further, greater productivity and more carbonate tests leads to deeper carbonate saturation, which thus deepens CCD. (2 for either explanation)

65. (3.00 pts) Present-day oceans or oceans during the Cretaceous period

Expected Answer: Current oceans have a deeper CCD (1) because current atmospheric CO2 is lower than the atmospheric CO2 during the Cretaceous (2).



Above is the chemocline for iron. The red and blue represent data from the Atlantic and Pacific Oceans respectively.

66. (1.00 pts) What is plotted on the y axis?

Expected Answer: Depth

67. (4.00 pts)
Based on this figure, justify why ocean fertilization projects have looked at iron as a potential nutrient for inducing planktonic carbon capture. Start by classifying iron as either a bio limiting, a conservative, or a scavenged nutrient.

Expected Answer: We see that iron concentration significantly increases with depth (1). This indicates that iron is a very bio-limiting nutrient (1). Plankton need iron to perform photosynthesis, as it is an essential nutrient, but they only require extremely minimal amounts (1). Thus, ocean fertilization with iron at the surface can significantly boost the productivity of phytoplankton (1).

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