# DYNAMIC PLANET C

## SSSS 2020-2021

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TEAM NAME: _____ TEAM NUMBER: _____

PARTICIPANTS: _____ AND _____

This test consists of 3 parts.

- Part 1: True or False **[20 pts total]**
- Part 2: Multiple Choice **[80 pts total]**
- Part 3: Extended Response **[92 pts total]**

SCORE: ____/192

# Part 1 [True/False] – 1pt each

1. Average ocean salinity is 35 parts per thousand [T/F]
2. In the presence of thick clouds, the majority of shortwave radiation is reflected [T/F]
3. Sea surface temperature remains consistent wherever you measure it [T/F]
4. There are 4 major ocean basins [T/F]
5. Basalt is the main rock type found in oceanic crust [T/F]
6. Salinity changes rapidly with depth in the halocline [T/F]
7. Atolls are formed when longshore currents strike the beach at an angle [T/F]
8. Wave height is unaffected by fetch. [T/F]
9. Objects are deflected to the left in the southern hemisphere due to the Coriolis effect [T/F]
10. Geostrophic currents are a result of the balance between pressure gradient and Coriolis force [T/F]
11. Upwelling leads to surface water becoming nutrient deficient [T/F]
12. Deep ocean currents are primarily affected by temperature and salinity [T/F]
13. Meteorological tides result from gravitational effects [T/F]
14. The rate of sea level rise is not the same everywhere [T/F]
15. Niskin bottles are designed to obtain samples of water at a specific depth [T/F]
16. Phases of the pacific decadal oscillation typically lasts for 12 to 15 years [T/F]
17. The equation for the speed of an intermediate (transitional) water wave is $\sqrt{\frac{gL}{pa}\tanh\left(\frac{d}{T}\right)}$ [T/F]
18. Wave speed is more correctly known as celerity [T/F]
19. Concentrations of mercury (Hg) can be used as a powerful tracker of oceanic processes [T/F]
20. The rate at which pressure increases as you descend in the ocean is exponential [T/F]

## Part 2 [Multiple Choice] – 2pts each

21. Which of the following is correct about seawater salinity?
    a. Sea surface salinity increases as you move towards the poles
    b. It has a greater impact on density than temperature
    c. Salinity does not affect pH
    d. Freshwater is denser than sea water

22. Place the following ionic constituents of seawater in order of highest to lowest concentration in typical seawater. Bromide ($Br^-$), Fluoride ($F^-$), Chloride ($Cl^-$), Calcium (Ca).
    a. $Cl^-$, $Br^-$, Na, Ca, $F^-$
    b. $Cl^-$, Na, Ca, $Br^-$, $F^-$
    c. Na, Ca, $Br^-$, $F^-$, $Cl^-$
    d. Na, $Cl^-$, $Br^-$, Ca, $F^-$

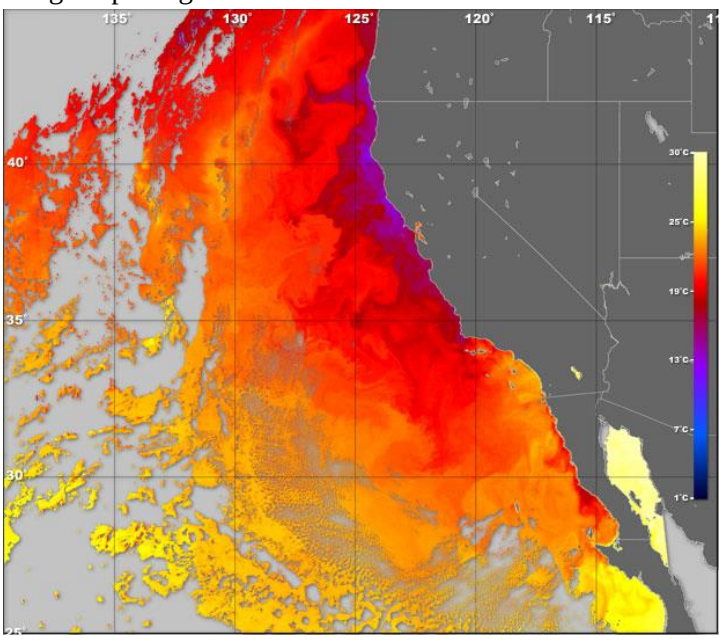
23. Which of the following is a result of water's high specific heat capacity?
    a. Its effects help to moderate temperatures near large bodies of water
    b. It is known as a universal solvent
    c. It creates surface tension
    d. Its effects contribute to the formation of common weather patterns

24. The Redfield ratio of 106:16:1 describes the near constant ratio of _____ : _____ : _____ in the deep ocean.
    a. Oxygen : Sodium : Fluoride
    b. Carbon : Nitrogen : Phosphorus
    c. Carbon : Sodium : Nitrogen
    d. Oxygen : Phosphorus : Fluoride

25. Primary coasts are…
    a. Found where the ocean's energy tears apart rock outcrops on a shoreline
    b. Generally young and shaped by terrestrial processes
    c. Generally older and shaped mainly by ocean processes
    d. Characterized by abundant sediment supply that results in the net deposition of sediment

Eastern boundary currents flow from high latitudes down to the equator. The following image is composed of Sea Surface Temperature (SST) data from the MODIS instrument aboard a NASA satellite. The reds and oranges represent higher SSTs while the blues and purples (near the coast) represent lower SSTs.

Image depicting the California Current




26. From the image above, specifically the purple region by the Californian coast, what process can you infer as occurring?
    a. A decrease in salinity
    b. Coastal upwelling
    c. A decrease in pH
    d. Coastal downwelling

27. Which of the following best describes water beneath the thermocline?
    a. Highly variable in temperature
    b. Warmer than most surface waters
    c. Relatively uniform and cold in temperature
    d. Variable by latitude

28. Terrigenous sediments are commonly found…
    a. Spread throughout the ocean floor
    b. In the central region of ocean basins
    c. Near the shoreline of continents
    d. They are spread out evenly in the ocean

29. Oxygen minimum zones, as the name suggests, are areas of low oxygen concentration in the oceans. These areas are normally found at depths of 200m to 1500m. Oxygen minimum zones typically occur along the _____ of continents due to _____.
    a. West coast; upwelling
    b. West coast; downwelling
    c. East coast; upwelling
    d. East coast; downwelling

30. The majority of earthquakes occur along/within the…
    a. Circum-superior belt
    b. Neritic zone
    c. Circum-pacific belt
    d. Sino-Japanese region

31. _____: An isolated undersea hill or mountain.
    a. Isthmus
    b. Guyot
    c. Seamount
    d. Tombolo

32. The presence of siliceous sediments in sediment cores allow paleoclimatologists to identify if…
    a. There had been a meteorite impact
    b. Ocean environments were relatively cool
    c. Maine life had developed yet
    d. There were ancient deposits of minerals

33. A container of oxygen at sea level contains 100L of air. The container is lowered to a depth of 500 meters. Calculate its new volume.
    a. 0.52L
    b. 5L
    c. 0.2L
    d. 2L

34. Climate change can lead to which of the following?
    a. Increased average ocean pH
    b. Less extreme weather patterns
    c. Expanding oxygen minimum zones
    d. Increased biodiversity due to speciation

Imagine that you have a personal yacht, and you decide to go off the Southern tip of South Africa for a swim. After some diving, you realize that you forgot to anchor down your boat!

35. If the wind is blowing due north, in which general direction should you start looking?
    a. North
    b. East
    c. South
    d. West

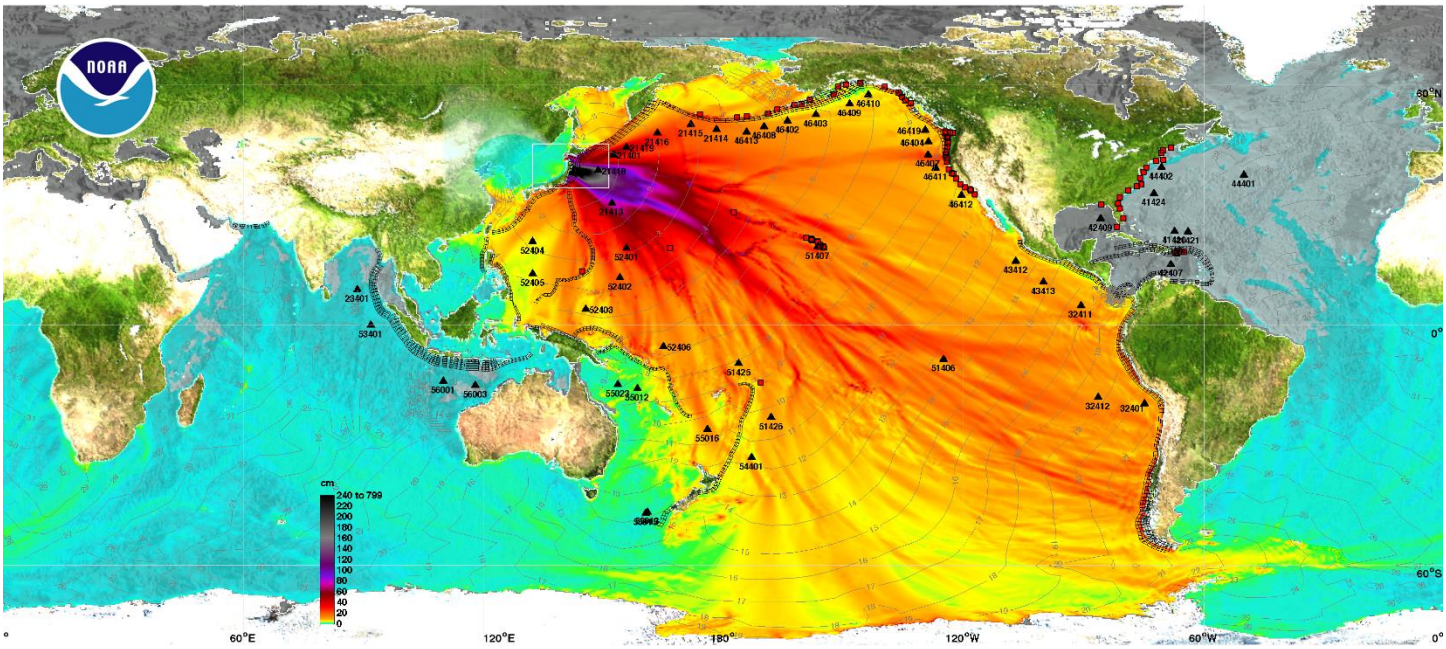
36. The Wilson Cycle refers to the…
    a. Lifecycle and evolution of ocean basins
    b. Recurring cycle of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin
    c. Monthly tidal cycle of 29½ days
    d. The processes by which carbon and nitrogen nutrients are cycled throughout oceanic ecosystems

37. Bjerknes feedback describes how…
    a. Positive SST anomalies in the Pacific reduces the east-west SST gradient, strengthening Walker circulation, in turn enhancing positive SST anomalies.
    b. Ocean-atmosphere interactions results in the Hadley Circulation Cell
    c. Warm SSTs increases evaporation rates, the extra water vapor absorbs more heat, → higher temperatures → warmer SSTs
    d. Warming temperatures will result in events that lead to further warming

38. The following image depicts a…

    a. Rip tide
    b. Rip current
    c. Undertow
    d. Longshore current

Tōhoku Earthquake and Tsunami – March 11, 2011




39. What does the image above highlight?
    a. The spread of radiation from the Fukushima Daiichi nuclear disaster due to the Tōhoku Tsunami
    b. Maximum wave amplitudes from the Tōhoku Tsunami
    c. Areas of high tectonic activity
    d. Concentrations of the radioactive particle Cesium-137

40. The bending of waves around an obstacle is known as _____.
    a. Wave train
    b. Wave dispersion
    c. Wave diffraction
    d. Wave shoaling

Oh no! An earthquake was just reported off the coast of Seward Alaska. The earthquake has produced a tsunami at a depth of 4000 meters with a wavelength of 400 km.

41. Estimate the speed of the tsunami (in km/h) and the time it will take for the tsunami to reach Kodiak, Alaska (310 km) and Kauai Island, Hawaii (4300 km)
    a. 284 km/h; 1 hour 5 minutes; 15 hours
    b. 198 m/s; 1 hour 34 minutes; 22 hours
    c. 713 km/h; 26 minutes; 6 hours
    d. 62 km/h; 5 hours; 70 hours

42. A hypothetical wave traveling along a section of the Pacific Ocean (depth of 2500 meters) has a wavelength of 150 meters. What type of wave is it? And roughly what speed is it traveling at?
    a. Deep Water Wave; 15.296 m/s
    b. Deep Water Wave; 156.525 m/s
    c. Shallow Water Wave; 15.296 m/s
    d. Shallow Water Wave; 156.525 m/s

43. If the wind is traveling south, where would downwelling hypothetically occur?
    a. The east coast of Mozambique
    b. The west coast of the United States
    c. The west coast of Chile
    d. The west coast of Portugal

44. Which of the following are responsible famous surfing waves off the west coast of the US?
    a. Diurnal tides
    b. Meteorological tides
    c. Semi-diurnal tides
    d. Mixed tides

45. Tidal resonance effects are greatest when…?
    a. The wavelength is 1/7 the basin's length
    b. The wavelength is 1/2 the basin's length
    c. The basin's length is 1/8 wavelength
    d. The basin's length is 1/4 wavelength

46. Waves at the surface of the ocean are classified as _____ waves.
    a. Medial
    b. Longitudinal
    c. Orbital waves
    d. Rotational

47. Below is a list of geographic locations paired with continental margins classified as either "passive" or "active" margins. Which of the following is incorrectly paired?
    a. East coast of India; Active margin
    b. West coast of Japan; Active margin
    c. East coast of Australia; Passive margin
    d. West coast of Chile; Active margin

48. We can envision tides as a point on Earth rotating through two _____ caused by gravity from the Moon and Sun, and inertia.
    a. Tidal waves
    b. Swells
    c. Elliptic declinations
    d. Tidal bulges

49. What oceanic tool used for research is shown in the image above?
    a. Bathyphotometer
    b. CTD Sensor
    c. Acoustic Doppler Current Profiler
    d. Niskin bottles

50. What are piezolytes responsible for in deep sea organisms?
    a. Preventing cell membranes from solidifying
    b. Making echolocation possible
    c. Helping them withstand the pressure
    d. Optimizing the absorption of oxygen

51. The historic average for ocean pH is ~8.16. Due to excessive greenhouse gas emissions, it is now ~8.07 today. Calculate the change in pH.
    a. 1.46
    b. 1.01
    c. 1.53
    d. 1.23

52. James Cameron is attributed for…
    a. Being the first person to solo dive to the deepest part of the Mariana trench
    b. Setting a record for the deepest dive without a tether
    c. Discovering and exploring the wreckage of the RMS Titanic
    d. None of the above

53. A hypothetical wave is traveling along a section of the Australia with a depth of 800 meters. This wave has a wavelength of 4800 meters. What speed is this wave traveling at?
    a. 113.87 m/s
    b. 86.53 m/s
    c. 76.45 m/s
    d. 88.54 m/s

54. Which of the following is not a tidal constituent?
    a. Principal lunar semi-diurnal
    b. Principal lunar semi-annual
    c. Lunar fortnightly
    d. Elliptical lunar semi-diurnal

55. The rate at which a wave loses its energy is _____ to its _____.
    a. Inversely proportional; Velocity
    b. Proportional; Depth
    c. Proportional; Period
    d. Inversely proportional; Wavelength

56. How do cold core eddies affect tropical cyclones?
    a. CCE's weakens their intensity and limits their development
    b. They increase barotropic instability which inevitably strengthens TCs
    c. The cold water of CCEs enhances the temperature gradient that leads to TCs
    d. They do not affect tropical cyclones

# Part 3 [Extended Response] – Point Values Indicated

57. As you know, our climate is a vastly complex system with a multitude of inputs. Two of these inputs are ENSO and PDO. Depending on their phase, they can have widely varying effects, from increasing droughts to flooding. All of which have very tangible economic effects. **[12 pts total]**
    a. Identify a major difference between ENSO and PDO. **[1 pt]**

    b. What climate variations occur when both processes are in sync (Southeast US)? **[2 pts]**

    c. Describe the relationship between trade winds and La Niña and its effects **[2 pts]**

    d. Using your knowledge of how the thermocline interacts with warm/cool water, predict how the general structure of the thermocline will change during an El Niño year. **[3 pts]**

    e. Climate change denialists tend to perpetrate the myth that "climate change" is merely a phase of the PDO. Explain why this is untrue. Provide specific evidence. **[4 pts]**

58. There are three major theories for the formation of barrier islands. Two of these theories are the Offshore Bar Theory (1845), proposed by Elie de Beaumont and the Spit Accretion Theory (1885), proposed by Grove Karl Gilbert. Please answer the following questions. **[6 pts total]**
    a. Name the third major theory, who proposed it, and when it was proposed. **[1 pt]**

    b. Briefly explain the importance of barrier islands **[2 pts]**

    c. Predict the effects on barrier reefs if sea levels continue to rise (Assume above normal rate of sea level rise) **[3 pts]**

59. During the time around 1819-1822, Alexander Marcet performed some of the first measurements of the concentrations of major salts in seawater. These observations would later be formulated into what is known as Marcet's principle. **[12 pts total]**
    a. Provide a rough run down of Marcet's principle. **[3 pts]**

    b. Explain the use of Marcet's Principle when measuring salinity. **[2 pts]**

    c. State another possible name for this general principle. **[1 pt]**

    d. When does this principle hold true? Your answer must reference residence time. **[2 pts]**

    e. Identify two elements/ions that holds true with Marcet's principle and their residence times. **[1 pt]**

    f. Name two areas and/or circumstances where this principle does not hold true. And provide an explanation as to why this is. **[3 pts]**

60. Climate change is undeniably one of the greatest threats of the century. By 2050, it is estimated that there will be over 200 million climate refugees globally. Its effects on land will be/are devastating, but just as devasting are its effects to the ocean. Please answer the following questions **[8 pts]**
    a. Explain the difference between shortwave and longwave radiation and relate this back to the greenhouse effect. **[3 pts]**

    b. According to the IPCC's 5th Assessment Report, since the 1970s over 90% of excess heat trapped by greenhouse gasses have been absorbed by the ocean. Why is this? [**4 pts]**

    c. Under a high emissions scenario (RCP8.5), how much will sea levels rise by 2100? **[1 pt]**

61. Aside for their beauty, coral reefs are hosts to some of the most diverse ecosystems on the planet. Despite covering less than 1% of the ocean's floor, they contain nearly 25% of all known marine species. Please answer the following questions on coral reefs. **[9 pts total]**
    a. List the three major types of coral reefs. Additionally, who proposed the Subsidence Hypothesis of Coral Reef Development? **[2 pts]**

    b. Identify a primary cause of coral bleaching and expand upon it. Additionally, assuming business as usual, what percentage of corals will be dead within the next 20 years? **[3 pts]**

    c. Use the following four chemical reactions to both explain how increasing levels of $CO_2$ relates to ocean acidification and identify how an overabundance of $CO_2$ leads to the stymieing of coral growth **[4 pts]**

| | | | |
|---|---|---|---|
| $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ | $H_2CO_3 \rightarrow H^+ + HCO_3^-$ | $CO_3^{2-} + Ca^{2+} \rightarrow CaCo_3$ | $CO_2 + H_2O \rightarrow H_2CO_3^-$ |

62. One defining feature standing in the way of the exploration of the ocean is pressure. The immense pressures make it virtually impossible to even begin exploring the ocean depths without a pressurized vehicle. Answer the following questions on pressure **[8 pts total]**
    a. What factors does pressure within a liquid depend on? **[2 pts]**

    b. Many fish species that live in the Epipelagic and Mesopelagic zones have swim bladders (gas filled organ) that allows them to control their buoyancy. However, may organisms living below the upper layers of the ocean do not a have swim bladder. Using your understanding of pressure, explain why this is. **[3 pts]**

    c. Black smokers are a type of hydrothermal vents that can emit water with upwards of 350°C. Despite this being considerably above boiling point, the water emitted from these vents remain in as a liquid. Hypothesize as to why this is and justify your claim. **[3 pts]**

63. The importance of the study and understanding of tides affects tasks ranging from the study of sea levels to coastal navigation. Not only that, but by placing a dam of sorts in bays and estuaries, tidal energy can be harnessed. Please respond to the following questions on tides. **[10 pts total]**
    a. Why tides are considered shallow water waves. **[1 pt]**

    b. If focused only on the Equilibrium (Static) Theory of Tides, one would expect any given location to experience high tide twice a day. However this is not the case. Explain why this is. **[3 pts]**

    c. Based on what you identified in part (b), describe the general path of a tide in the Northern Hemisphere. Fully (in detail) explain your reasoning. **[4 pts]**

    d. Renewable energy is now in more demand than ever. Identify one location that can provide a strong source of tidal energy and justify your choice. **[2 pts]**

64. Estuaries, commonly referred to as the "nurseries of the sea" are not only important to wildlife but also provide incredible economic benefits, including but not limited to tourism, fisheries, and areas for recreational activities. Please answer the following questions on estuaries. **[9 pts total]**
    a. Based on the densities of freshwater and seawater, describe the pattern of circulation of water in and out of an estuary. **[3 pts]**

    b. On a geologic timescale the majority of estuaries are actually quite young (>10,000 years old). Briefly explain why this is so. Provide evidence. **[3 pts]**

    c. Following the arrival of the Mäori in what is now known as New Zealand and the eventual arrival of European settlers, large swaths of forests were cleared to make way for farmland. Predict the effects of deforestation on local estuaries. **[3 pts]**

65. From surfing to tsunamis, waves can be anything from a source of recreation to a deadly force. And although uncommon, some waves have been recorded with heights in excess of 34 meters (USS Ramapo). Answer the following questions. **[18 pts]**
    a. The wave height of a wind generated wave is a function of… **[2 pts]**

    b. After a equilibrium condition called a fully developed sea is achieved, waves can no longer grow. Briefly state why this is. **[2 pts]**

    c. As a wave enters shallower water, its wavelength generally decreases while its height increases. Explain why this is. **[3 pts]**

    d. Following part (c), describe the conditions that results in a wave breaking **[3 pts]**

    e. The group velocity for deep water waves is about 1/2 the phase velocity. While with a shallow water wave, the group velocity is equal to the phase velocity. Hypothesize as to why this is and justify your answer. (HINT: Wave dispersion) **[4 pts]**

    f. Based on the formula for the velocity of an idealized wave (presumably the same formula you used to solve question #53) demonstrate how you can derive the formula for a shallow water wave from it. Show and explain all steps. **[4 pts]**