

Welcome to 2020 Camas Invitational!

You are about to embark on a **Dynamic Planet adventure.**

You have 50 minutes from the time you start to submit your completed test. If you have not submitted your responses at the end of that time, your responses will be submitted automatically.

1. (1.00 pts) The deepest trench we know of is the Mariana Trench.

☒ True ☐ False

2. (3.00 pts) Name the three features of the continental margin.

Expected Answer: 1pt for each Continental Shelf Continental Slope Continental Rise

3. (5.00 pts) Describe what a mid-ocean ridge is and how it forms.

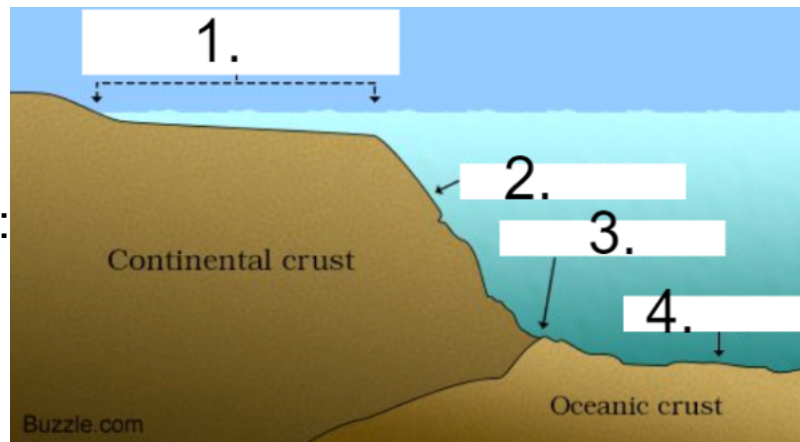
Expected Answer: 2 points for what a mid-ocean ridge is 3 points for the description of the formation A mid-ocean ridge, or mid-oceanic ridge, is an underwater mountain range formed by diverging tectonic plates. As tectonic plates diverge, a rift forms. This rift allows for molten rock to rise to the seafloor. As the molten rock rises to the seafloor, it cools and creates new crust. This process, over time, creates ridges in the ocean above the fault line and these ridges are called mid-ocean ridges.

4. (2.00 pts) What evidence convinced scientists that ocean plates diverge at midocean ridges?

Expected Answer: matching paleomagnetic bands on either side of ridges

5. (4.00 pts) Label 1-4 on Image B.

Image B:



Expected Answer: 1 pt for each 1. Continental Shelf 2. Continental Slope 3. Continental Rise 4. Abyssal Plain

6. (9.00 pts) Name each stage of the Wilson Cycle in order and briefly describe what happens at each one.

Expected Answer: MUST BE IN THIS ORDER 0.5 pt for correct order and name 1 pt for each correct description 1. Embryonic- There is a stable Continental Craton, which has a hot spot just underneath. This warm hot spot heats up the craton and causes it to swell upwards and the crust begins to crack. 2. Juvenile- The spreading of earth plates starts and a small ocean forms between the newly broken up continents. The edges of both continents will sink below the newly formed sea. 3. Mature- A large ocean has formed between two continental margins and spreading still occurs. A mid ocean ridge will have formed. 4. Declining- A subduction zone has formed and the ocean begins to close up. A subduction zone forms at the edge of a continent. 5. Terminal- The continents are almost colliding. Formation of magma happens in the subduction zone and small mountains build up. Both metamorphism and faulting occur. 6. Suturing- The two continents moving towards each other will collide and a mountain chain forms.

7. (2.00 pts) Rank the following categories of water by increasing salinity

- ☐ A) Brine, brackish, saline, seawater
- ☐ B) Brackish, brine, saline, seawater
- ☒ C) Brackish, saline, brine, seawater
- ☐ D) Brine, brackish, seawater, saline
- ☐ E) Brackish, seawater, brine, saline

8. (2.00 pts) What is the average salinity of seawater?

- ☐ A) 1%
- ☒ B) 3.5%
- ☐ C) 5%
- ☐ D) 6.8%

☐ E) 8.9%

9. (2.00 pts) The current standard for ocean water salinity is:

- ☐ A) Practical Salinity Scale
- ☒ B) Reference Salinity Scale
- ☐ C) Revised Salinity Scale
- ☐ D) Standard Salinity Scale
- ☐ E) Normal Salinity Scale

10. (1.00 pts) Seawater density increases as you go deeper in the ocean.

☒ True ☐ False

11. (6.00 pts) Identify the six main salts found in sea water in order from highest to lowest composition by mass.

Expected Answer: MUST BE IN THIS ORDER 1 pt for each 1. Chloride 2. Sodium 3. Sulfate 4. Magnesium 5. Calcium 6. Potassium

12. (2.00 pts) What is the typical range of density for seawater?

- ☐ A) 995-1010kg/m³
- ☐ B) 1010-1018 kg/m³
- ☒ C) 1020-1027 kg/m³
- ☐ D) 1035-1044 kg/m³
- ☐ E) 1045-1051 kg/m³

13. (3.00 pts) Give a thorough explanation of how precipitation causes the salinity of the ocean to increase.

Expected Answer: When slightly acidic rainwater falls on land, it physically and chemically breaks down rocks and carries salts and minerals away as ions. Rivers carry these ions in runoff into the ocean. Ocean organisms use many of these ions. Unused ions build up in the ocean, increasing salinity.

14. (1.00 pts) The primary input to the oceanic heat budget is geothermal heat.

☐ True ☒ False

15. (2.00 pts) To what depth does shortwave radiation penetrate ?

- ☐ A) 100-1000m
- ☐ B) 0.1-1m
- ☐ C) 0.01-0.1m
- ☒ D) 1-100m
- ☐ E) 1000-10000m

16. (2.00 pts) Water is almost _____ to longwave radiation.

- ☐ A) Translucent
- ☒ B) Opaque
- ☐ C) Hazy
- ☐ D) Transparent
- ☐ E) Colorless

17. (2.00 pts) What is the average temperature of ocean surface waters?

- ☐ A) 16°C (60.8°F)
- ☒ B) 17°C (62.6°F)
- ☐ C) 18°C (64.4°F)
- ☐ D) 19°C (66.2°F)
- ☐ E) 20°C (68.0°F)

18. (2.00 pts) What is the definition of advection?

- ☒ A) The bulk transport of heat, mass, or some of a substance.
- ☐ B) Heat transfer in a gas or liquid by the circulation of currents from one region to another.
- ☐ C) An introduction of something from an outside source.
- ☐ D) A physical movement of water; if in the ocean, called an ocean current, which can be further subdivided into surface currents and deep currents.
- ☐ E)

A process by which materials move through fluids by random molecular movement from areas of high concentration to areas in which they are in lower concentrations, thus becoming evenly distributed.

19. (2.00 pts) Order the three main layers of the ocean from top to bottom:

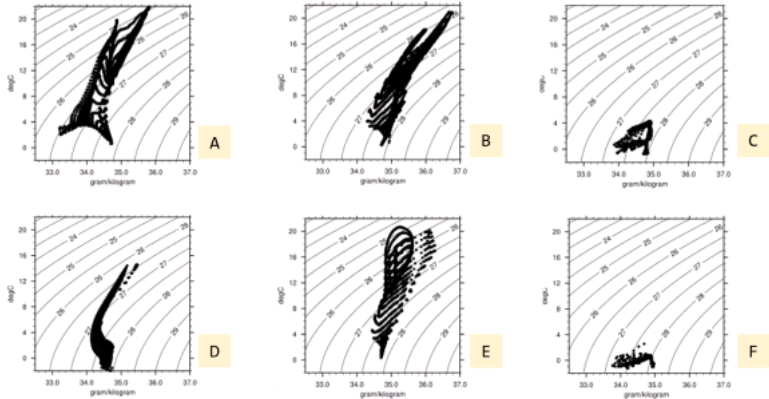
- ☐ A) Deep, Mixed, Pycnocline
- ☐ B) Mixed, Deep, Pycnocline
- ☐ C) Pycnocline, Mixed, Deep
- ☐ D) Pycnocline, Deep, Mixed
- ☒ E) Mixed, Pycnocline, Deep

20. (3.00 pts) Differentiate between pycnocline, halocline, and thermocline.

Expected Answer: 1 pt for each Pycnocline: The pycnocline encompasses both the halocline (salinity gradients) and the thermocline (temperature gradients) refers to the rapid change in density with depth. Goes to about 1km in depth. Halocline: The region where salinity changes sharply with depth. Thermocline: A thin but distinct layer in a large body of

fluid in which temperature changes more rapidly with depth than it does in the layers above or below.

21. (3.00 pts) Identify the letter for these three oceans, in order: Pacific, Atlantic, Indian.



A

B

E

22. (3.00 pts) Identify the following three oceans by letters in the image of the previous question: Southern Ocean, Arctic Ocean, Labrador Sea.

D

F

C

23. (2.00 pts) These are all aspects of upwelling **EXCEPT**:

- ☐ A) It is wind-driven.
- ☐ B) It consists of the motion of cool nutrient-rich water towards the surface.
- ☒ C) Cool water at the surface is displaced by water coming up towards the surface.
- ☐ D) Nutrientless water at the surface is displaced by water coming towards the surface.
- ☐ E) It is the opposite of downwelling.

24. (1.00 pts) Are you more likely to see downwelling occur at colder waters or warmer waters?

Expected Answer: Colder

25. (2.00 pts) State which way gyres travel in the Northern and Southern Hemispheres.

Expected Answer: 1 pt for each Northern: Clockwise Southern: Counterclockwise

26. (2.00 pts) The motion of individual water molecules in a wave is

- ☐ A) Straight Forward
- ☐ B) Random
- ☐ C) Up and Down
- ☐ D) Side to Side
- ☒ E) Circular

27. (2.00 pts) Waves on the surface of the ocean are considered _____ waves.

- ☐ A) Transverse
- ☐ B) Rotational
- ☐ C) Longitudinal
- ☐ D) Medial
- ☒ E) Orbital

28. (2.00 pts) Which is true of a wave as it approaches the shore?

- ☒ A) Its frequency stays constant
- ☐ B) Its wavelength stays constant
- ☐ C) Its amplitude stays constant
- ☐ D) Its velocity stays constant
- ☐ E) All 4 of these quantities stay constant
- ☐ F) None of these quantities stays constant

29. (2.00 pts) Give a thorough explanation of longshore currents.

Expected Answer: A longshore current is an ocean current that moves parallel to shore. It is caused by large swells sweeping into the shoreline at an angle and pushing water down the length of the beach in one direction.

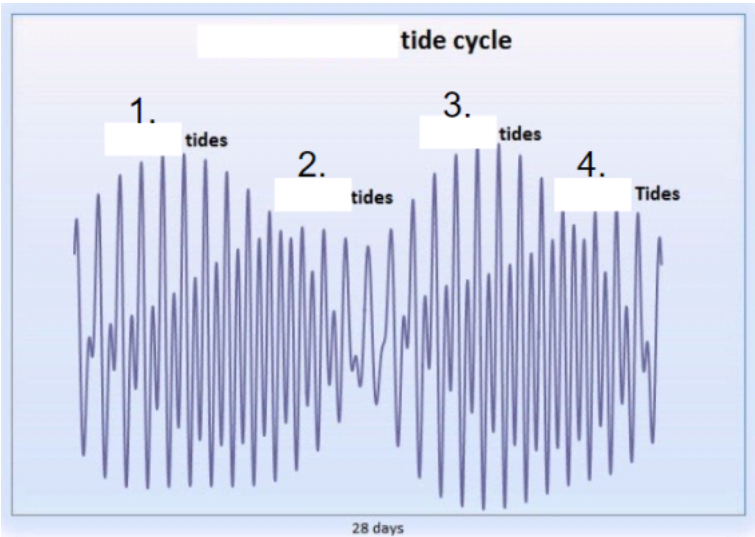
30. (1.00 pts) Wave refraction is when waves in shallow water become bent and begin to run perpendicular to the shoreline.

- ☐ True
- ☒ False

31. (4.00 pts)

Label 1-4 on Image A.

Image A:



Expected Answer: 1 pt for each 1. Spring 2. Neap 3. Spring 4. Neap

32. (1.00 pts) The critical ratio of wave height to wavelength is 1:7.

☒ True ☐ False

33. (2.00 pts) A wave has a speed of 9.8 m/s and a period of 20 seconds. What is its wavelength?

Expected Answer: $9.8 = \text{wavelength} / 20$ wavelength = 196m

34. (2.00 pts) A certain wave has a wavenumber, k , of 0.628 feet and amplitude 0.625 feet. Can this wave exist?

Expected Answer: 1 pt for Yes 1 pt for ratio being less than 1/7. $0.628 \text{ feet} = 2\pi / \text{wavelength}$ wavelength = 10 feet $10 / (2 * 0.625) = 0.125$ Answer: Yes, $0.125 < 0.143$

35. (4.00 pts)

Tsunami André, formed by an earthquake off the coast of Candyland, hits Waffleland after 7.8 hours. Candyland and Waffleland are 4200 km away from each other. Assuming the average wavelength of a tsunami is 200 km, what is the wave period of this tsunami **in minutes**? Round to 2 significant figures.

Expected Answer: $4200\text{km}/7.8\text{hour} = 538.46\text{ km/hr}$ $538.46 = 200/T$ $T = 22\text{ minutes}$ 1/2 points if answer is in anything but minutes. (22 min = 0.37 hr = 1337 s)

36. (2.00 pts) Where are the rates of sediment accumulation highest?

- ☐ A) Beneath the equator
- ☒ B) Near the mouths of large rivers
- ☐ C) Along the mid-ocean ridge
- ☐ D) In the deep sea, far from land
- ☐ E) Near the edge of glaciers

37. (2.00 pts) Turbidity currents produce all of the follow **EXCEPT**:

- ☒ A) Underwater seamounts
- ☐ B) Fans
- ☐ C) Graded Deposits
- ☐ D) Submarine Canyons
- ☐ E) None of the above

38. (2.00 pts) What is isostasy?

- ☐ A) The process in which waves grow larger as the sun sets.
- ☒ B) A condition of equilibrium in which Earth's crust floats on the mantle.
- ☐ C) An effect that occurs as surface current flows past an island and causes surface water to be carried away from the island on the downcurrent side.
- ☐ D) The period of time associated with the peak of low tide when there is no visible flow of water into or out of bays and rivers.
- ☐ E) Long journeys undertaken by many marine species for the purpose of successful feeding and reproduction.

39. (1.00 pts) What does SONAR stand for?

Expected Answer: Sound Navigation and Ranging

40. (8.00 pts) Give one sentence describing the following Oceanic Tools:

- a. Bailer-
- b. Dipper-
- c. Level Loggers-
- d. Pressure Loggers-

- e. Dredges-
- f. Acoustic Doppler Current Profiler (ADCP)-
- g. BIOMAPER-
- h. Gravity Corer-

Expected Answer: 1 pt for each Bailer- Hollow tube apparatus used to retrieve groundwater samples. Dipper- Sampling containers attached to long handles for retrieving liquid samples from a distance. Level Loggers- Tools for measuring water level. Pressure Loggers- Measures the pressure levels of water sources. Dredges- An apparatus for bringing up objects or mud from a river or seabed by scooping or dragging. Acoustic Doppler Current Profiler (ADCP)- Measures how fast water is moving across an entire water column. BIOMAPER- Used to learn about phytoplankton and zooplankton over areas that are too large to study with the traditional net-and-microscope method. Gravity Corer- Instrument for collecting sediment cores from coastal and deepwater sites for sample analysis.

41. (2.00 pts) What does the Alvin do?

Expected Answer: Alvin is a 3-person research submersible that takes scientists deep into the ocean. They can also use Alvin's equipment to sample rocks, sediment, fluids, and sea life.

42. (4.00 pts) What is the EM 300 system, what does it do, and how does it work?

Expected Answer: 1 pt for definition 2 pts for what it does 1 pt for how it works The EM300 system is a system used to obtain detailed maps of the seafloor. EM300 can be used in water as shallow as 10 meters and as deep as 5000 meters. The EM300 system is very helpful to scientists mapping volcanic seamounts and mid-ocean ridges, as well as submarine volcanoes near subduction zones and hot spot ocean island chains. The EM300 system is also applicable to marine biological habitat analysis. It works by sending out pings of 30 kHz acoustic energy, pulsing the seafloor with a series of soundings perpendicular to the track of the vessel. The EM300 system collects information about the relative hardness of the seafloor (sediment vs. lava) by measuring the amplitude of the echoing sound waves.

43. (1.00 pts) What does ENSO stand for?

Expected Answer: El Niño-Southern Oscillation

44. (2.00 pts) Differentiate between El Niño and La Niña.

Expected Answer: 1 pt for each El Niño: The large-scale ocean-atmosphere climate interaction linked to a periodic warming in sea surface temperatures across the central and east central Equatorial Pacific. La Niña: La Niña episodes represent periods of below-average sea surface temperatures across the east-central Equatorial Pacific. Global climate La Niña impacts tend to be opposite those of El Niño impacts.

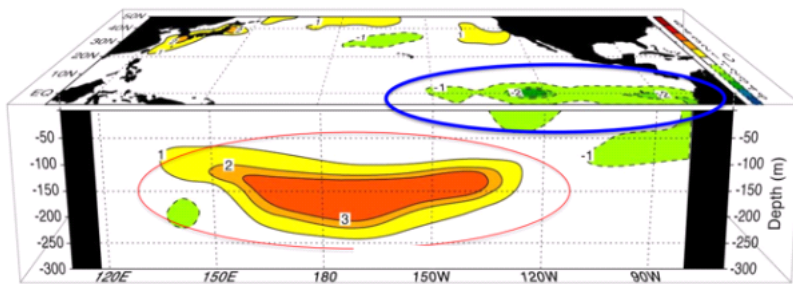
45. (3.00 pts) What is the Pacific Decadal Oscillation and where is it located?

Expected Answer: 1 pt for definition 1 pt for having Pacific Basin/Ocean 1 pt for north of 20°N The Pacific Decadal Oscillation is a robust, recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin. The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of 20°N.

46. (2.00 pts)

Picture below shows the three-dimension temperature anomaly in Pacific Ocean, with red circle representing positive temperature change vs. average, and blue circle representing negative temperature change vs. average.

- 1) What is the impact of such anomaly to thermocline?
- 2) Such anomaly can be a precursor for _____ event in about one year.



Expected Answer: 1) Deeper thermocline in mid Pacific Ocean, more upwelling (shallower thermocline) on the east Pacific. (simple answer of upwelling receive no credit) ■ 2) El-Nino or ENSO warm phase. (simply answer ENSO receives no credit)

47. (4.00 pts) Describe the 4 types of reefs.

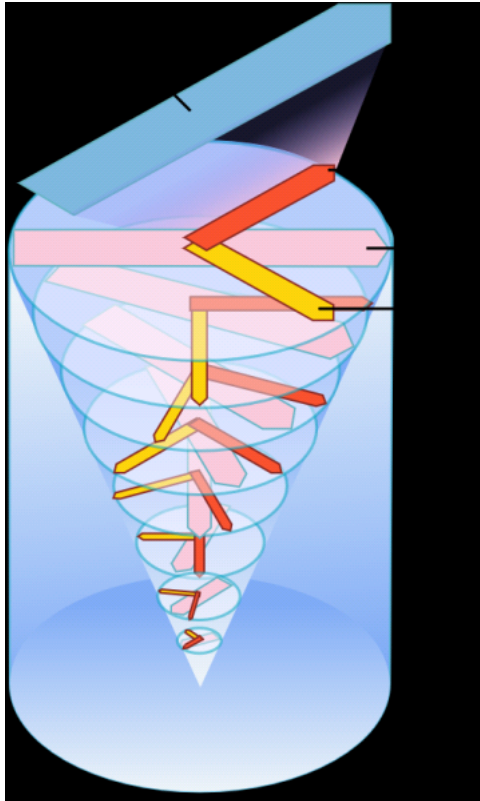
Expected Answer: 1 pt for each Fringing Reef: It is distinguished from the other main types of reefs in that it has either an entirely shallow back reef zone (lagoon) or none at all. Barrier Reef: They are separated from land by an expanse of water. This creates a lagoon of open, often deep water between the reef and the shore. Atoll: An atoll sometimes called a coral atoll, is a ring-shaped coral reef including a coral rim that encircles a lagoon partially or completely. Platform Reef/Patch Reef: A coral reef found on continental shelves and characterized by a primarily radial growth pattern. A platform reef may or may not lie behind a barrier reef and may undergo elongation if established on a sandbank.

48. (2.00 pts) In the Northern Hemisphere, the Coriolis Effect deflects moving objects

- ☐ A) To the Left

- ☒ B) To the Right
- ☐ C) Up
- ☐ D) Down
- ☐ E) It has no effect

49. (2.00 pts) Consider this image of an Ekman spiral.



What does the the blue arrow represent?

What does the yellow arrow represent?

What does the pink arrow represent?

force from wind

force from induced Coriolis

net force

50. (3.00 pts) For a parcel of water at an latitude of 30° with a northward velocity of 2 m/s, what is the acceleration due to Coriolis effect, in m/s^2 ?

Describe the solution step to get full points.

Expected Answer: $f = 2 \omega \sin(\phi) \times v = 2 \times 7.292 \times 10^{-5} \times 0.5 \times 1 = \text{Answer: } [1.4584 \times 10^{-4}] \text{ m/s}^2$ - Note original question has the wrong unit for the acceleration, which caused some confusion.

51. (5.00 pts)

Assume we have a rapid flow in a channel of 4 km width on the north America continent with a poleward velocity of 2 m/s. If we ignore the effect of density stratification, turbulence, wind, just consider the geostrophic balance, what is the difference in height on the two side of the bank, in meters? Which side will be taller, east or west?

Describe your solution steps and rationale to get full points.

Expected Answer: First, the geostrophic flow is balance between Coriolis force and pressure gradient. [1 pt] The net Coriolis force push the water eastward, leading to higher elevation on the east bank. [1 pt] Slope of the free surface is based on the ratio of Coriolis acceleration vs. gravity, one can get angle of $(2 \omega \sin(\phi) v)/g = (14.584 \times 10^{-5})/9.8 = 1.488 \times 10^{-5}$ [2 pts] So across 4km length, this angle leads to an elevation of 0.0595 meter, or ~ 6cm.

52. (8.00 pts)

Now a more difficult question - In reality, density of the water is not uniform across the depth. Assume we can treat the water parcel as a top layer of density ρ_1 above another layer of density ρ_2 , there is a sharp interface at a center depth of density discontinuity. Let's reconsider the same scenario described in the previous question except now that flow is only happening in the top layer with density ρ_1 . We can further assume $\rho_1 = 0.99\rho_2$, i.e. with low density water above .

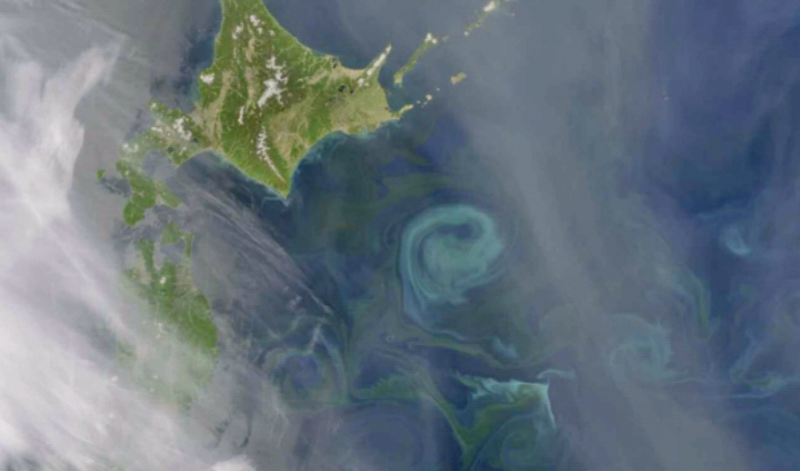
- 1) Under geostrophic balance, would low density top water shift to the east bank or west bank? [1 pt]
- 2) Calculate the tilting angle of this density interface under such idealistic flow condition (top layer = 2m/s, bottom layer = 0m/s), Express your answer in degrees [5 pts]
- 3) In Oceanography, we can detect the direction of geostrophic flow based on iso-thermal depth profile, or shifts in pycnocline. Why is that? [2 pts]

Expected Answer: 1) East bank ■ 2) Angle = $(\rho_1)/(\rho_2-\rho_1) \times$ free-surface tilt angle calculated in previous question. So it is $(14.584 \times 10^{-5} / 9.8) \times (0.99)/(1-0.99) = 0.084$ degree. ■ 3) Ocean density is often determined by temperature and salinity profile. Pycnocline ~ halocline. Knowing the tilting of the pycnocline defines the direction of geostrophic flow. ■

53. (9.00 pts)

Kuroshio, also known as the Black or Japan Current (黒潮), is a north-flowing, warm ocean current on the west side of the North Pacific Ocean.

- 1) What is the main driving force for Kuroshio current [1 pt]
- 2) This current spins off strong eddy as shown in the picture below. How does such eddy contribute to global warming? [2 pts]



(3) A cross section of the strong eddy at the main branch of Kuroshio current is show below with velocity contours marked in unit of cm/s. Here the shaded area indicate weaker south-west flow.

Estimate the flow rate of the stronger north-eastward flow (unshaded area), express your answer in Sverdrup. [5 pts]

- 4) This is data collected in 1993. what is the likely technique used to get such velocity profile? [1 pt]

