Assessment Schedule – 2020

Earth and Space Science: Demonstrate understanding of processes in the ocean system (91413)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	In the polar regions, lack of solar heating, due to indirect solar radiation because of the Sun's oblique angle, means that surface waters that have travelled north from the Equator will cool. As polar winds move across the ocean, surface waters evaporate, and in doing so, remove heat from the surface water. This cools the surface water to the extent that sea ice begins to form. The sea ice is freshwater. The surrounding water becomes more saline, and therefore denser. This creates a density gradient whereby the denser saline water begins to sink under the influence of gravity towards the ocean floor, i.e. downwelling. In the Arctic region, as more surface ice continues to form during the autumn and winter months, the density of the underlying saline water increases, and a combination of downwelling and ocean floor topography pushes the saline deep-water flow southward along the Atlantic floor, towards Antarctic waters. As the waters flow along the ocean floor, they pick up nutrient materials. A similar process takes place along the edge of the Antarctic land mass; sea ice forms during its autumn / winter months. This combines with the flow of deep saline water flowing down from the Arctic region and creates a circumpolar flow of cold saline, nutrient-rich waters around the Antarctic continent. At various stages along this flow, either due to continental landmass or surface winds, the cold waters are forced upwards (upwelling) and warm as they move towards the Equator. The surface waters, now warmed by the equatorial heat, return to the polar regions assisted by surface winds. Equatorial heat is transferred to the atmosphere / land as the currents flow back towards the polar regions. In the short term, as climate warming continues, the amount of sea ice that forms will decrease. More fresh water from the melting ice caps will sit on the denser saltwater, and with the lack of sea ice formation, the downwelling process slows down. This in turn will slow down the thermohaline linked surface currents that carry heat away from the Equator. Temperate regions, particularly Europe, can expect as a result colder winters and hotter summers with changes in rainfall patterns. Storm events will be more severe in both tropic and temperate regions. In the long term, the thermohaline circulation could stop. This would bring about complete changes in the pattern, speed and direction of the warmer surface currents and gyres. Climate would be permanently altered on continental landmasses as changes occur to the heat transfer patterns between ocean and land. This could lead to more extreme weather events, for example massive heat gains in the Indian Ocean and changes in the monsoon cycle. Lack of upwelling will also bring about a depletion in the release of nutrient and carbon dioxide into upper ocean	To demonstrate understanding of the processes, the candidate explains by: • linking lack of heating in the polar regions to cooling of ocean surface water • linking increase in ocean salinity / density with the formation of sea ice • linking sinking / downwelling / of the more saline water to increase in density • linking warm surface currents and / or the THC, to the transfer of heat from equatorial regions to higher latitudes • linking sea ice formation in the polar regions to the global thermocline current • linking the change in the downwelling to the slowing of the thermohaline current • linking the change in downwelling to changes in climate on landmasses OR sea surface salinity OR	To demonstrate in-depth understanding of the processes, the candidate: • explains how cooling in ocean temperature (heat loss to the atmosphere) creates a density gradient and hence downwelling • explains how cooling and sea ice formation increases salinity and creates a density gradient and hence downwelling • explains how the thermohaline current eventually upwells and warmed by solar heating, moves warm surface waters to higher latitudes, warming landmasses • explains how the lack of sea ice formation / downwelling in polar regions could slow down the thermohaline current, resulting in changes to heat / nutrient / carbon distribution.	To demonstrate comprehensive understanding of the processes, the candidate: • explains fully the formation of the thermohaline current and its role in heat distribution around the Earth AND the possible future consequences of changes in the current due to continued climate warming.

	waters with consequences to marine ecosystems. Lack of downwelling will mean less sequestration of carbon dioxide from the atmosphere. Warming in polar waters will accelerate, due to the lack of any albedo associated with ice presence.	carbon sequestration OR nutrient distribution.		

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1 partial idea from Achievement.	2 partial ideas or 1 full idea from Achievement.	2 ideas from Achievement.	3 ideas from Achievement.	1 idea from Merit.	2 ideas from Merit.	Discussion with minor omissions.	Full discussion.

Q	Evidence	Achievement	Merit	Excellence
TWO	The South Pacific Gyre is the result of the interaction between trade winds, the Coriolis effect, gravity, landmass and surface ocean currents. The ocean surface currents of the northern part of the South Pacific Gyre are the result of frictional drag by the south-east trade winds driving surface waters in a westerly direction parallel to the Equator. (The friction forces are the result of moving air particles interacting with the water's surface.) At the western extreme of this current flow, landmass and the prevailing westerlies in the mid latitudes assist to direct the flow in a southerly direction towards the Antarctic circumpolar current. This current is driven by the constant westerly winds that prevail in these latitudes. This is the bottom of the gyre. The easterly movement of the gyre reaches the west coast of the South American continent, (Chile and Peru). The landmass effectively drives the current north up the coast. This is in part due to the pressure of water moving from the west, and the coastal offshore winds. Driven westward, the waters in the western Pacific equatorial region expand due to the extreme solar heating in the Equatorial region. This expansion also creates a "mounding" of water in this region, and the subsequent flow of water "downhill" under the influence of gravity towards the centre of the gyre. The anticlockwise rotation of the Earth causes a deflection of the surface currents in the Southern Hemisphere towards to left (an anti-clockwise direction). This is the Coriolis effect. The equatorial westerly surface currents are now deflected through 45 degrees to a south-westerly direction. The easterly southern flow of the gyre is deflected in a north-easterly direction. The overall effect of this combination of wind and currents is to create a vortex, like a giant whirlpool. The currents rotate inwards towards the centre, eventually creating a large area of stable ocean. Buoyant material that has been dumped can be eventually washed out to sea via rivers, streams and storm drains from the coastal areas around the South Pacific Ocean. Material can also be dumped at sea. This buoyant material, which can be floating at different depths, can become caught up in ocean surface currents as tides and winds carry the material away from the coastal regions. The debris can travel for thousands of kilometres and eventually find its way into the currents that form the South Pacific Gyre. The debris ends up in the calm stable area of ocean that forms as a result of the gyre, and hence the reference to the Garbage Patch.	To demonstrate understanding of the processes, the candidate explains by: • linking surface current to the friction forces created by air movement • linking the current direction to the trade / easterly / westerly winds • linking the role of landmass to direction of surface current • linking the role of gravity to gyre formation • linking the role of the Coriolis effect to deflecting the direction of the ocean currents • linking land-based material to that found in the gyre carried by rivers, offshore winds and ocean currents • linking the effect of the gyre vortex to keeping material in the gyre.	To demonstrate in-depth understanding of the processes, the candidate: • explains how the action of wind generates surface ocean currents in a westerly (north of the gyre) and easterly direction (south of the gyre) through friction and energy transfer • explains how the current moves down/up the Australian/ South American coasts through the action of landmass, and wind • explains how the Coriolis effect creates the movement with the westerly currents towards the Australian coast AND/OR easterly currents towards the South American coast • explains how material can be transported from the land into the ocean and consequently the South Pacific Gyre.	To demonstrate comprehensive understanding of the processes, the candidate: • comprehensively accounts for TWO of the ocean processes that form the South Pacific Gyre AND how the debris becomes transported into this ocean region.

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Q	Evidence	Achievement	Merit	Excellence
THREE	Equatorial regions are likely to suffer the greatest from sea level rise. Sea level rise in the western Pacific is projected to increase at the rate of at least 3 mm per year, with Kiribati projected to have an increase in sea level on its shores in the range of 13–30 cm by the year 2030. Two factors that will contribute to sea level rise are thermal expansion and ice melt. Solar heating in the equatorial regions is greatest as a result of the sun's radiation falling "directly" onto the Earth's surface. i.e. high energy input per m^2 of surface area or insolation. Much of the energy is absorbed in the top 200 m. The result of the extra heat energy absorbed by the water results in an increase in volume, i.e. thermal expansion. Climate warming is causing glaciers and ice sheets to melt and decrease in size at an accelerated rate and has contributed well over half of the sea level rise to date. The ice melt contribution comes about through the breaking off of ice sheets into the ocean and is directly linked to atmospheric warming from above and ocean warming from below. The water from these regions flows away from the colder regions towards the Equator, contributing towards the sea-level rise in these areas. (The large ice caps exert a gravitation pull on the ocean water. As the ice melts, so the effect of gravity on the sea water in the polar regions declines.) La Niña is part of the Southern Oscillation. It occurs when there is a strengthening of the easterly trade winds, and results in a massive body of warm equatorial waters being pushed towards the west of the Pacific Ocean. This pushes even more water up against the coastal regions of islands in the western Pacific. Combining these three factors with the normal tidal behaviour of the ocean will impact on the reach of the high tide inland. Sea-level increase is the vertical height measurement. On low-level atolls, the effect will be for the high-tide mark to reach further inland, reducing space available for habitation. Additional extreme tidal events, e.g. king tides move the high-tide levels further inland. For the population of low-lying atolls, the effects of sea-level rise, climate events, and tidal movement will be: • increased shoreline erosion • increased flooding caused from seawater • damage to crops, property and freshwater supplies from wells • damage to the reef. • storm surge • heavy rainfall / tropical storms.	To demonstrate understanding of the processes, the candidate explains by: • linking thermal expansion of ocean waters in equatorial regions to climatic heating • linking the increase in sea level to the increase in heat energy retained by the oceans • linking the melting of glaciers and land-base / polar ice sheets due to atmospheric warming to sea level rise • linking ocean warming to the melting of ice sheets on the Antarctic continent Greenland and sea level rise • linking La Niña event (increase in trade wind strength) to an increase in sea levels in the western Pacific Ocean • linking an impact of sea level rise to the atoll population and infrastructure.	To demonstrate in-depth understanding of the processes, the candidate: • explains the role solar heating has in increasing the height of the mean sea level or high / low tide level in the equatorial-west Pacific region • explains the role ice melt in the polar regions have in increasing the height of the mean sea level or high / low tide level in the equatorial-west Pacific region • explains the role a La Niña event has in increasing the height of the mean sea level / high-tide level in the equatorial west Pacific region • explains ONE effect of the combination of La Niña and / or sea level rise (due to climate warming), on the atoll's population and infrastructure.	To demonstrate comprehensive understanding of the processes, the candidate: • explains in detail two physical processes that can result in changes in mean sea level height / high and low tide marks AND how these can impact on equatorial Pacific atoll nations such as Kiribati.

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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 06	07 – 12	13 – 18	19 – 24