Assessment Schedule – 2021 FINAL VERSION

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	During an El Niño event, the easterly trade winds in the Pacific weaken (or reverse direction). This is the warm phase of ENSO, El Niño. Under normal conditions, the westerly flow of surface water causes the sea level to be higher in the Western Pacific (WP). As the trade winds weaken, there is less transport of surface water to the west, therefore the sea level across the Equator becomes more level as water remains in the east. . This also causes a build-up of warm surface water in the eastern Pacific (EP), for example, off the coast of South America (SA). The build-up of warm water off the coast of SA pushes the normally shallow thermocline deeper. The thermocline becomes more level across the Pacific Equator, shallower in the WP and deeper in the EP. (The deepening thermocline blocks the upwelling of cold, nutrient-rich water along the coast of SA.) Increasing global temperatures adds more energy to the pacific climate system. This could possibly cause an increase in the frequency and intensity of strong El Niño events, which could lead to more severe flooding in areas such as western Americas and more severe drought in Australia and India during El Niño events. *Note: evidence may be taken from the diagram*	Explains: • trade winds / wind flow from east to west weakening / reversing • reduced flow of water / currents reduced • equatorial sea level flattening/ EP rises / WP lowers • thermocline deepening in EP / becomes flatter • sea surface temperature warms / EP temperature warms • El Niño events may become more frequent / intense with climate change. • one impact of El Nino events. E.g. increased rainfall / flooding in EP / reduction in nutrient upwelling.	Explains the relationship between: • weakened / reverse trade winds and reduced water flow/current from EP → WP • reduced water flow from EP → WP and sea level changes • reduced water flow from EP → WP and build-up of warm surface water in EP • build-up of warm surface water in EP and deepening thermocline • El Niño events may become more frequent / intense with climate change, (due to more energy in the system) OR link to more intense droughts in WP and / or flooding in EP or deepening thermocline and reduced upwelling.	Explains fully: • the relationship between weakened trade winds, reduced equatorial water flow from EP → WP, and flattening of sea level and sea surface temperature changes • the relationship between weakened trade winds / water flow to build-up of warm surface water in EP, deepening of the thermocline • climate change may result in El Niño becoming more frequent and intense, leading to more extreme weather events, such as drought in India / Australia and flooding in western Americas and/or decreased ocean productivity due to decreased nutrient upwelling.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	One partial point from Achievement.	ONE points from Achievement.	TWO points from Achievement.	THREE points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence linked together.

Q	Evidence	Achievement	Merit	Excellence
TWO	Due to wind and the Coriolis effect, ocean surface currents circulate around ocean basins in a clockwise direction in the Northern Hemisphere, and anticlockwise in the south. As winds blow along the surface of the ocean, friction between the air and the surface of the water causes the water to move due to a transfer of energy. In the south Pacific winds blow surface water currents towards South America. The surface current is deflected to the left due to the Coriolis effect. The Coriolis effect is the deflection to the left caused by the Earth's rotation. It meets the west coast of South America and this landmass also directs the current and it moves north along the coast towards the Equator, causing the Humboldt Current, which is an example of an eastern boundary current (EBC). As the water of the Humboldt Current moves north in the Southern Hemisphere Coriolis causes deflection again. The current moves from an area of slower rotation into an area of faster rotation, so deflects left again. As the surface currents move north along the coast of SA, they are deflected at depth due to the Coriolis effect away from the coast (Ekman). This surface water moving away from the coast is replaced by cold, nutrient-rich water from the deeper layers of the ocean. As this nutrient-rich water reaches the surface and sunlight, it enables huge amounts of phytoplankton to grow. The phytoplankton is a rich source of food for a wide range of marine life, so rich diversity and biomass results in the marine food web.	Explains: • the role of wind in the formation of currents • the Coriolis effect as deflecting water to the left / anticlockwise in the southern hemisphere • South America / landmass deflects / aids formation of Humboldt Current • movement of surface water away from the coast due to Coriolis (OR Ekman) • upwelling as replacement of water by (nutrient-rich) water from below • nutrient-rich water leading to algal bloom / rich marine life.	Explains in detail: • how wind produces surface currents, e.g. by friction or energy transfer • deflection of water to the left by the Coriolis effect / rotation of the earth to form surface currents / EBCs • water moving away from the coast due to wind / Ekman / Coriolis resulting in replacement by deep ocean water rising / being pulled to the surface • relationship between upwelling / deep water and nutrient supply to surface water leading to marine life. (*This evidence may be in the form of a detailed annotated diagram/s.*)	Explains comprehensively: • relationship between; wind, landmass and Coriolis forming EBC (OR Ekman transport) • the relationship between upwelling, deep water, nutrients, and marine productivity.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	One partial point from Achievement.	ONE points from Achievement.	TWO points from Achievement.	THREE points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence with minor omission.	ONE point from Excellence in full or TWO with minor omission.

Q	Evidence	Achievement	Merit	Excellence
THREE	Ocean water is divided into three layers: **Surface / mixed layer** is the least dense. The temperature changes with seasonal weather and salinity changes based on evaporation / dilution of the water. Surface water is less dense because it has a lower salinity or higher temperature than the deeper zones. Wind is responsible for the most mixing. **The transition layer**, between 300 and 1000 m, determines the biological and physical properties of the ocean. The pycnocline / density changes rapidly with depth and is determined by factors affecting the thermoclines and haloclines. This zone forms a strong barrier that prevents mixing between low- and high-density water / between the surface layer and deep ocean. **The deep layer** (below 1000 m) is consistently cold (below 3 °C) and density increasing gradually with pressure and depth. Salinity is relatively constant. A **thermocline** is a vertical zone in oceanic water column, where temperature decreases rapidly with depth, located between the warmer mixed water at the surface and the cooler deep water below. A **halocline** is a vertical zone in the oceanic water column in which salinity changes rapidly with depth, located below the well-mixed, uniformly saline surface water layer. (A halocline is better developed in mid latitudes than at the Equator because precipitation and run-off exceed evaporation.) The **pycnocline** is the vertical zone in the oceanic water column, where water density increases rapidly with depth in response to changes in temperature and salinity. The pycnocline encompasses both the halocline (salinity gradients) and the thermocline (temperature gradients), and refers to the rapid change in density with depth. Because density is a function of temperature and salinity, the pycnocline is a function of the thermocline and halocline. Simplified: thermocline + halocline = pycnocline. Temperature tends to be a dominant factor influencing seawater density, so despite smaller decreases in salinity which would decrease density, the larger decrease in temperature results in the overall density increase and pycnocline formation.	Explains: • the surface / mixed layer as being affected by weather / wind / rainfall / evaporation /sunlight • the formation of a strong barrier that prevents mixing between low- and high-density water / between the surface layer and deep ocean • the deep layer (below 1000 m) as being consistently cold (below 3 °C) and density increasing gradually with depth. • TWO of thermocline, halocline, and pycnocline • thermocline + halocline = pycnocline concept • how temperature affects water density • how salinity affects water density.	Explains in detail: • two of three vertical zones; surface, transition and deep well. • the transition layer / pycnocline acts as a strong barrier that prevents mixing between low- and high-**density** water between the surface layer and deep ocean • the relationship between thermocline, halocline and pycnocline in broad terms • the effects of conditions in the surface layer that influence salinity and temperature.	Explains comprehensively: • the relationship between thermocline, halocline, and pycnocline • the relationship between the three layers and how the pycnocline acts as a barrier, isolating the surface and deep water.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	One partial point from Achievement.	ONE points from Achievement.	TWO points from Achievement.	THREE points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	BOTH points from Excellence .

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24