Assessment Schedule – 2017

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	Sydney is on the western side of the Pacific Ocean where water travels down the coastline from warmer, lower latitudes. Near the Equator, where maximum solar energy is received, the ocean absorbs much heat, warming the water, making it less dense. The trade winds blow the warm water towards the western side of the Pacific. This creates a mounding effect with less dense warm water piling at the Equator and along eastern coastlines of the Pacific. This water moves south in the Southern Hemisphere and north in the NH due to gravity (flows downhill), creating a south-easterly flowing current bringing warm water to Sydney. The Coriolis effect plays a role here, deflecting water as it moves south, turning it relative to the wind (via Ekman transport). This water is nutrient-poor as it is surface water, with most nutrients sinking lower in the water column. This does not allow enough nutrients to support a large fishing industry. (Also, less oxygen in warm water so many species cannot tolerate it.) The water pushed up against the continent by the south-easterly trade winds downwells as it is pushed under, taking heat with it. On the eastern side, at Valparaiso, the surface ocean current moves in a northerly direction along the coast. This water has come from the southern Pacific, where water is cold due to less solar energy at higher latitudes to be absorbed, so is a colder current. The westerly winds blow this cold water towards South America, where it continues north along the coastline. Upwelling occurs along the eastern side of the Pacific due to the fact that there is a shallow thermocline, which allows for cold water from the deep ocean to upwell through the thermocline layer to the surface, bringing rich nutrients from dead organisms stored in the depths up to the surface mixed layer. This cold, nutrient-rich water allows phytoplankton to flourish and support a thriving ecosystem, including fish. The upwelling process on this coastline is vital to supporting the fishing industry.	• Links latitude to solar radiation. • Links direction of ocean surface currents with wind. • Links surface currents to downwelling • Links surface currents to upwelling. • Links Coriolis effect to direction of surface currents. • Links fishing to nutrient levels. • States or gives diagram showing correct direction of currents on both sides of ocean basin. • Links land mass and Coriolis effect to current formation.	• Explains the reasons for the movement of either the western or eastern boundary current. • Explains the temperature of water in Australia AND Valparaiso • Explains how upwelling occurs. • Explains how downwelling occurs • Explain why the fishing is poorer / richer on the western / eastern coasts of the ocean basin. • Explains how the Coriolis effect assists in circulation patterns of the Pacific.	• Comprehensive explanation of why water on the western boundaries of the ocean basin are warmer and have poorer fishing than the eastern side (must refer to both fishing AND water temperature).

Not Achieved			Achievement		Merit		Excellence	
NØ = no response; no relevant evidence.	N1 = 1 partial point from Achievement.	N2 = 1 points / 2 partial points from Achievement.	A3 = 2 points	A4 = 3 points	M5 = 1 pont.	M6 = 2 points	E7 = One minor omission / error.	E8 = Point fully explained.

Q	Evidence	Achievement	Merit	Excellence
TWO	The **physical** / solubility pump is driven by the fact that carbon dioxide solubility is greater in cooler water (as the water particles have less kinetic energy, so can maintain weak bonds with the gas). Carbon dioxide from the atmosphere dissolves in surface seawater. As water cools and sinks, (pressure also increases CO_2 solubility) more CO_2 dissolves, increasing concentration of dissolved inorganic carbon. This acts to pump carbon from the atmosphere into the ocean's depths. This dissolved CO_2 then undergoes further equilibrium reactions to form hydrogen carbonate and carbonate, reducing the dissolved CO_2, allowing more CO_2 to dissolve from the atmosphere. When deep water upwells in warmer, equatorial latitudes, it strongly outgasses carbon dioxide to the atmosphere because of the reduced solubility of the gas, but the carbon can be stored for centuries in the deep ocean before the thermohaline circulation returns it to the surface. The **biological** carbon pump starts as phytoplankton use dissolved CO_2 to photosynthesise, storing carbon in their bodies and through the food web. Living organisms, including decomposers, respire, returning CO_2 to the water / atmosphere. Skeletons and shells that fall to the ocean floor become limestone rock through sedimentation, allowing carbon to be stored for longer on the ocean floor. Some plankton and other animals use CO_3^{2-} and HCO_3^- ions to build $CaCO_3$ shells, and these and other nutrient wastes sink to the ocean depths to be stored until recycled via upwelling of the thermohaline circulation along western coastlines and regions near the Equator.	• Links CO_2 solubility between ocean and atmosphere. • Links effect of temperature on CO_2 solubility / diffusion / dissolving (NOT absorption). • Links depth to decreasing temp and increasing CO_2 storage. • Links a carbon reaction in seawater to a carbon pump. • Explains short term storage of carbon. • Explains long terms storage of carbon. • Explains how CO_2 can be returned to the ocean / atmosphere by the biological pump. • Explains the role of upwelling in the cycling of carbon.	• Explains the physical / solubility carbon pump. • Explains the biological carbon pump. • Explains a link between the physical and biological pumps.	• Comprehensive explanation of the processes involved in the transport and storage of carbon in the ocean.

Not Achieved			Achievement		Merit		Excellence	
NØ = no response; no relevant evidence.	N1 = 1 partial point	N2 = 1 point / 2 partial points	A3 = 2 points	A4 = 3 points	M5 = 1 point	M6 = 2 points	E7 = Point with minor omission / error	E8 = Point fully explained.

Q	Evidence	Achievement	Merit	Excellence
THREE	**Role of sea ice affecting thermohaline current** As sea water freezes, the fresh water crystallises, leaving more salt in the surrounding water. This increased salinity contributes to increased density and sinking of the surface layer. **Role of temperature affecting thermohaline current** Warm water travels from the Equator towards the poles as large surface currents. This warm water is cooled as it reaches the ice, becomes denser as it is cooler and sinks, helping to pull more warm water from the lower latitudes. This water can take thousands of years to return to the surface so is important in keeping the ocean cool. **Reason for the declining sea ice** Because ice is bright and white / light coloured, it largely reflects solar energy rather than absorbing it (albedo effect), so little solar energy can heat the ice and the polar regions remain cold with much ice. As global temperatures have increased, the ocean water temperature at the poles has increased, causing the sea ice to melt. **Effect of declining sea ice on thermohaline current** When ice melts, less dense fresh water is released, diluting the salinity and slowing the downwelling into the deep ocean as the density gradient is much reduced. This in turn reduces the surface currents such as the Gulf Stream, so less heat will then reach the higher latitudes, theoretically allowing the ice to refreeze. This is difficult to predict, but the storage of heat and nutrients via the thermohaline circulation is important, so any slowing of this system could have major climate effects. If temperatures continue to rise, leading to no sea ice and warmer water, the thermohaline current could stop. Declining sea ice will also mean that there is more ocean water exposed to solar radiation, which could absorb more heat. By absorbing more heat, the temperature of the water would increase leading to more melting, and so on, causing a runaway effect.	• Explains role of sea ice in increasing salinity of water / melting ice decreasing salinity. • Links effect of direct / indirect sun on warming / cooling of water at equator / poles. • Links density to temperature of water. • Links increasing salinity to increased density of water. • Links global warming to declining sea ice / rising sea temperatures. • Links slowing of thermohaline current to declining sea ice.	• Explains roles of temperature AND salinity on thermohaline current. • Explains how sea ice increases salinity AND density of water. • Explains how increased sea ice loss will decrease salinity AND density of water. • Explains an effect of declining sea ice on the thermohaline current.	• Comprehensive explanation of the effect of sea ice on the thermohaline current AND how the continued decline in sea ice will affect the thermohaline current.

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Cut Scores

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