

## Assessment Schedule – 2025

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

#### Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE	<p>Ocean layers form due to differences in density, which results from different temperatures and / or salinity. The surface layer is less dense, due to higher temperature, while deep ocean is densest, due to lowest temperature and highest salinity. The transition layer is an intermediate density layer between surface and deep layers, where greatest changes in temperature, salinity, and density occur.</p> <p>The ocean surface is heated by solar radiation. During different times of the year, mid-latitudes experience variation in how much radiation they receive, resulting in colder temperatures in winter and warmer temperatures in summer. The deep ocean is at a constant temperature of approximately 2° C. The thermocline is a temperature gradient between the surface ocean to deep ocean.</p> <p>At mid-latitudes, summer ocean surface temperature is very high and winds less strong. Limited mixing occurs in the surface layer; high temperatures at surface, decreasing with depth in the surface mixed layer and transition layer. The difference in surface vs deep temperature is great, causing formation of a strong thermocline.</p> <p>During winter, surface temperature is much lower and more similar to deep ocean. Strong winds cause substantial mixing of the surface layer, causing a more uniform temperature. The thermocline is less steep in the transition layer as a result.</p> <p>During spring and autumn, the surface layer has a moderate temperature and is reasonably uniform, due to strong winds and vertical mixing. However, during spring the surface layer is still colder after winter, thus vertical mixing is not as deep as in autumn when more heat energy is available. The thermocline during these seasons is between the summer and winter thermoclines.</p> <p>Temperature influences density of water, so during summer, surface density is lower, causing a more pronounced pycnocline, while during winter when surface temperature is colder, density increases, causing a less developed pycnocline layer. However, salinity also influences density of water, and thus precipitation will cause lower density and evaporation will cause higher density at the surface. This may cause minor changes in the pycnocline.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• layers have different densities</li> <li>• thermocline as layer where temperature changes</li> <li>• seasonal change in thermocline (diagram)</li> <li>• seasonal surface temperature changes</li> <li>• deep ocean has constant temperature</li> <li>• winter more vertical mixing due to wind</li> <li>• thermocline less developed in winter, OR well developed in summer</li> <li>• thermocline for autumn OR spring (between summer and winter)</li> <li>• temperature influences density</li> <li>• summer lower density surface, OR winter opposite</li> <li>• pycnocline as layer where density changes.</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• differences between surface and deep layer temperature and density</li> <li>• effect of surface temperature on thermocline (gradient)</li> <li>• impact of wind and vertical mixing on thermocline (depth)</li> <li>• differences in thermocline in summer and winter</li> <li>• effect of temperature on pycnocline development.</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• how the three layers of the ocean form and the function of thermocline as a transitional / barrier layer</li> <li>• how seasonal influences affect thermocline development (temperature, wind, mixing, ALL seasons)</li> <li>• how seasons (summer and winter) impact formation and gradient of the pycnocline around New Zealand.</li> </ul>

<b>NØ</b>	<b>N1</b>	<b>N2</b>	<b>A3</b>	<b>A4</b>	<b>M5</b>	<b>M6</b>	<b>E7</b>	<b>E8</b>
No response or response does not relate to the question.	Describes ONE idea at Achievement level.	Describes TWO ideas at Achievement level.	Describes THREE ideas at Achievement level.	Describes FOUR ideas at Achievement level.	TWO Merit answers.	THREE Merit answers.	ONE Excellence answer.	TWO Excellence answers.

Q	Evidence	Achievement	Merit	Excellence
TWO	<p>Atmospheric gases such as carbon dioxide, CO<sub>2</sub>, dissolve at the surface of the ocean, which is affected by wind, waves, and surface mixing. As this surface water is much colder than anywhere else around the globe, atmospheric gases such as CO<sub>2</sub> will dissolve more rapidly here than elsewhere.</p> <p>The biological pump involves photosynthetic marine organisms such as phytoplankton that perform photosynthesis to convert CO<sub>2</sub> into glucose. This then forms a part of the marine food web, as organisms incorporate the carbon into their bodies or shells. Much phytoplankton is eaten by other sea creatures, transferring the carbon into other organisms via the ocean food web, which may then die or defecate and fall to the bottom of the ocean as “marine snow”. This carbon may then build up in layers and is stored in the deep ocean; alternatively, the carbon may then be released back into the (deep) ocean by respiration or decomposition.</p> <p>The physical pump involves CO<sub>2</sub> entering the ocean by dissolving in the surface layer. Wave action and lower temperatures can increase the rate at which the CO<sub>2</sub> dissolves, so in the rough, cold Southern Ocean, the dissolving rates are likely to be high. This is known as the physical ocean pump. This CO<sub>2</sub> may be drawn down to deeper layers of the ocean by downwelling, which lowers the concentration of the CO<sub>2</sub> in the surface layer. Rapid downwelling in these areas is also likely to increase the amount of CO<sub>2</sub> that is absorbed in the Southern Ocean.</p> <p>As large amounts of CO<sub>2</sub> are dissolved in the Southern Ocean, this has the effect of making the ocean more acidic. CO<sub>2</sub> from the atmosphere is absorbed by the ocean, where it reacts with seawater to form carbonic acid.</p> $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ <p>Then, carbonic acid dissociates (breaks-up) to form bicarbonate ions and hydrogen ions (H<sup>+</sup>, hydronium, H<sub>3</sub>O<sup>+</sup>, protons, or acid particles).</p> $\text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$ <p>Some of the bicarbonate ions then further dissociate into carbonate and more acid (H<sup>+</sup>) particles.</p> $\text{HCO}_3^- \rightleftharpoons \text{H}^+ + \text{CO}_3^{2-}$ <p>The increasing carbon dioxide entering the ocean will cause a shift in the equilibrium of these reactions, resulting in an increase in acid particles and reduced ocean pH.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• role of atmospheric carbon dioxide in ocean decreasing pH</li> <li>• how temperature affects physical pump</li> <li>• how downwelling affects physical pump</li> <li>• how waves affect the physical pump</li> <li>• role of photosynthesis in biological pump</li> <li>• role of marine snow in biological pump</li> <li>• links increased CO<sub>2</sub> uptake to acidification / pH</li> <li>• any one relevant chemical equation or description (balancing not required).</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• how the physical pump takes carbon dioxide into the ocean</li> <li>• how the biological pump takes CO<sub>2</sub> out of the water through photosynthesis AND marine snow OR calcification</li> <li>• how dissolving CO<sub>2</sub> leads to increased carbonic acid and ocean acidification</li> <li>• two relevant chemical equations with charges (balancing not required) with supporting explanations</li> <li>• explains high levels of CO<sub>2</sub> absorption by linking to temperature / waves / downwelling (2 of 3).</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• the biological and physical pumps as mechanisms for sequestering large amounts of CO<sub>2</sub> in the Southern Ocean</li> <li>• how increasing CO<sub>2</sub> affects the equilibrium of the carbonate chemistry of the Southern Ocean resulting in acidification</li> <li>• links between temperature, waves, and downwelling to the physical and biological pumps in the Southern Ocean to explain high levels of absorption.</li> </ul>

N0	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE idea at Achievement level.	Describes TWO ideas at Achievement level.	Describes THREE ideas at Achievement level.	Describes FOUR ideas at Achievement level.	TWO Merit answers.	THREE Merit answers.	ONE Excellence answer.	TWO Excellence answers.

Q	Evidence	Achievement	Merit	Excellence
THREE	<p>Upwelling is the rising of cold bottom waters towards the surface of the ocean. It is generally the result of strong surface currents moving surface water away from a coastline.</p> <p>During the northern hemisphere summer months of June to September, a strong monsoon wind blows towards the north-east off the Somalian coast. This causes a strong surface current to form towards the north-east, as wind friction directs surface ocean currents.</p> <p>However, in the northern hemisphere, currents are deflected towards the right, due to the Coriolis effect. This causes the current off Somalia to deflect towards the east. As the warm surface water is pulled away from the coast, cold deep water moves up to the surface to replace it.</p> <p>Cold, deep water is rich in nutrients, which provides food for plankton in the area of upwelling. This forms the base of the ocean food web, and increases the abundance of fish and other marine species. As such, the fishing industry flourishes during these months in Somalia.</p> <p>During November to February, the current flows in its normal direction from the north-east, therefore preventing upwelling from occurring, and resulting in lower productivity in the ocean. This is because the wind moves surface waters towards the south-west and Coriolis causes the waters to move towards the coast, preventing upwelling. The change in direction is due to the Sun moving south when it's winter in the northern hemisphere.</p>	<p>Describes with understanding:</p> <ul style="list-style-type: none"> <li>• cold water wells up to take place of warm surface water</li> <li>• wind drives surface current</li> <li>• Coriolis deflects to right in NH</li> <li>• cold bottom water full of nutrients</li> <li>• upwelling of nutrient rich water promotes plankton / productivity</li> <li>• in winter no upwelling</li> <li>• in winter surface water moves towards the coast.</li> </ul>	<p>Explains in detail:</p> <ul style="list-style-type: none"> <li>• role of monsoon wind to cause current</li> <li>• deflection of surface current to east due to Coriolis</li> <li>• how cold deep water replaces warm surface water during upwelling</li> <li>• increased nutrients from deep ocean lead to increased productivity</li> <li>• no upwelling during winter due to change in wind direction and current</li> <li>• process of downwelling in water / thickening surface layer barrier in winter</li> <li>• decaying matter from ocean floor becomes nutrients in deep ocean.</li> </ul>	<p>Explains comprehensively:</p> <ul style="list-style-type: none"> <li>• how wind direction, Coriolis and upwelling (e.g. due to Ekman spiral) are linked off the Somali coast in summer</li> <li>• how wind direction, Coriolis and downwelling (e.g. due to Ekman spiral) are linked off the Somali coast in winter</li> <li>• how seasonal monsoon winds affects productivity linked to source of marine nutrients.</li> </ul>

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### Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24