

Assessment Schedule – 2016**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>The mixed layer or surface layer is the least dense layer, with wind-driven surface currents restricted mostly to the top 100 m, but which changes in response to variations in the wind, precipitation, heating, or cooling. This water is less dense as it is heated by absorbing solar radiation and heat from the air. Stirring of surface waters by the wind and waves produces a well-mixed layer of similar density, which ‘floats’ on the more dense water below. The water is isothermal due to the mixing.</p> <p>The pycnocline acts as a boundary between the mixed layer and the deep ocean, and is an area where density increases rapidly with depth. Changes in density occur due to colder temperatures and higher salinity (or higher pressure).</p> <p>The deep layer is very stable due to high density and separation from mixing by the pycnocline, with slow currents. It is isothermal and has a high salinity.</p> <p>The mixed layer is limited at the Equator as it receives a lot of sun all year round, so is continually heated, restricting mixing as the very top layer is very warm and buoyant. Insufficient wind / doldrums to mix the top layer to a deeper level, so it is very shallow.</p> <p>No mixed layer or pycnocline exists in the highest latitudes (above 60 degrees) as so much heat is lost to the atmosphere (which is very cold) that the temp cools very quickly to a similar temp to the bottom water, i.e. no temp gradient. The water is also very salty due to sea ice formation. This cold, salty water sinks at the poles, causing the water to become uniform in density. The large amount of ice acts to cool the water and to reflect the limited sunlight, avoiding heating. There is a wide pycnocline in the mid and low latitudes due to the large difference between surface temp and the deep layer.</p> <p>The areas on the diagram with the wide mixed layer and pycnocline are in the Tropics of Cancer (NH) and Capricorn (SH). These areas vary with season, with the Tropic of Cancer receiving much direct solar radiation in the NH summer, transferring much heat to the ocean, but significantly less in the winter due to the tilt of the Earth (and the converse for the Tropic of Capricorn). The strong westerly winds operate in this region also, producing strong surface currents stirring the mixed layer to a great depth through friction. Many storms occur in this region too, so salinity changes due to evaporation and precipitation are regular, altering water density regularly and the depth of the layers.</p>	<p>To demonstrate understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Links the depth of the surface layer to varied heating. • Links how density / pycnocline varies with temperature or salinity. • Links the mid latitudes to seasonal change. • Links mid latitudes to strong wind and currents. • Links the depth of the deep layer to lack of solar radiation and higher density. • Describes 2 of 3 layers in terms of temp / salinity / density. • Links a property of the pycnocline to why it acts as a barrier. • Links an environmental factor to an increase / decrease in salinity. 	<p>To demonstrate in-depth understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Explains how the depth of the mixed layer is linked to strength of winds / currents / heating. • Explains why the mixed layer and pycnocline are absent at high latitudes. • Explains why the mixed layer is small at low latitudes. • Explains the properties of one layer in terms of density / salinity / temperature. 	<p>To demonstrate comprehensive understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Gives a discussion covering the properties of each layer / how season and latitude affect the depth of each.

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

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TWO	<p>Near the Equator, water is warmed by the sun. The sun is more direct in this area, so it warms the air and ocean more than the indirect sunlight of higher latitudes. This absorption of heat energy causes molecules of water to move more rapidly and take up a greater volume, thus decreasing the density of water and creating a bulge or hill of warm water which then flows down the sides of the hill due to gravity, i.e. moving north. It moves westward with the friction caused by the trade winds and then is deflected north by the North American continent, transporting the heat into higher latitudes, as shown in the graphic (warm water = red / orange). The shape of the continent pushes the water eastward across to Europe aided by the westerly winds at this latitude. The heat is then transferred to the cooler air, giving a warmer climate to this region than that found at similar latitudes without the Gulf Stream influence (e.g. Greenland or Canada opposite is cooler than Britain and the Scandinavian countries).</p> <p>The Gulf Stream is very salty as much evaporation occurs near the Equator due to the high temperature, carrying water vapour and heat into the atmosphere, but leaving the salt to concentrate in the ocean water. This makes it more dense, but it is still less dense than lower water due to the higher temperature, so it doesn't sink but is carried north.</p> <p>Nearer the North Pole, the water cools as the temperature is low, due to indirect sun and the high albedo (reflectivity) of ice. Cooler water has a higher density as the molecules slow down and move closer together, decreasing its volume (energy lost), causing it to sink. This creates a downward pull as water from the surface layer sinks through into the deep ocean, producing a density gradient. The deep water then moves south along the ocean basins.</p> <p>At the poles, as seawater freezes it becomes more salty as only fresh water is locked in the ice, concentrating the salinity of liquid water. Saltier water is more dense / heavier so sinks into the deep ocean, giving a salinity gradient. Strong winds in this region cause evaporation also (even more salt left in the water). The combination of this down-welling, pulling water into the deep ocean and pulling the warm water up from warmer regions to replace it, drives the Gulf Stream current.</p> <p>If this current slowed or stopped, Europe would have a much colder climate, as the heat transfer from the warm Equator to the higher latitudes would be much less, and higher latitudes receive little solar radiation due to the Earth's tilt, especially in winter. Places like Britain may freeze over in winter. The current concern is that less freezing at high latitudes or melting of ice due to global warming will cause the sinking of the dense, salty water to lessen or stop (as fresh water from ice melt will float as is less dense), so decreasing the 'pull' of the Gulf Stream from warmer regions and resultant decrease of heat transfer north.</p>	<p>To demonstrate understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Outlines the effect of temperature on water density. • Links gravity and heating to movement of water. • Links heating at the Equator to increased solar radiation <p>OR</p> <p>Links colder temp at pole to decreased solar radiation.</p> <ul style="list-style-type: none"> • Links evaporation or freezing to increased water density. • States that less heat would be transferred to Europe if the Gulf Stream slowed, as solar radiation is limited at high latitudes. 	<p>To demonstrate in-depth understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Explains how water is heated near the Equator and flows north (gravity and thermal expansion). • Explains how heat from the Gulf Stream is transferred to the atmosphere, warming the climate (latent heat). • Compares normal with an absent / slowed Gulf Stream, i.e. reduced heat moved north leading to much cooler climate (in Europe). • Explains how salinity is increased by 2 factors at high latitudes, leading to increased density of water. • Explains how energy loss to the atmosphere leads to cooling of water, increasing the density leading to the water sinking 	<p>To demonstrate comprehensive understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Fully discusses the formation of the Gulf Stream and its role in both warming of the European climate and the thermohaline circulation, and the effects if it is slowed or stopped.

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THREE	<p>A gyre is a surface circulation feature, so is driven mainly by the friction of wind and the Coriolis effect. In the Southern Hemisphere these gyres circulate anticlockwise. Near the Equator the trade winds move east (as the winds move toward the warmer low pressure zone of the Equator), and the water below is pulled in the same direction due to friction.</p> <p>The Coriolis effect is the deflection to the left caused by the Earth's rotation. As the air / water moves south in the Southern Hemisphere, it moves from an area of slower rotation into an area of faster rotation, so deflects left. This effect is added to as the friction transfers through the water column, deflecting further left (effect of the Ekman spiral) to give the west-moving current at the top of the gyre.</p> <p>The bottom of the gyre is similarly driven by the westerly winds, and the current is then deflected at South America (by the continental shelf) and moves up the coast of Chile. Offshore winds keep the current heading north as the Ekman spiral / Coriolis effect works to deflect the current left again. This causes a net movement away from the coast, and this can carry any floating matter / debris from the beaches and rivers flowing into the ocean. It is then picked up by current driven by the Trade Winds and transported around the gyre.</p> <p>The very warm waters in the Equatorial Western Pacific expand (due to the high amount of solar radiation absorbed near the Equator), mound up and then flow 'downhill' due to gravity, moving south to complete the anticlockwise gyre loop.</p> <p>As the winds and currents effectively point into the gyre, floating debris is trapped and accumulates and water mounds up in the centre. As this moves outward, deflection continues to give a huge circulating current. Debris floating out into the ocean (blown by offshore winds, carried by tides and local currents) from south east Asia, Australia, and NZ can all find its way into the South Pacific Gyre as well as marine-origin debris.</p>	<p>To demonstrate understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Links wind to surface currents. • Links current direction with trade / easterly / westerly / winds. • Describes Coriolis effect as deflection due to rotation of earth. • Links offshore winds / current to debris entering ocean from the land. • Describes effect of gravity on the current. • Links the effect of land masses to the direction of current. • Links the matter getting stuck in the gyre to the movement of water in the centre. • Links the effect of land masses to the direction of the current. 	<p>To demonstrate in-depth understanding of processes, the candidate:</p> <ul style="list-style-type: none"> • Explains how wind friction transfers energy to the westerly current in the north of the gyre or the easterly in the south. • Explains why the current moves north up the South American west coast. • explains why the current moves south down the east coast of the Pacific. • Explains how matter is transported. • Explains how the Coriolis effect and land masses contribute to gyre formation. 	<p>To demonstrate comprehensive understanding of processes, the candidate:</p> <p>Gives a discussion covering formation of the South Pacific Gyre linked to 2 of winds, heat, Coriolis effect and land masses and transport of matter (leading to accumulation of debris).</p>

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Cut Scores

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0 – 6	7 – 12	13 – 17	18 – 24