Assessment Schedule – 2018

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	Surface salinity is the proportion of dissolved salts in seawater in the surface layer. Salinity is affected by evaporation, precipitation, freezing, and inflow of freshwater from land or ice melt. **Why surface salinity is low at low latitudes** Evaporation turns water into vapour to rise in the atmosphere when water contains enough heat energy (absorbed from sun). Only water vaporises: the salts are left in the water, increasing salinity as higher salt concentration per mL. More heat = more evaporation. The Equator has most due to highest insolation, but much of this precipitates / rains back into the equatorial ocean, reducing / diluting surface salinity again, as the less dense fresh water tends to float above the more dense water. **Why surface salinity is highest at mid latitudes / in the tropics (Tropic of Cancer and Capricorn)** In the sub tropics, there is still much heating and evaporation, but less precipitation (high-pressure zone with sinking dry air), hence the higher salinity. This water remains near the surface due to low density, as it is still warm, i.e. higher temp has a greater effect on density than increased salinity, which would generally increase density due to more particles per mL. Seasonally, surface salinity varies with temperature, as above, due to differing insolation but as surface currents carry the water towards higher latitudes, it gets saltier as more fresh water is evaporated and the cooling temp makes the water more dense (lower volume as water cools with the same salt amount = higher salinity). **Why surface salinity is lowest at high latitudes** Near the poles, ice from freezing water due to lower temperatures has a major effect on salinity, as ice is largely freshwater, with the salts concentrating in the remaining seawater as the ice crystallises when freezing, increasing salinity and creating a dense brine,(water with high salt content) which sinks below the ice. When this ice melts in spring / summer, the freshwater released lowers salinity. Freshwater has lower density, so remains on the surface, giving the average lower salinity. The dense saltier water sinks to the deep ocean as part of the thermohaline circulation. In winter, the surface salinity would be higher, as there is little meltwater sitting at the surface, due to lower temp. The seasonal variations average out to produce a lower annual surface salinity. Temperature affects salinity as above – with higher temp = more evaporation = higher surface salinity, so if this link was constant, salinity would decrease with decreasing temp as latitude increases. But the pattern / link is **disrupted by the excess precipitation at the**	To demonstrate understanding of processes, the candidate explains by: • Linking regions of low solar heating (insolation) to low rates of evaporation / freezing of seawater • Linking high rates of evaporation to intense solar heating (insolation) at the equator and sub tropics. • Linking evaporation to increases concentration of salt / salinity • Linking precipitation / run off to decrease in salinity / increase in dilution of salt content • Linking lower surface salinity with lower density / freshwater remaining **on surface.** • Linking freezing water to increase in salinity at depth in the high latitudes / polar regions. Linking lower surface salinity with lower density / fresh water remaining **on surface** after melting	To demonstrate in-depth understanding of processes, the candidate: • Explains surface salinity is low at high latitudes because the brine / salt water formed by freezing is dense and sinks rapidly, so does not increase surface salinity, but low density meltwater remaining at the surface decreases salinity. • Explains the salinity levels at the equator in terms of evaporation counteracted by rainfall / run off. • Explains why mid latitudes are highest in salinity. • Explains why temperature and salinity curves do not match.	To demonstrate comprehensive understanding of processes, the candidate: • Gives a comprehensive discussion of the factors that affect surface salinity at low, mid and high latitudes and explains why temperature and surface salinity curves do not match.

	Equator, reducing surface salinity again, and the effect of the dry-aired 30 degree regions with lots of evaporation as still warm, but less rain and the effect of less dense fresh meltwater at the surface of higher latitudes.			

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

Q	Evidence	Achievement	Merit	Excellence
TWO	**Upwelling** is the movement of colder, denser water from the deep layer to the surface, driven by wind and the Coriolis effect. **Coastal upwelling** occurs on the western coastlines of continents / eastern ocean boundaries as cold currents move along the coast from higher latitudes towards the Equator. The Coriolis effect acts on these currents to pull the water away from the coast. This is due to Ekman transport. With friction from wind and deepening water layers successively deflecting water further to the left in the Southern Hemisphere, and to the right in the Northern, this gives a net flow at 90 degrees away from the coastline. **This allows deep, colder water from below the thermocline to rise** to replace it. Upwelling also occurs at the Equator / ITCZ region when winds blow from the north-east and south-east and converge along the Equator, mounding up warm surface waters, which then flow away from the Equator. This divergence of **water allows denser, nutrient-rich water to be upwelled** from below to replace it. Also, there is some similar wind-driven upwelling in the Southern Ocean. (Candidates may explain in terms of Ekman transport.) **Downwelling is the movement of surface water down into the deep layer**. This occurs on eastern continental coastlines as mounded-up warm water pushed by trade winds piles up against the coast and pressure forces it under, taking heat energy from the surface to the deeper ocean. It also occurs near the poles, when higher salinity (denser) water is cooled due to the cold climate at the poles, and becomes even more dense and sinks below the surface layer. **Transporting energy and regulating the Earth's climate** Upwelling has a **cooling effect on the climate, as the cold water rising takes heat energy from the atmosphere.** The overturning of the cold water into the warm surface layers helps to **cool warmer areas to regulate the climate** and transfer heat through the ocean layers and around the globe. **Downwelling, as part of the thermohaline circulation, also has a cooling regulatory effect as it takes heat energy, carbon and other nutrients to be sequestered in the deep ocean.** This keeps the Earth's climate **more stable, as water has a high heat capacity to hold heat** energy. **Sequestering carbon through downwelling also limits carbon dioxide** in the atmosphere, thus slowing greenhouse effect warming, although this eventually outgasses in upwelling regions.	To demonstrate understanding of processes, the candidate explains by: • Linking coastal upwelling to the action of surface ocean currents and wind. • Linking upwelling near the Equator to surface wind movement. • Linking coastal downwelling to the action of ocean currents and wind. • Linking downwelling near the poles to surface changes caused by freezing seawater. (Marker Note: Thermohaline) • Linking upwelling heat transfer between surface water and atmosphere. • Linking downwelling OR upwelling to the removal of carbon (carbon dioxide) *May show understanding by use of annotated diagram / s.*	To demonstrate in-depth understanding of processes, the candidate: • Explains the link between wind direction, Earth's rotation with upwelling and / or downwelling. • Explains how upwelling occurs and causes a cooling climate effect. • Explains how downwelling occurs and regulates climate by transferring heat. • Explains link / feedback between downwelling carbon dioxide and climate. • Explains link / feedback between upwelling, carbon dioxide and climate.	To demonstrate comprehensive understanding of processes, the candidate: • Gives a comprehensive discussion of the role of upwelling and downwelling in the transport of energy and regulation of the climate.

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

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<tr><th>Q</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
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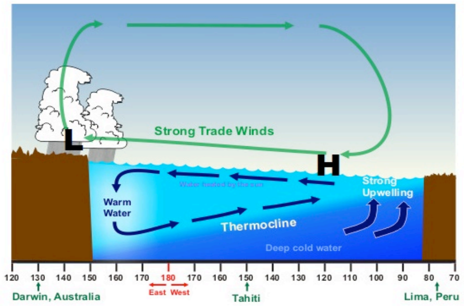
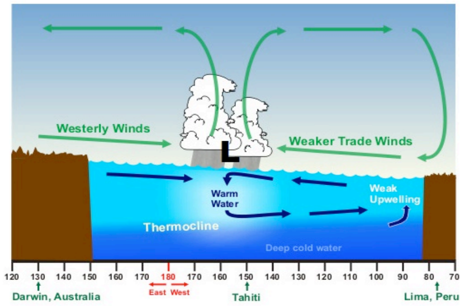
<td>THREE</td>
<td>El Niño formation and effects on thermocline, climate and fishing in Peru
El Niño occurs when the surface warm waters are in the eastern Pacific, nearer Peru, as a result of a weakening or reversal of the trade winds. The upwelling at the eastern coast is lessened, as the pull from the wind is decreased and the thermocline deepens on the east coast, making it more even across the Pacific, due to a smaller difference in temperature between the western and eastern Pacific. This causes reduced upwelling (weak) from higher in the water column, where fewer nutrients exist, i.e. the deep, cold water is not brought to the surface.
Higher evaporation occurs in warmer water, resulting in lots of water vapour rising due to its lower density. This heat is re-radiated into the atmosphere, heating the air. Warmer air holds more water vapour than cold, which causes rain and flooding to Central / South America.
The reduced nutrient load allows less plankton to thrive, so animals higher up the food chain have less food, so numbers of fish decrease, causing hardship to the fishing industry.
The climate in the western Pacific is much drier than normal, with cooler water and with less wind from the trade winds to bring moisture across the Pacific, leading to little rainfall and possible drought.


La Niña


El Niño
La Niña formation and effects
La Niña forms when the warmest region is in the western Pacific, resulting in a strengthening of the trade winds, replacing rising warm air and pulling water, due to friction, away from the South American coastline. The thermocline is quite deep due to the mass of warm, less dense water above in the west, but shallow in the cooler east, as in the diagram above. This, combined with the strong trade winds, increases upwelling of deep, cold water to the Peru coast, cooling the water and bringing nutrients from the deep. The strengthening of the trade winds means that the air descending on the east is very dry, resulting in little rainfall and possible drought. Fishing in Peru is excellent, due to increased nutrients driving the food chain (more plankton, more fish). In the western Pacific, the strong trade winds cause a strong current, increasing the moisture to the warmer air with higher sea level, leading to increased rainfall and stormy weather.</td>
<td>To demonstrate understanding of processes, the candidate explains by:
• Linking El Niño to change in wind strengths and ocean temperature.
• Linking La Niña change in wind strengths and ocean temperature.
• Linking thermocline changes to nutrient upwelling.
• Linking the change in fishing patterns to the correct phase.
• Linking the change in weather patterns to the correct phase.
May show understanding by use of annotated diagram / s.</td>
<td>To demonstrate in-depth understanding of processes, the candidate:
• Explains why the thermocline changes as the phases form.
• Explains climate effects of named regions in El Niño or La Niña conditions.
• Explains why fishing in Peru is poor in El Niño conditions OR is good in La Nina conditions</td>
<td>To demonstrate comprehensive understanding of processes, the candidate:
• Gives a comprehensive discussion of El Niño and La Niña, including their formation and effects on thermocline, Pacific climate and fishing in Peru.</td>
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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 –18	19 – 24