Assessment Schedule – 2023

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

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE	At the poles, density of surface water increases, due to reducing temperatures and increasing salinity. Due to strong cooling winds from the polar ice caps, the surface layer of the ocean is cooled rapidly, as heat energy is released from the water to the atmosphere. Cooling water reduces in volume, and therefore increases density. In addition, when the water cools past freezing point, ice forms from the water, leaving the salt component of the ocean water behind to increase salinity. This increased salinity also increases the density of the surface water. This dense water sinks to the bottom of the ocean (downwelling), forming deep currents as a part of thermohaline circulation, and is replaced by warmer surface currents moving to the higher latitudes, continuing the cycle. Atmospheric gases such as carbon dioxide, CO_2, 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_2 will dissolve more rapidly here than elsewhere. However, as climate change has resulted in increasing global temperatures, polar ice caps have been reducing, which adds significant amounts of fresh water back into the ocean surface surrounding the poles. This fresh meltwater will reduce the density of the surface layer by reducing the salinity. This, and warmer surface waters, have caused the ocean currents to slow due to reduced polar downwelling. Warming surface waters at the poles are likely to reduce the amount of atmospheric CO_2 that is dissolving, as gases dissolve more rapidly in colder water. Also, warmer and less saline surface water will mean that less downwelling occurs, and therefore less CO_2 will be removed from the atmosphere and stored in the deep ocean, reducing one of the largest global carbon sinks and potentially further increasing the CO_2 concentration in the atmosphere.	Describes with understanding: • downwelling due to reduced temperature / increasing salinity • increased density of the ocean in polar regions (leading to downwelling) • gases (CO_2) dissolve more rapidly in cold water (at high latitudes) • melting ice reduces the salinity / density of the surface ocean • reduced sea surface density linked to less downwelling.	Explains: • mechanism for increasing salinity due to ice formation linked to increasing density • mechanism for downwelling by decreasing temperature / inc salinity of surface water linked to density • physical carbon pump with increased rate of gas dissolving in the ocean • effect of melting ice on reducing the salinity of surface layer and therefore reducing downwelling • warmer waters lead to reduced CO_2 dissolving / downwelling linked to increase in atmospheric CO_2.	Explains comprehensively: • how salinity AND temperature cause increasing density leading to downwelling • increased rate of gas dissolving in cold polar water compared to warmer water, linked to downwelling • effect of climate change / increasing global temperatures leading to increased melt water reducing the density of the surface layer of ocean and slowing downwelling.

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

Q	Evidence	Achievement	Merit	Excellence
TWO	Solar radiation, in the form of light and UV, penetrates the top layer of the ocean and is absorbed by water molecules, causing the top layer of the ocean to warm. Conduction and mixing spread this heat through the top layer of the ocean, but as this layer is warmer and less dense, it tends to float on top of the cooler, deeper layers. Climate change has increased the global mean temperatures, and as the ocean acts as a major heat sink, some of this extra heat is being absorbed by the surface layer of the ocean. Therefore, the average temperature of the ocean is also likely to continue to increase over the next decades. This is likely to increase marine heatwaves (MHWs) as winds, currents and cycles like ENSO move heat energy around the oceans and focus it in particular areas at particular times. ENSO is a 3–7 year cycle of changing currents in the Pacific Ocean. During La Niña, easterly winds along the Equator strengthen, which drives warm equatorial waters towards the western Pacific. The Coriolis effect deflects this warm water to the left in the Southern Hemisphere towards New Zealand, bringing warmer subtropical currents down the east coast of Australia towards New Zealand. More intense episodes of La Niña bring more warmer waters towards New Zealand, resulting in more intense and longer marine heat waves. Climate change has resulted in more heat energy being absorbed by the ocean, and the ENSO circulation has become more intense. This results in more extremes of ocean surface temperature, bringing more warm waters to New Zealand during the La Niña phase of the cycle and increasing the intensity of MHWs around the coast of New Zealand, which puts a huge amount of pressure on fish stocks and marine environments.	Describes with understanding: • sunlight is absorbed by and heats the top layer of the ocean / water molecules • conduction and mixing spread the heat through the surface layer of the ocean / top 200 m • warmer water is less dense and remains at the surface • warming atmospheric temperatures warms the ocean • equatorial currents increase during La Niña • more warm waters drawn to New Zealand during La Niña • climate change increases frequency / intensity of MHWs.	Explains: • conduction and mixing spread heat through the surface layer which is less dense / remains at the surface • climate change is warming the globe which transfers more heat / energy to the surface layer of the ocean. • equatorial winds and currents are stronger during La Niña which draws more warm waters towards New Zealand increasing MHWs.	Explains comprehensively: • how climate change is warming the globe which transfers heat to the surface layer increasing MHWs, as well as increasing the intensity and frequency of ENSO • how more intense La Niña pushes more warm waters towards New Zealand, increasing the temperature of the (warm subtropical) currents and the oceans surrounding New Zealand.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence.

Q	Evidence	Achievement	Merit	Excellence
THREE	Surface ocean currents form due to winds creating friction at the surface. The friction transfers movement energy to the surface of the water and moves the water in the direction the wind is travelling. In the South Pacific, strong westerly winds (from the west) move along the Southern Pacific, and friction causes the surface layer of the ocean to move in the same direction. When this current meets the west coast of South America, it is deflected left in the Southern Hemisphere due to the Coriolis effect, becoming an eastern boundary current. Closer to the equator, friction on the surface layer of the ocean from strong easterly (Trade) winds (to the west) cause water movement to the west. When this current reaches the east coast of Australia it piles up on the coast and the Coriolis effect and gravity cause it to deflect to left, down the coast of Australia becoming a Western Boundary Current. This creates an anti-clockwise surface current in the South Pacific known as a gyre. Circling Antarctica there are very strong westerly winds that form as there are few major land masses blocking the flow of wind or water. Transfer of movement energy due to friction leads to a strong Antarctic Circumpolar Current (ACC) being formed that travels all the way around the globe. This current is the strongest ocean current in the world, and some of this is deflected up the coast of South America to join the South Pacific Gyre (SPG). Debris from all over the globe that enters rivers, or the ocean, may end up in these currents. The ACC may bring debris from as far as Europe as it is the only current that joins and mixes all the world's major oceans. It may then reach the Pacific and be deflected North to form part of the SPG, and as it spins, the debris moves towards the centre of the gyre due to the circular motion and towards Henderson Island.	Describes with understanding: • the role of wind in forming surface currents • Coriolis as deflection to the left / anticlockwise (in SH) • links between land mass and the effect on current direction • links between ACC forming and few blocking land masses • effect of gravity (e.g. downhill) on currents • links between ACC and SPG (which can carry debris from other oceans) • debris moving towards the centre of the gyre due to circular motion of currents.	Explains: • how winds transfer energy to ocean by friction, which generates surface currents in same direction (e.g., trade winds / westerlies) • how Coriolis effect deflects currents to the left in the southern hemisphere due to the rotation of the Earth • how SPG is deflected south from the equator towards due to Coriolis / bulge / gravity • how SPG is deflected due to continental barrier(s) / ACC • ACC as the only current that links the world's oceans, which may carry debris from around the globe • Plastic debris that enters the ocean anywhere may form part of the ACC then join the SPG.	Explains comprehensively: • The formation of the SPG (winds and currents, Coriolis and land masses / (gravity)) • The formation of the ACC (winds, land masses, continuous fetch) • links currents through movement of debris from around the globe via ACC towards centre of the SPG as ACC links all oceans.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	TWO points from Merit.	THREE points from Merit.	ONE complete point from Excellence and a second with minor omission.	TWO complete points from Excellence with link.

Cut Scores

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