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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Earth & Space Science 2023

91413 Demonstrate understanding of processes in the ocean system

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of processes in the ocean system.	Demonstrate in-depth understanding of processes in the ocean system.	Demonstrate comprehensive understanding of processes in the ocean system.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 10

QUESTION ONE: CARBON DIOXIDE ABSORPTION AT THE POLES



Figure 1: Global ice area since 1979

Source: <https://tamino.wordpress.com/2011/01/14/monckton-skewers-truth/>

Deep ocean currents store carbon dioxide and reduce its concentration in the atmosphere. However, polar ice has been reducing as a result of climate change, and melting polar ice may disrupt the ocean currents that enable this removal of carbon dioxide.

Explain the significance of melting polar ice in the removal of atmospheric carbon dioxide.

In your answer, you should consider:

- the causes of downwelling at the poles
- the physical ocean carbon pump at high latitudes
- the significance of melting ice to the polar ocean surface.

You do not need to discuss carbon chemistry or thermohaline circulation.

An annotated diagram may assist your answer.



A range of factors lead to downwelling at the poles including temperature and density variations. At the polar regions ~~the~~ ultra violet exposure is least compared to other regions such as at the equator. This causes solar heating and thermal expansion to be at a minimum. Due to this water temperature drops. As density is directly linked to water temperature it increases. This is the main cause of downwelling at the poles. Increased density of water causes it to sink and downwell. At high ~~the~~ latitudes cold conditions ~~causes~~ an increase in carbon dioxide absorption. This is because water is more soluble in cooler conditions. Because of high pressure zones at the poles an increased amount of winds ~~with~~ higher velocities are present this causes the transfer of energy ~~into~~ onto the water's surface due to friction creating waves with kinetic energy. Increased winds mean an increased amount of carbon dioxide being transferred from the atmosphere into the ocean at polar regions. Melting ice due to an increased amount of carbon dioxide in the atmosphere ~~has~~ has a great significance towards our ocean and planet. An increased amount of carbon dioxide ~~in~~ in the atmosphere is caused by processes such as ^{combustion} ~~the~~ the

There is more space for your answer to this question on the following pages.

burning of ~~that~~ natural fuel. As global warming occurs, ice is forced to melt reducing albedo. Albedo is caused by the white conditions at the poles to reflect incoming ultraviolet rays back into the atmosphere. This effect stops the warming of the ocean in polar regions as ice remains solid. With increased ice melt the albedo effect reduces. This allows solar radiation to have a larger area of affect with more water surface and less ice surface present. This creates a positive feedback mechanism causing the ocean to heat more, and ice to melt more. ~~The~~ Ice ~~water~~ displaces roughly the same amount as water. ~~So~~ Ocean ice would not contribute to sea level rise, however, land ice melt does. As the increased temperature in the atmosphere, due to carbon dioxide, causes land ice to melt, ~~the~~ large amounts of water are introduced to the ocean and displace ~~the~~ roughly the same amount of volume that it did on land. This leads to sea level rise and increased amount of solar radiation (positive feedback mechanism) to occur further increasing earths ocean temperatures.

QUESTION TWO: MARINE HEATWAVES

When the surface ocean temperature is unusually high for a period of time, scientists consider this to be a marine heatwave. These events cause habitat destruction due to coral bleaching, seagrass destruction, and loss of kelp forests, as well as the death of fish and other marine species.



Figure 2: 2021–2022 marine heatwave in Fiordland, southwest New Zealand

Adapted from: www.odt.co.nz/regions/southland/bleaching-fiordland-sea-sponges-may-be-largest-its-kind

In recent years, the coastal waters around New Zealand have experienced some of the most extreme and persistent marine heatwaves on record, with Fiordland reaching 6 °C higher than previously recorded maximum temperatures. The warm water was likely caused by a mixture of climate change and the prolonged La Niña conditions.

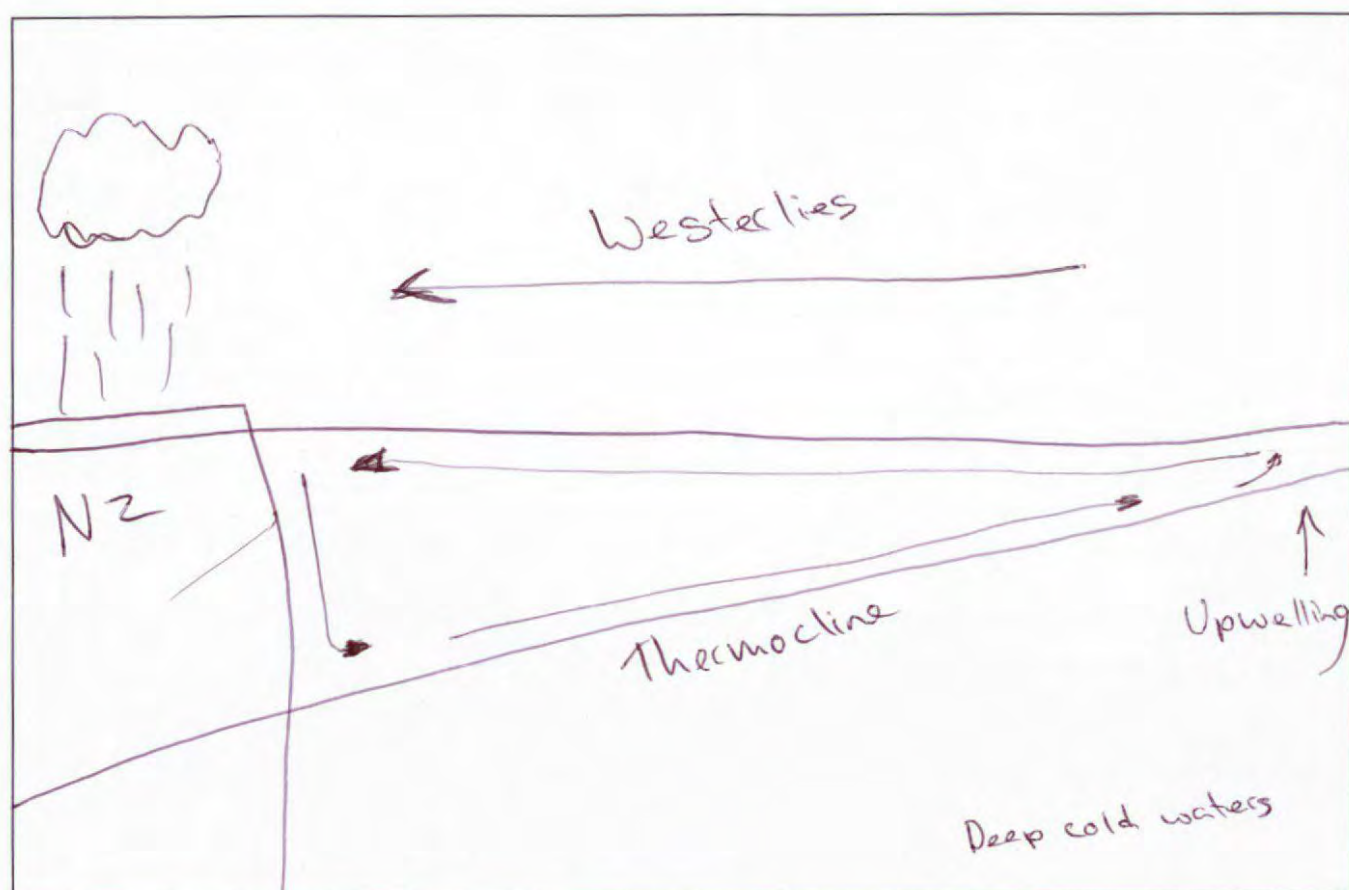
Discuss how climate change and La Niña may contribute to the increasing frequency and severity of marine heatwaves around New Zealand.

In your answer, you should consider:

- how the surface layer of the ocean is heated
- the effects of climate change on surface water temperature
- the effect of La Niña on the surface water temperature around New Zealand.

An annotated diagram may assist your answer.

The surface layer of the ocean is heated due to thermal expansion. In specific areas thermal expansion is increased due to higher concentration from the sun. The sun's radiation provides Ultra violet rays to heat the oceans surface in some places ~~this~~ this causes



molecules to expand and separate from one another causing an increase in volume and kinetic energy. ~~Be~~ Because of an increased amount of ~~co~~ carbon dioxide entering the atmosphere due to processes such as combustion, global warming is increased/accelerated. As the atmosphere is hotter and the ozone becomes more damaged higher rates of ~~e~~ radiation can enter the atmosphere and warm the ocean. With more thermal expansion warmer surface water temperatures ~~g~~ begin to occur. This can be ~~seen~~ ~~in the~~ a factor involved in the ~~the~~ marine heatwave seen in coastal waters around New Zealand. La Niña is caused by strong westerlie winds

There is more space for your answer to this question on the following pages.

created in the Ferrel cell. These winds cause a ~~as~~ ~~to~~ high amount of evaporation and precipitation to occur on the coast of New Zealand. As well as a ~~data~~ surplus of warm water to build ~~up~~ around the coast. Because of the water surplus seen here the thermocline is present at a increased bias gradient towards ~~then~~ ~~and~~ ~~where~~ New Zealand.

Because of this increased water temperature ~~the~~ New Zealand's coastline experiences persistent marine heatwaves, ~~affecting~~ causing habitat destruction due to coral bleaching, sea grass destruction as well as the death of fish and other marine ~~again~~ species.

QUESTION THREE: THE MOST PLASTIC-POLLUTED ISLAND ON EARTH

Henderson Island is a tiny uninhabited island in the Pitcairn Islands, and lies within the South Pacific Gyre. Beaches on Henderson Island contain an estimated 38 million items of plastic debris. On the island, researchers have found plastic rubbish from South America, Australia, and even as far away as Europe.



Figure 3: Ocean currents around Henderson Island and plastic rubbish on its beaches

Source: www.weforum.org/agenda/2017/05/the-untouched-south-pacific-island-choking-on-38-million-bits-of-plastic/

Discuss how surface ocean circulation has led to such a large accumulation of plastic debris on Henderson Island.

In your answer, you should consider:

- how the South Pacific Gyre is formed
- how the Antarctic Circumpolar Current is formed
- how plastic debris travels thousands of kilometres from around the globe to accumulate on Henderson Island.

An annotated diagram may assist your answer.

Ocean Surface currents affect only the top 100 m of the ocean. They are formed due to heat, wind, friction and the Coriolis Effect. These factors cause the movement of ^{surface currents} ~~ocean waters~~ in a spiral like pattern in the form of gyres.

Thermal expansion causes water molecules to ~~the~~ ~~war~~ heat and expand due to an increased amount of kinetic energy. ~~and~~ This ~~is an~~ causes an increase in volume this ~~generally~~ happens at ^{lower} ~~higher~~ latitudes ~~moving downwards~~ as ~~so~~ the distance ~~from~~ away from the sun is ~~g~~ less. The warm water, equatorial bulge, ~~moves~~ ~~downwards~~ towards the poles due to gravity.

~~Low~~ ~~pressure~~ Wind traveling from ~~low~~ high to low pressure zones causes high velocity winds to form. These winds transfer energy. As they move past the water surface friction occurs causing wave formation and surface currents. Surface currents are generally in the direction of prevailing winds.

There is more space for your answer to this question on the following pages.

The Coriolis Effect is another factor responsible for the creation of the South Pacific gyre. The Coriolis effect is the apparent deflection of an object from its original straight line path. In the Northern Hemisphere water moves in a clockwise direction. In the Southern Hemisphere water moves in an anticlockwise position.

The Antarctic Circumpolar current is formed as it follows the thermohaline current. This starts ~~at~~ in Europe with downwelling and continues downwards along Antarctica and up the coast of South America. It is large scale water circulation. Waves ~~over~~ ^{transport} energy, not matter. Ocean currents transport matter. The thermohaline current is responsible for the accumulation of plastic debris found ~~&~~ on Henderson Island. As the current downwells and starts at Europe travels down past Antarctica past Australia and past South America the ~~an~~ ocean current can transfer rubbish from all these places and deposit it ~~to~~ at Henderson Island.

Achievement

Subject: Earth & Space Science

Standard: 91413

Total score: 10

Q	Grade score	Marker commentary
One	A4	<p>The candidate states that decreasing temperatures causes increased density, and then describes how increasing density causes downwelling.</p> <p>Proceeds to link dissolving of carbon dioxide into the water, with its increased rate at the poles.</p>
Two	A3	<p>The candidate describes absorption of solar energy by the surface layer of the ocean.</p> <p>Also describes how a warmer atmosphere warms the ocean surface, and how more warm water is drawn to New Zealand's coast.</p>
Three	A3	<p>The candidate links the force of the wind on the surface of the ocean to the formation of surface currents in the same direction as the wind.</p> <p>They also state that Coriolis Effect deflects water currents anticlockwise.</p>