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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 ( ). 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.

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.

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

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.

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

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.

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

Extra space if required.
Write the question number(s) if applicable.

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