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91413

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NZQA

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Level 3 Earth and Space Science, 2019

91413 Demonstrate understanding of processes in the ocean system

2.00 p.m. Thursday 28 November 2019
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 and clearly number the question.

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

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

Merit

TOTAL 17

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QUESTION ONE: THE THERMOCLINE AND SEASONAL VARIATIONS

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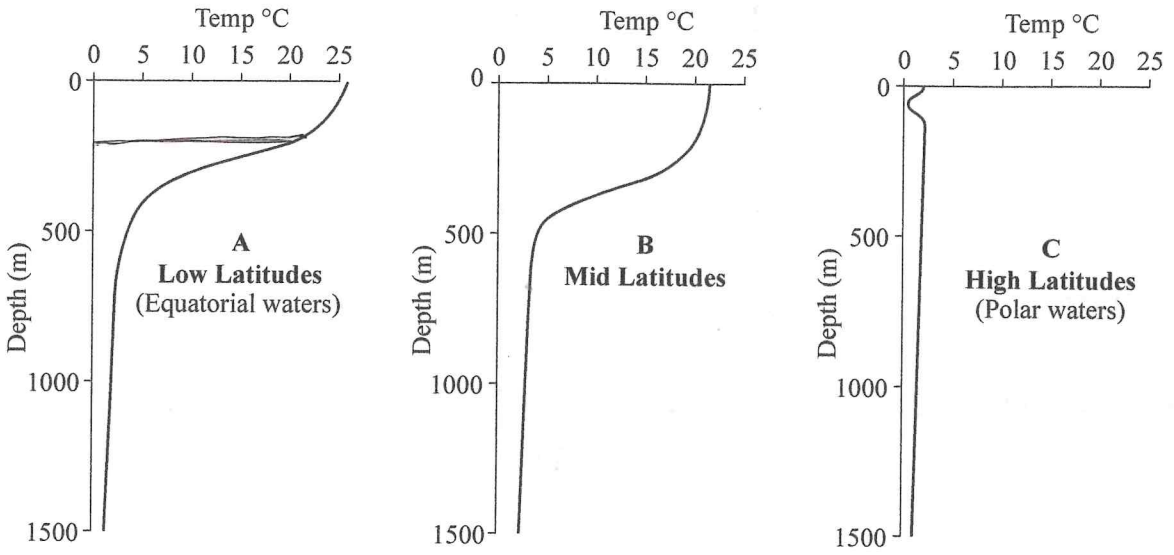
The resource below shows three thermoclines that were sampled in one year in March, in the Southern Hemisphere for equatorial, mid, and polar latitudes.

Typical Temperature Profiles

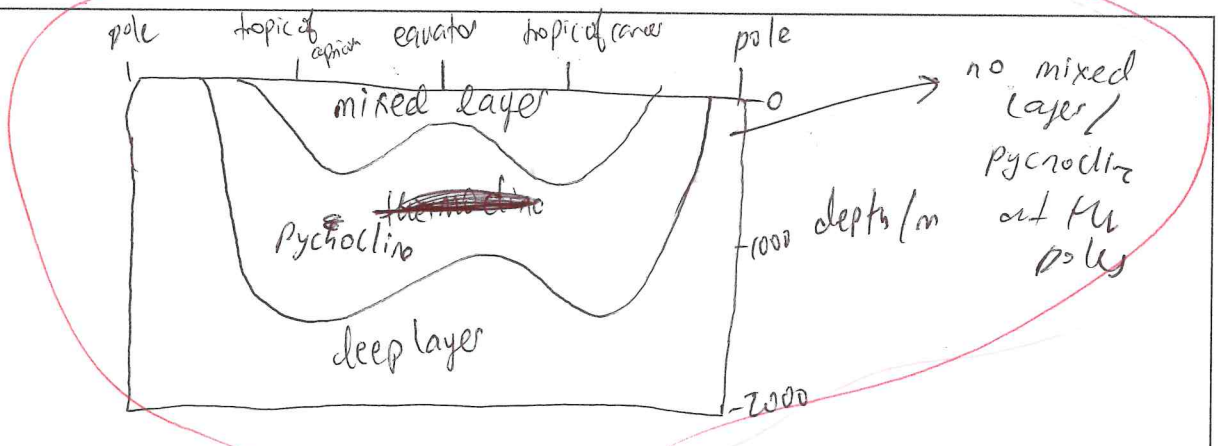


With reference to the above graphs, explain the reason behind the trends shown in the three thermoclines in terms of the thermal energy in the oceans, AND explain the likely consequences on the thermoclines of further global warming.

In your answer you should consider:

- what a thermocline is ✓
- the links between the layers, latitude, and solar heating for each thermocline ✓
- how seasonal heating can affect the thermocline ✓
- the effect of global warming on the ocean layers. ✓

You may use an annotated diagram to assist your answer.



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~~The thermocline is the layer of the ocean in which there is a sudden, drastic temperature change in the water. The thermocline is found between the mixed layer (closest to the surface) and the deep layer (closest to the sea bed.)~~

The thermocline is the variation in temperature in the ocean with increasing depth. The thermocline is often expressed as a graph, and it helps to identify the extent of the three layers of the ocean. The three layers of the ocean are the mixed layer (the layer of the ocean closest to the surface), the pycnocline (the layer through which temperature dramatically decreases and density dramatically increases) and the deep layer (the cold, bottom layer of the ocean packed full of nutrients). We can use the graph of the thermocline to identify the start and end of each layer which helps to explain the characteristics of each separate thermocline. In the equatorial regions, the solar radiation from the sun is direct with a large heating effect, causing a lot of evaporation from the surface. This means that the upper, mixed layer is relatively shallow compared to the mid-latitudes, so the drastic decrease in temperature from the pycnocline begins at a relatively shallow depth of about 200m. In contrast, the mid-latitudes have a deeper mixed layer as the strong winds at these latitudes create a mixing effect. Additionally, the solar radiation received at these latitudes is at an angle and therefore not as intense as what is received by tropical latitudes. This means that less evaporation of water occurs, which also contributes to a deeper mixed layer. This means that the dramatic temperature decrease of the pycnocline occurs at a greater depth than observed at tropical latitudes, as shown in the diagram of typical

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

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temperature profiles. //

In contrast, the polar latitudes do not have a mixed layer or pycnocline at all, as the deep layer comes right up to the surface of the water. The water does not decrease or increase in temperature dramatically at any point at the polar latitudes — the only change in temperature is a small, temporary decrease to 0°C that is due to ice melt. As the amount of solar radiation received by the polar latitudes is even smaller and even more indirect than that received by the mid-latitudes, there is very little thermal energy supplied to the water and it is very cold, as shown in the graph. //

The tilt of the earth's axis means that the Northern and Southern hemispheres receive uneven heating throughout the year, which leads to a variation in the amount of solar radiation received by the water. In summer in a particular hemisphere, there is a greater amount of solar energy received by the water, which not only increases the temperature of the surface but also increases the evaporation that occurs, which will cause the steep decrease in temperature to occur at a shallower depth. The opposite happens in winter, when the water receives less solar radiation. //

Global warming would increase average surface temperatures, so the initial temperature of the thermocline would increase. Additionally, the increased evaporation would make the mixed layer shallower, leading to a the steep temperature change of the pycnocline happening sooner. //

QUESTION TWO: CARBON DIOXIDE AND OCEAN ACIDIFICATION

The photographs below show the development and thickness of the shell structure of 13-day-old green-lipped mussel larvae raised in different ocean water acidity conditions.

pH and Acidity Level	Shell	**Shell Cross Section Structure** (Taken from the area shown by the red square – thickness is shown in micrometres)
pH level 8.0 Normal ambient levels of ocean acidity		
pH level 7.7 Moderate level of ocean acidity		
pH level 7.3 Extreme level of ocean acidity		

Source: J. Ericson, *Effects of ocean acidification on fertilisation and early development in polar and temperate marine invertebrates*, MSc thesis (Dunedin, University of Otago, 2010), p. 117

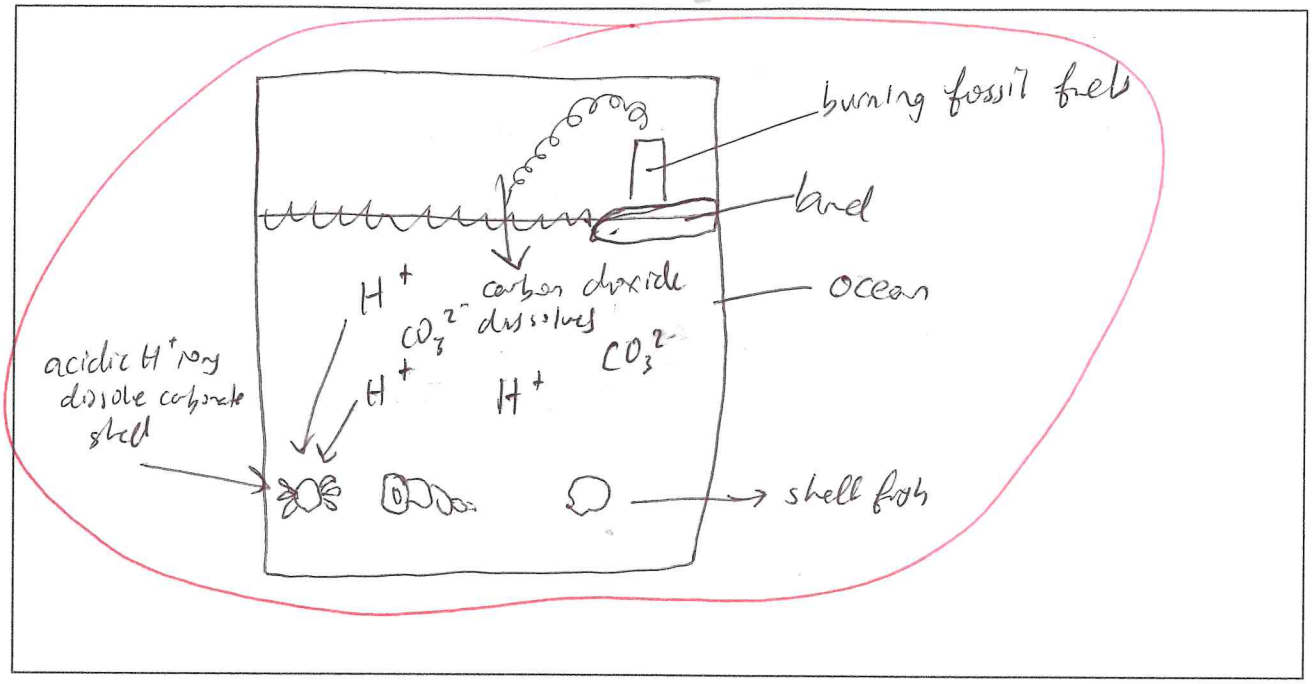
As more carbon dioxide dissolves in the oceans, ocean water is becoming more acidic.

Using the above resource to assist you, explain how the increasing levels of carbon dioxide in the oceans will impact ocean life.

In your answer you should consider:

- the reasons for increasing carbon dioxide in the oceans ✓
- what happens to the carbon dioxide when it enters the ocean; this should include the appropriate chemical equations ✓
- how changes to the ocean's carbonate levels will affect marine life. ✓

You may use an annotated diagram to assist your answer.



With the industrialisation of the world came the burning of fossil fuels for energy, which has massively impacted the Earth's biosphere in the last century. One effect of the burning of fossil fuels is the increase of CO_2 gas in the air. Some CO_2 stays in the atmosphere, but a large amount of CO_2 is dissolved in the water as the ocean is a major carbon sink.

When CO_2 dissolves in water, it forms carbonic acid:

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

which then dissociates into H^+ and CO_3^{2-} ions:

$$H_2CO_3 \longrightarrow 2H^+ + CO_3^{2-}$$

The H^+ ions produced in this dissociation increase the total concentration of H^+ ions in the water, decreasing the pH of the ocean as it becomes more acidic. ~~the ocean has normal~~ The normal ambient ocean pH is slightly alkaline at about 8.0, but the addition of CO_2 produced in recent years has brought that pH down in some areas to about pH 7. The acidity is an issue because the acid in the ocean reacts with the calcium carbonate, $CaCO_3$, shells of ~~the~~ shellfish

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

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making them thinner and more fragile. This has a negative impact on shellfish because their thinner outer shells make them more ~~susceptible to~~ vulnerable, which could see their populations dwindling. This could cause an upset in the marine food web and impact all ~~species~~ of its species.

QUESTION THREE: FISHING AND THE CHATHAM RISE

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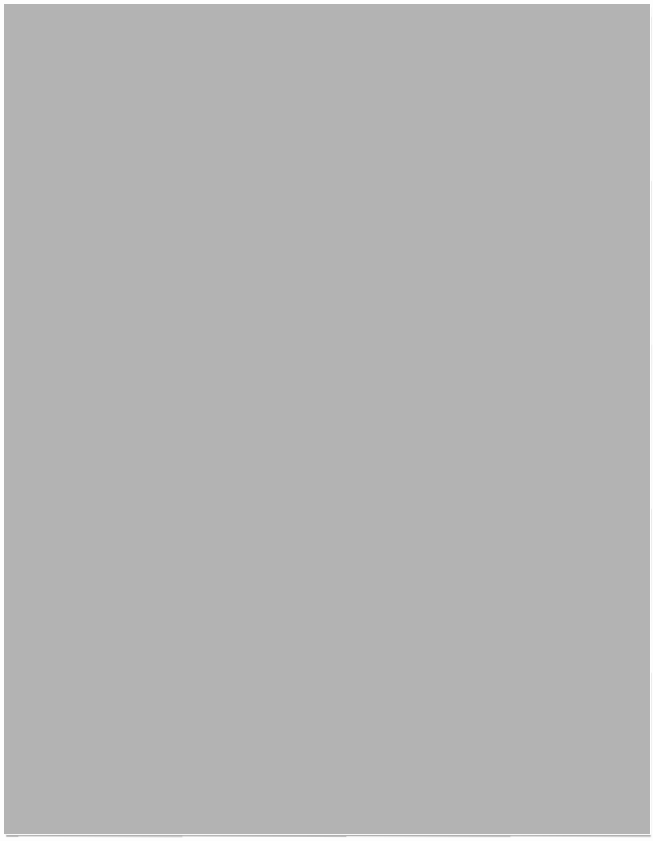
The resources below show the sea floor and ocean currents that circulate off the east coast of New Zealand, and a satellite image of a phytoplankton bloom in 2010 taken by a NASA satellite over the Chatham Islands and Rise.



Adapted from: https://www.niwa.co.nz/our-science/oceans/bathymetry/download-the-data and https://teara.govt.nz/en/map/5912/ocean-currents-around-new-zealand

Source: NASA Aqua satellite 5 December 2010. https://earthobservatory.nasa.gov/images/47621/bloom-around-the-chatham-islands-new-zealand

The Chatham Rise is an underwater mountain range that extends from the east coast of the South Island to beyond the Chatham Islands. It is the meeting point of surface and deep-water ocean currents.

Explain how this region of the ocean will have an influence on marine life and human activity.

In your answer you should consider:

- current formation and origin
- reasons for the different temperatures of the currents
- the reason why the two currents meet at the Chatham Rise.

You may use an annotated diagram to assist your answer.

The surface currents near the Chatham rise, such as the East and West Auckland currents, are caused by the strong westerly winds of the Ferrel ~~cell~~ circulation cell. In contrast, the deep ocean currents such as the Antarctic Circumpolar current are formed due to the cold waters that sink at the poles and

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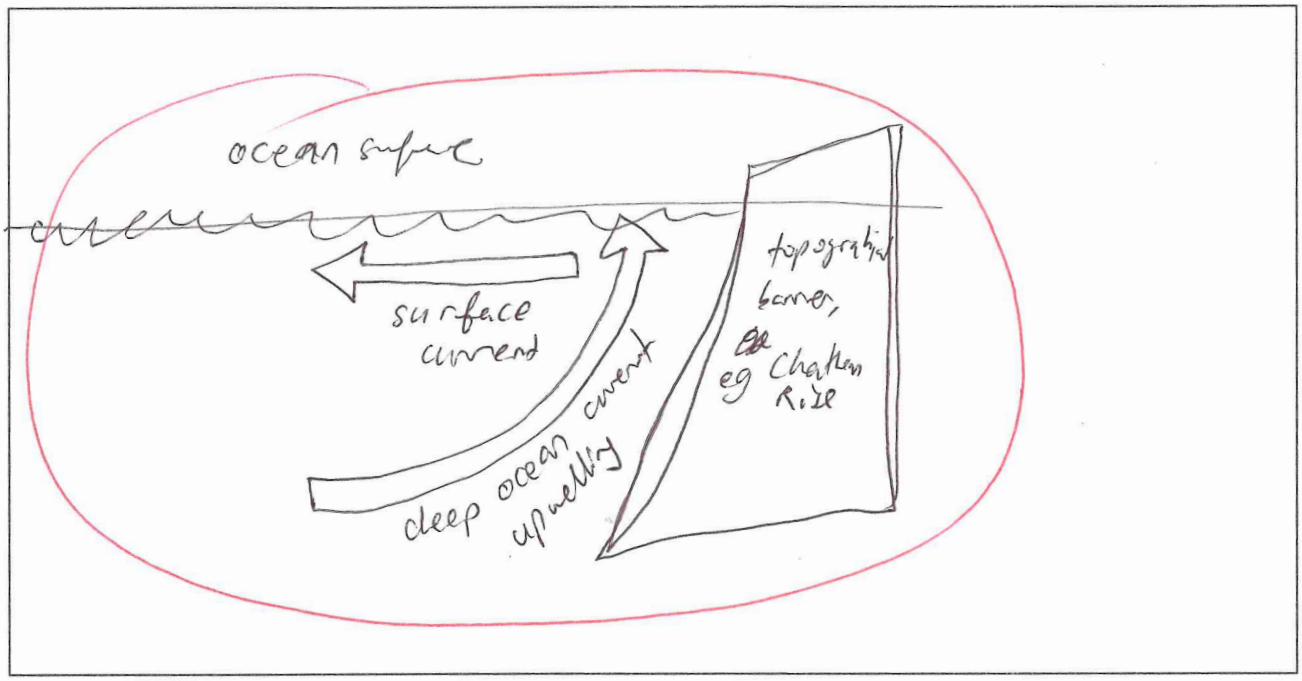

travel along the bottom of the ocean in the deep layer. This cold water is rich with dissolved gases and nutrients necessary for life. When the two currents meet at Chatham Rise, the underwater mountain range acts as a topographical barrier to the deep ocean current, causing the deep ocean current to rise to the surface. This is known as upwelling. This upwelling of the deep current pushes aside the surface current, forcing it away. The nutrient rich waters that result from the upwelling provide ideal conditions for organisms such as phytoplankton, which quickly grow and multiply to form a phytoplankton bloom, such as the one depicted in the diagram on the previous page. The fish and other marine life that feed on this phytoplankton will also have an increasing population, the marine life in this area will thrive. Human knowledge of these events could cause people to come out to the Chatham RISE for fishing purposes to take advantage of the abundant fish. In this way, the meeting of these currents can affect marine life and human activity.

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

Merit Exemplar 2019

Subject	L3 Earth and Space Science	Standard	91413	Total score	17

Q	Grade score	Annotation
1	M6	The candidate gives an explanation that links two key points in the relation of the seasonal changes that take place in the upper mixed layer and consequently the depth of the thermocline. This is linked to an explanation of the effect of global warming on the mixed layer.
2	M6	The candidate provides an explanation relating the increase of carbon dioxide in the ocean to increase in hydrogen ion concentration and acidity with appropriate chemical equations. The acidity increase is related to how shellfish and ecosystems are impacted.
3	M5	The candidate relates the phytoplankton bloom to the mixing of nutrient rich waters brought up from the deep ocean by the influence of the Chatham Rise. (An annotated diagram is provided to supplement the explanation. The consequences of the bloom are linked to marine life.

Confirmation of check	Y / N
This exemplar has been checked for similarities with current online exemplars.	Y