SUPERVISOR'S USE ONLY

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91413

914130

Draw a cross through the box (☒) if you have NOT written in this booklet

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Earth and Space Science 2025

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.

Achievement TOTAL 13

coriolis effect

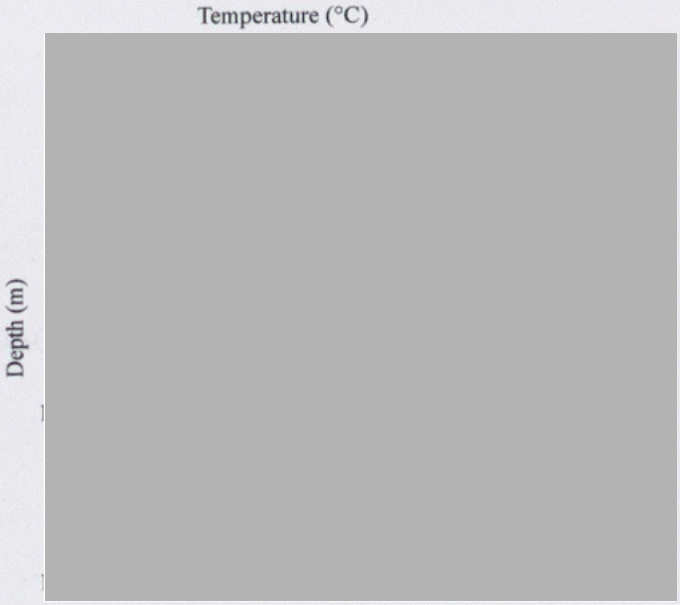
-1.954

QUESTION ONE: NEW ZEALAND'S THERMOCLINE

elkenn 90 L

New Zealand is in the mid-latitudes, where surface ocean temperatures vary widely between seasons. The gradient of the thermocline changes as surface temperature changes during the year. This also impacts formation of the pycnocline, which reflects changes in density of ocean water.

Seasonal thermocline changes



Adapted from: www.sciencedirect.com/topics/agricultural-and-biological-sciences/thermocline

Discuss seasonal changes in the thermocline and pycnocline near New Zealand.

In your answer, you should consider:

- how the thermocline forms
- formation of the three ocean layers
- reasons for seasonal variation in the thermocline at mid-latitudes
- how changes in the thermocline impact pycnocline formation. <- low temps = strong pycnocline high temp = shallow

An annotated diagram may assist your answer.

NHR SHL VW strong in low latitudes

cold water top warm bottom

Thermocline is a layer in which temperature changes rapidly with depth. The 3 layers of the ocean are ~~deep layer~~ mixed surface layer which temp varies with seasons / latitude and is only about 50m. The surface mixed layer contains warmer, less dense, lower salinity, lower pressure water. The layer below is the pycnocline - rapidly ~~the~~ changes density with depth / transition layer, conditions are rapidly changes such as salinity, temperature and density. last is deep waters these waters have sunk to the bottom as they are are much denser due to the temperature being much lower, salinity being much higher - cold salty water will sink below the less salty and cold water. Conditions in this layer are ~~[illegible]~~ generally consistent.

The thermocline will become shallower in spring / autumn however as the waters begin to heat up increase temp the thermocline is most prominent and at its deepest as thermocline are most ~~prom~~ pronounced in warmer waters. So in summer it becomes the most pronounced out of all the seasons.

~~As~~ ~~Pycnocline are~~ Density is determined by pressure, salinity, and temperature. * So therefore when the thermocline is more rapidly ~~decreasing~~ increasing decreasing in temperature, the pycnocline is more rapidly increasing with density. When the thermocline ~~temperature~~ is shallower the pycnocline is also more shallower and less pronounced.

* When the temperature of water is increased ~~[illegible]~~ decreased density is increased.

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

kewkewhdos

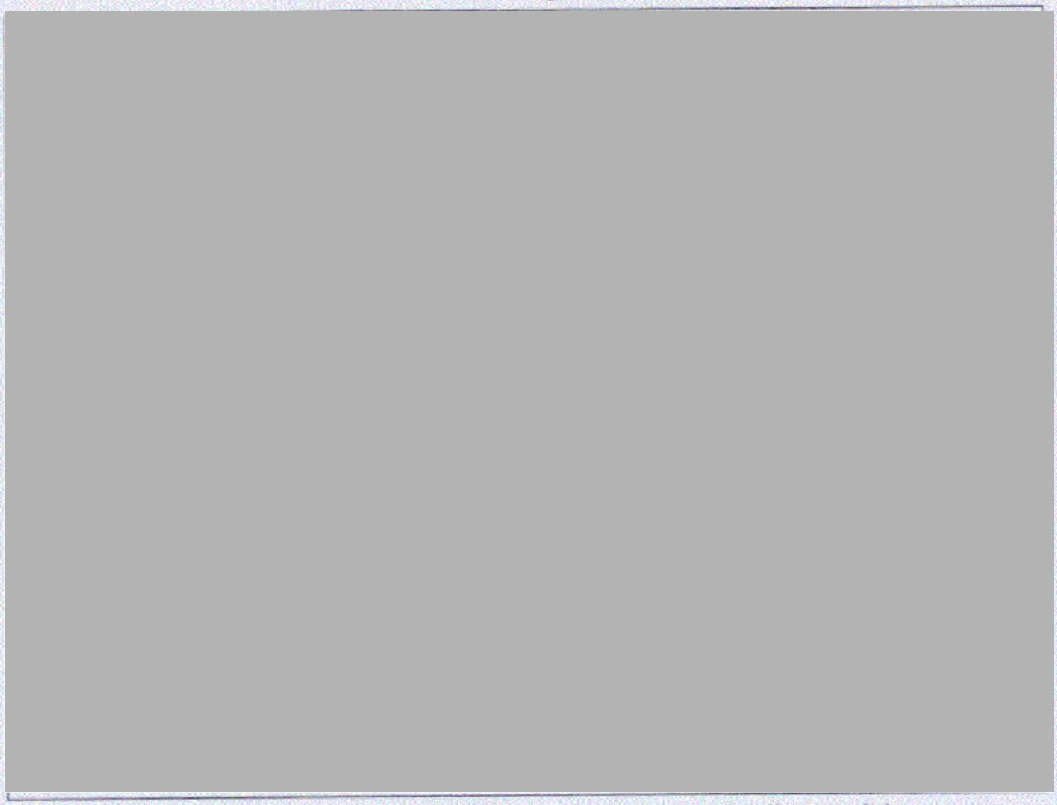
Southern ocean can because its colder

carbon dissolves better in cold water

QUESTION TWO: SOUTHERN OCEAN CARBON SINK

The Southern Ocean plays a central role in moderating the rate of climate change, absorbing approximately 40% of the carbon dioxide (CO_2) that has been produced by humans until now.

Cumulative ocean CO_2 uptake since 1850



Adapted from: https://scx2.b-cdn.net/gfx/news/hires/2022/improving-climate-mode.jpg

Explain how the Southern Ocean absorbs large amounts of carbon dioxide from the atmosphere.

In your answer, you should consider:

- the biological and physical pumps that take CO_2 into the ocean
- the effects that storing increased amounts of CO_2 may have on ocean chemistry
- reasons why the Southern Ocean can absorb such large quantities of CO_2.

Carbon dioxide (CO_2) is ~~blows~~ admitted into the ~~air~~ atmosphere by humans through things such as cars, planes, deforestration. The ocean then absorbs alot of this CO_2. ~~The~~ The 'biological carbon pump' is phytoplankton who absorb ~~CO_2~~ carbon dioxide through photosythesis. When these phytoplankton then die or get eaten this carbon that they absorbed falls to the ~~bottom~~ deep ocean layer and is stored in carbon sinks. phytoplankton ~~are~~ also play a big role in migigating carbon levels in ->

calcium carbonate carbonic acid

Shell building organisms

the ocean. → the atmosphere. However as the ocean is absorbing increased amounts of CO_2, as humans continue to admit more and more levels of CO_2 into the atmosphere it has has negative effects of storing increased amounts of CO_2 on Ocean chemistry. One of the main effects is on shell building organisms. When CO_2 is absorbed by the ocean it reacts with water (H_2O) to form carbonic acid. This however increases the amount of hydrogen (H^+) produced in the ocean. H^+ reacts with calcium carbonate, and therefore decreases the amount of calcium carbonate available in the ocean. Shell building marine animals shells are made up of and remain in for life calcium carbonate and therefore when hydrogen reacts with calcium carbonate, this leaves less available calcium carbonate for shell building organisms to build shells with. ~~Also when this CO_2 is taken into reacts with H_2O to form carbonic acid~~

Also the extra H^+ being produced because of increased the CO_2 absorption, makes the ocean water more acidic therefore ~~decreasing the~~ lowering the ph level of the ocean. In extreme cases shell building organisms can be disintegrated by this. Lowering ph levels even just a little has distrous effects on the ocean and all of its marine life.

As well as decreasing levels of food sources for humans and having major impacts for fisheries as more fish are unable to survive lower ph levels, meaning there is less fishes available for fisheries to sell.

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

The Southern ocean can absorb large amounts of CO_2 as it consist of much colder water. with lower temperatures than other oceans. ~~the~~ CO_2 dissolves more easier in colder waters hence why ~~the~~ the deep layer of the ocean has the highest levels of dissolved CO_2 due to it having the lowest temperature.

Strong trade winds

N/H summer

DV

QUESTION THREE: SOMALIA SEASONAL UPWELLING

→ La NINA

SAC dry
D= wet

Somalia is a country in East Africa. During the northern hemisphere summer, from June to September, a strong monsoon wind blows from the south-west along the coast. This causes upwelling and very good fishing compared to other seasons.

Surface currents in the western Indian Ocean

Adapted from: https://www.mdpi.com/2073-4425/11/3/278

Upwelling current at the Somali coast during southwest monsoon

Adapted from: https://commons.wikimedia.org/wiki/File:Upwelling_current_at_the_Somali_coast_during_Southwest_Monsoon.png

Compare the seasonal fishing conditions off the coast of Somalia during the summer and winter monsoons.

In your answer, you should consider:

- the role of wind from the south-west and the Coriolis effect to create strong seasonal upwelling
- the source of nutrients ← bringing up nutrients + dissolved CO_2
- the effect of strong seasonal upwelling in this area on productivity — More nutrients available, more CO_2 dissolved
- the conditions that lead to downwelling and poor fishing during the winter monsoon season.

La Nino

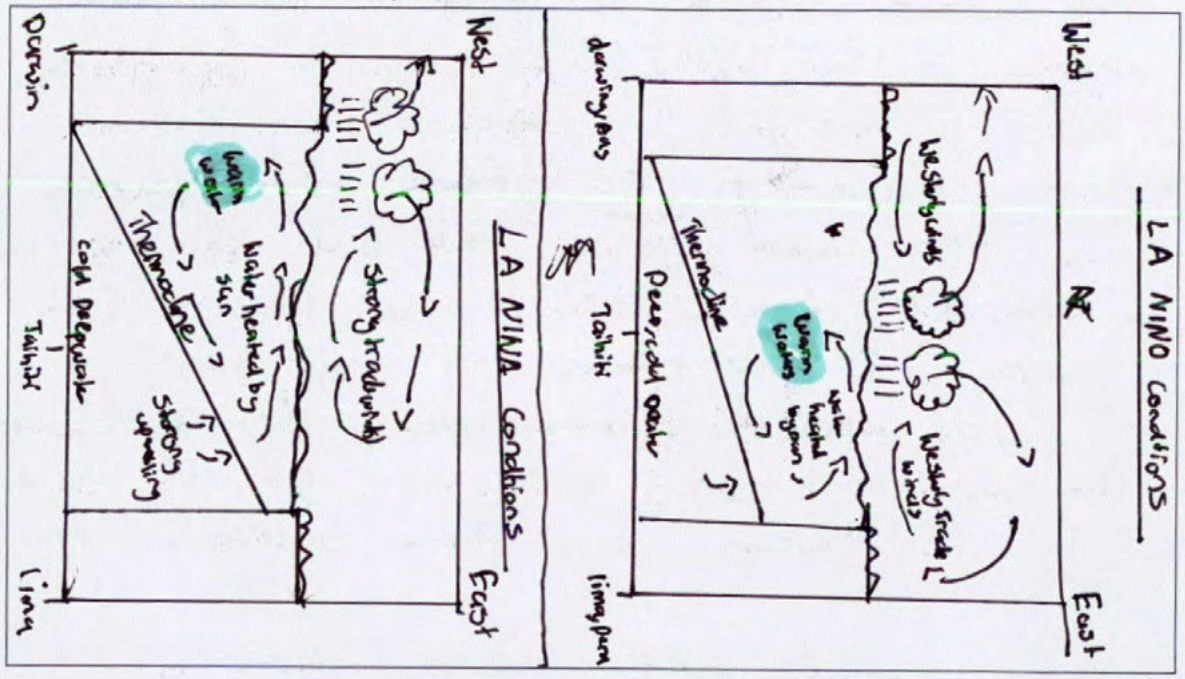
westerly Trade winds

westerly winds chino

= warm water to east

11 Trade winds come from N-E

An annotated diagram may assist your answer.



Corlios effect deflects currents, in the Northern hemisphere where Somalia is, the current is deflected to the Right.

The reason for good fishing conditions in the summer is because of an increase of nutrients available for fish. This is because due to ekmans transport, the strong moonsoon wind blowing along the coast would push surface waters further along the coast, meaning deep waters are uplifted to replace the diverging surface waters, These deep waters now become surface waters and contain lots of nutrients and dissolved CO_2 as they are upwelled they bring these nutrients to the surface waters. —>

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

These extra/new nutrients increase the amount of nutrients/energy available to fish, leading to an increase in population, & leading to more fish for fisheries to fish. / increased fishing condition. However in the ~~summer~~ winter ~~causes~~ La NINO causes ~~less~~ weaker /WO trade winds to ~~blow~~ move surface water, meaning little to no ~~no~~ upwelling occurs, meaning ~~no~~ new nutrients are brought from deep waters to surface waters. Which ~~di~~ decreases the amount of nutrients ~~for~~ available for fish resulting in a decrease of fishing conditions in winter.

Strong seasonal upwelling leads to a increase in productivity as there is now an increase of nutrients available to fish, meaning they are able to reproduce as much, leading to a decline in fish population during winter. ~~leading to less fishing~~ leading to a decrease in fishing condition.

Downwelling is where surface water is blow by wind along the coastline, and is ~~subsidenth~~ pushe down into deeper waters, this then brings oxygen to the deeper layer, which is essential for many deep sea animals

Achievement

Subject: L3 Earth & Space Science

Standard: 91413

Total score: 13

Q	Grade score	Marker commentary
One	4	The candidate demonstrates a basic Level 3 understanding by defining the key structures in the ocean layers and then showing some elementary understanding of how they change in different seasons.
Two	4	The candidate shows understanding of a wide range of ideas related to carbon cycling in the ocean, including an aspect of the biological pump in marine snow, an aspect of the physical pump in the effect of water temp on dissolving CO_2, and the process of ocean acidification. However, there was limited depth to the explanations for these processes, and ideas were not linked into a cohesive argument.
Three	5	The candidate showed understanding of the connection between the upwelling of cold, deep, nutrient rich waters and the impacts on the food web, and therefore fishing industry off the coast of Somalia, which demonstrated Merit level understanding. However, they did not link in the idea of Coriolis Effect/Eckman Spiral and how that enhances the movement of water away from the coast to increase the rate of upwelling.