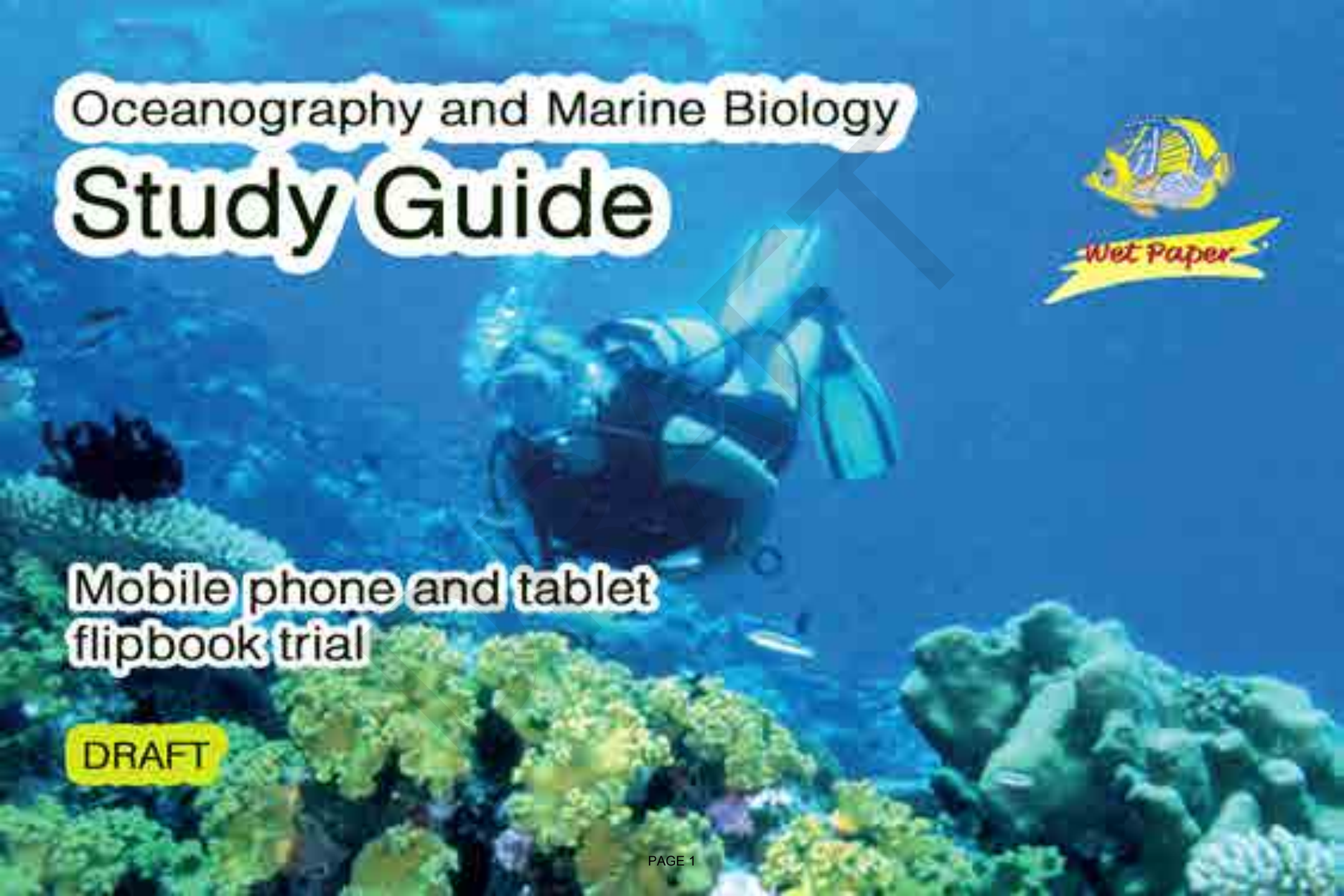

Oceanography and Marine Biology

Study Guide

Wet Paper

Mobile phone and tablet flipbook trial

DRAFT

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T001 Bathymetric features

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Syllabus statement

The syllabus says ... you should be able to

describe bathymetric features of the ocean floor, including the continental margin, ocean-basin floor, deep-sea trenches, mid-ocean ridges and abyssal plain

Describe - give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something.

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Question

Give an account of the shape of ocean bathymetric features.

DRAFT

Definition

A bathymetric feature is the shape of underwater terrain

Bathymetric features include

A. Continental margin
B. Seamounts
C. Volcanic islands
D. Deep-sea trenches
E. Mid-ocean ridges
F. Atolls
G. Ocean-basin floor including abyssal plains and hills

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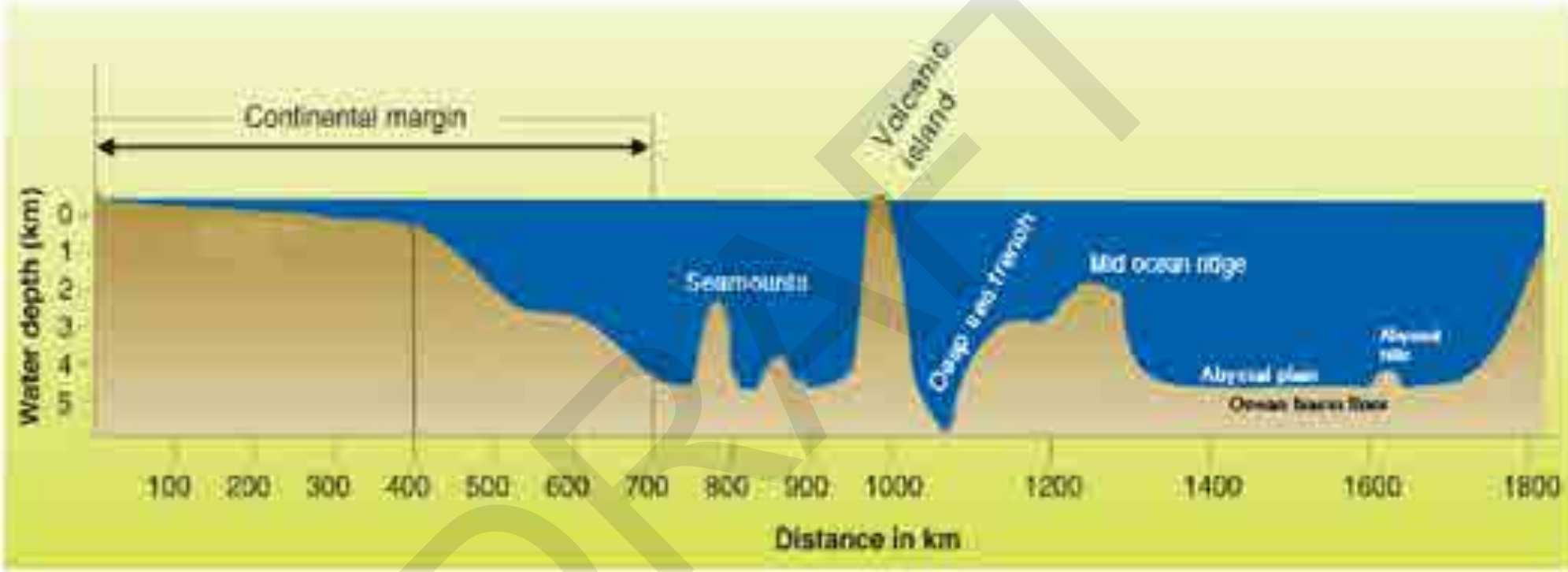
The following is a summary diagram
– you will have to redraw this.



Ocean topography divisions
Illustration Bob Moffatt

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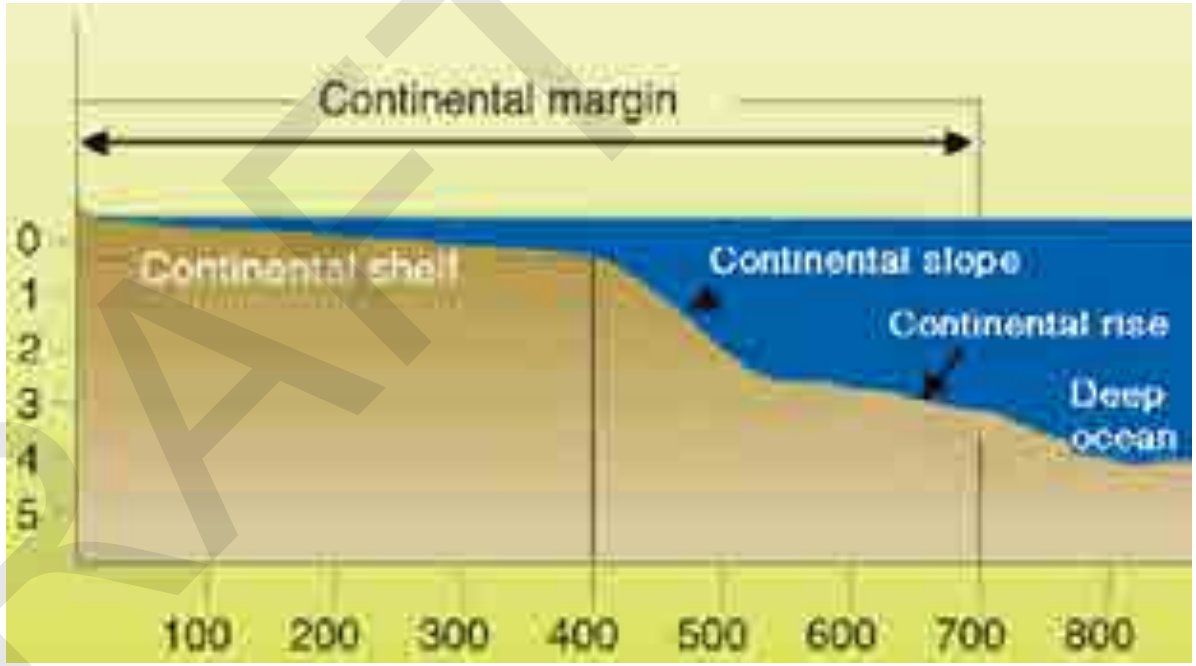
Continental margin

The continental margin has a
Shelf
Slope and
Rise.

It stretches out from the land as far as the eye can see.

The average distance for the continental margin is 65 kilometres and its character varies from place to place.

In Australia it consists of the continental shelf (mostly fairly narrow), the continental slope, and the continental rise.



Continental margin
Illustration Bob Moffatt

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In Australia the margin looks like this.

Australian continental margin

Illustrations Bob Moffatt and Geoscience Australia

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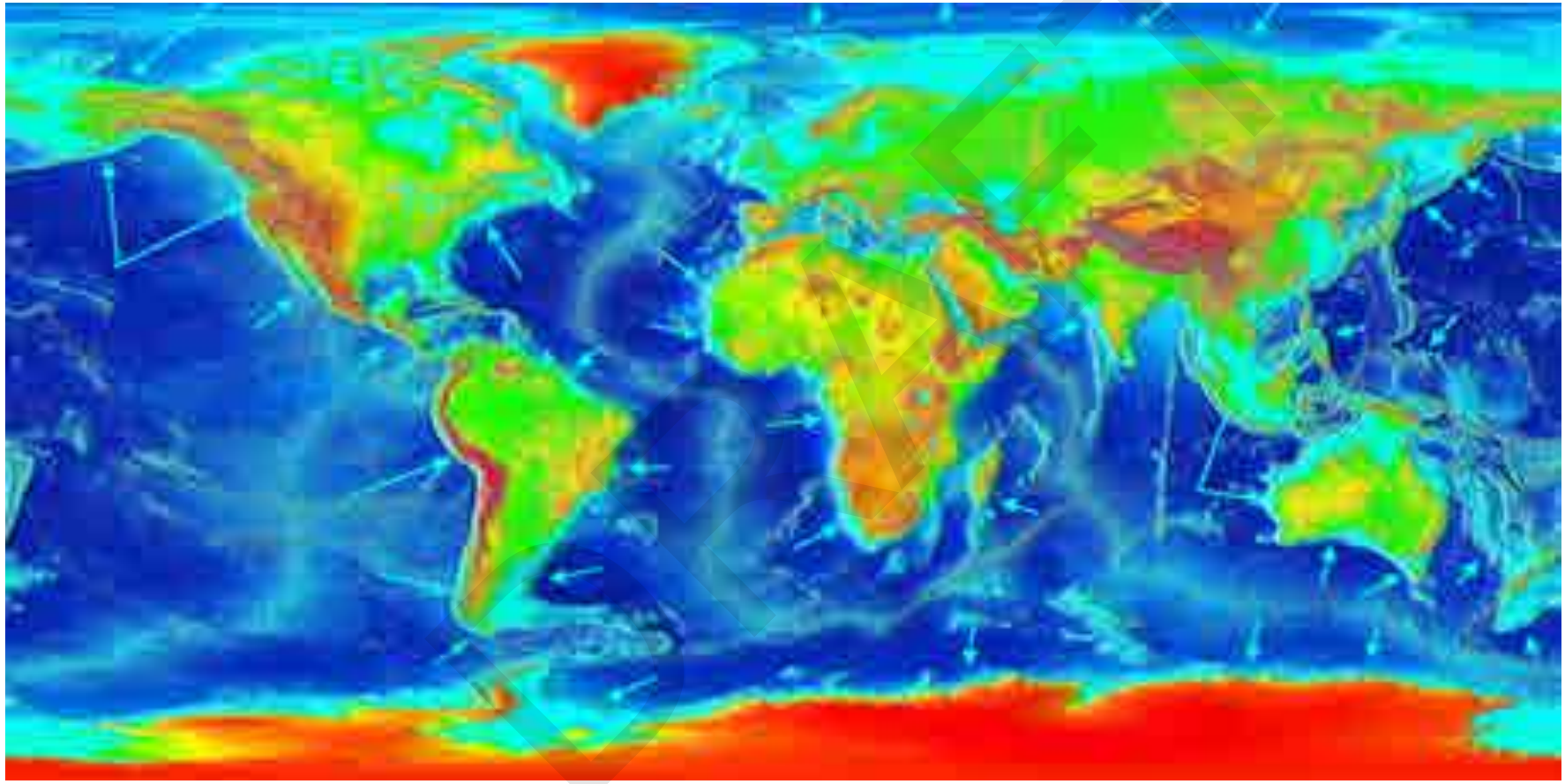
The shelf

The continental shelf is an underwater landmass which extends from a continent, resulting in an area of relatively shallow water known as a shelf sea.



Global continental shelf, highlighted in cyan

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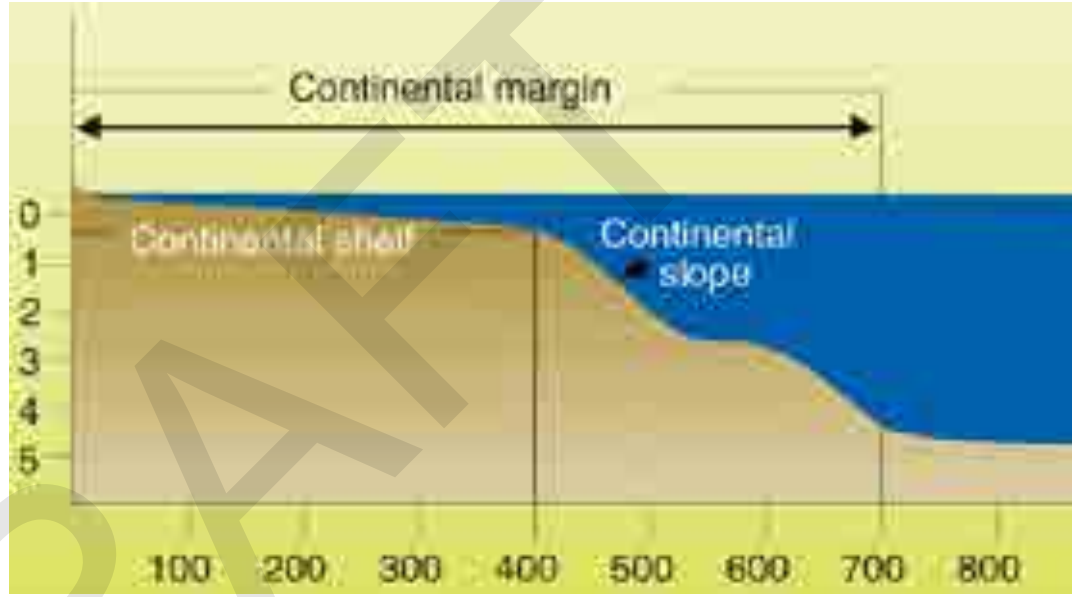
The slope

The continental slope is the area of seafloor between the continental shelf and the continental rise (or oceanic trench in some places of the world).

Usually to a depth of about 200 meters.

The continental slope typically has a relatively steep grade from 3 to 6 degrees.



Continental slope
Illustration Bob Moffatt

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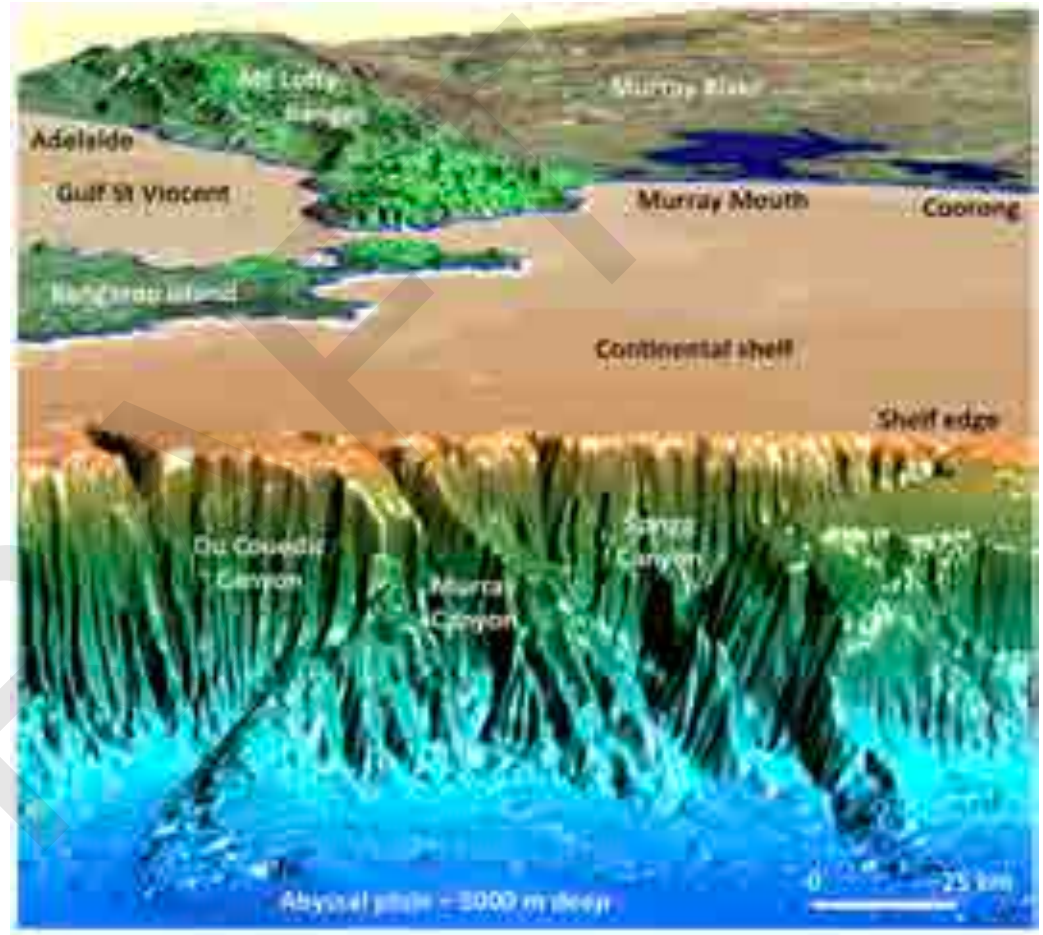
The slope itself can be quite irregular and may be eroded by river-like currents to form valleys and canyons.

Larger valleys are called submarine canyons.

In South Australia off Kangaroo Island there exists deep cuts into the continental shelf.

Canyons also trap sediments from the land and transport these to the ocean depths.



Submarine canyons off Kangaroo Island
(Supplied: Peter J Hill and Patrick De Dekker)REF:http://www.abc.net.au/catalyst/stories/s838745.htm

References:
BLUE PLANET 2 Episode 2

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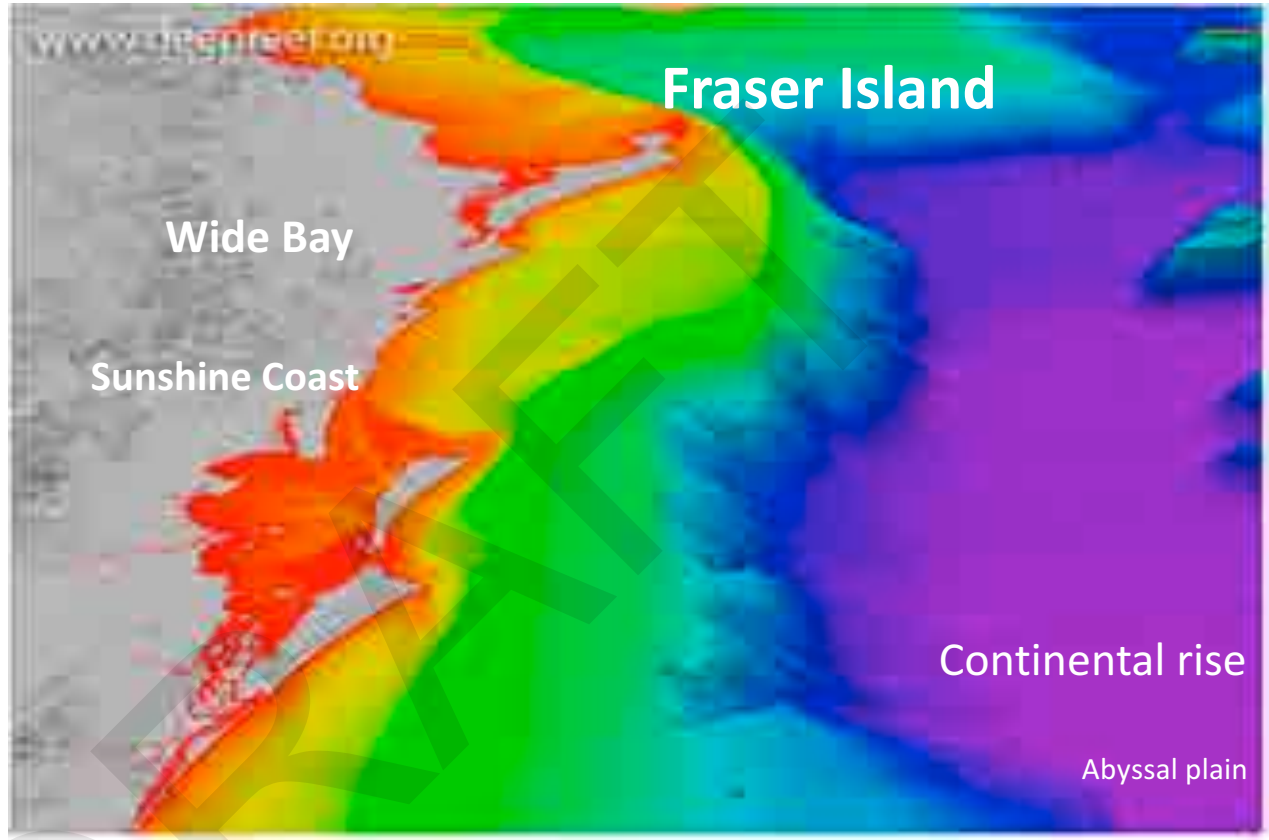
The rise

The continental rise is an underwater feature found between the continental slope and the abyssal plain.



Offshore South East Queensland

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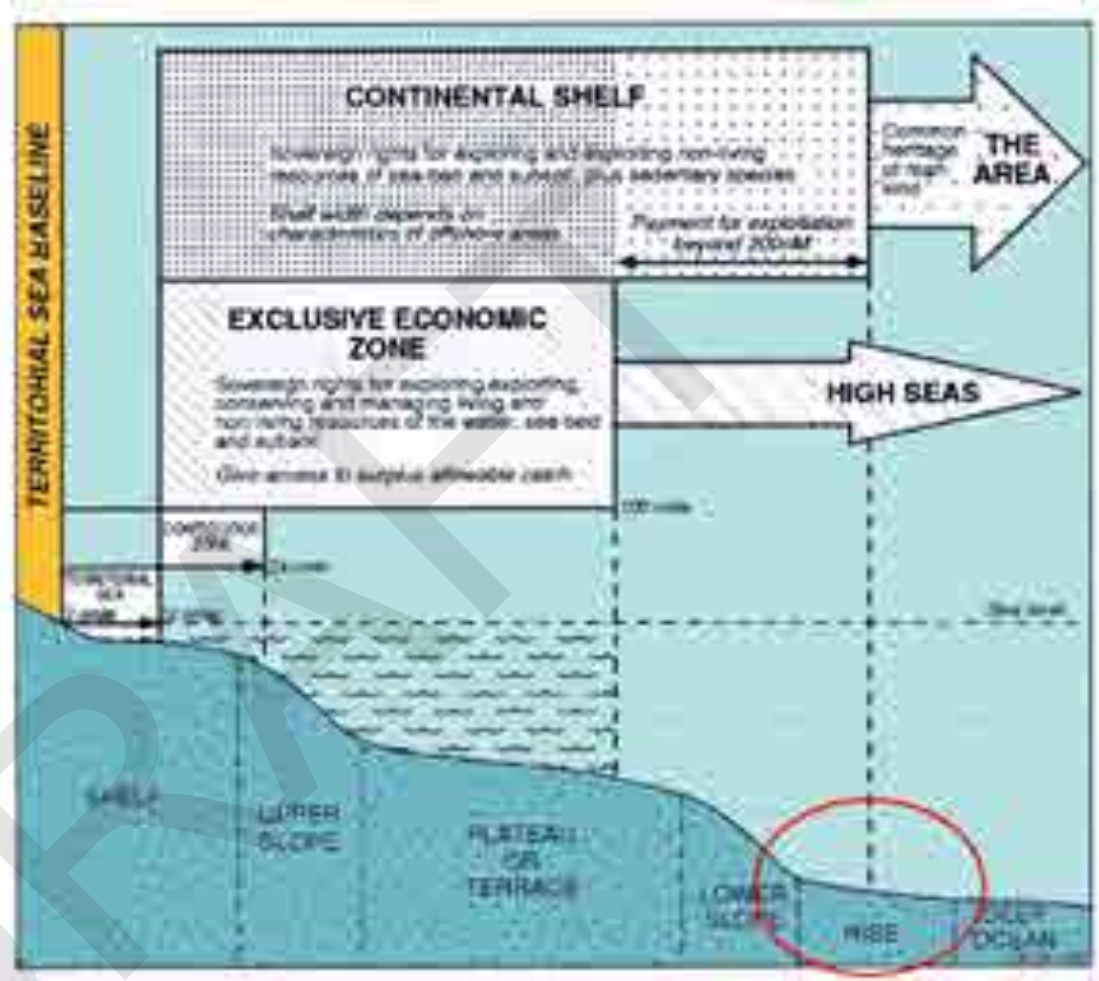
The rise is like an underwater hill composed of tons of accumulated sediments.

The rise depicts the area in Australia where sovereign rights exist for the exploring and exploiting non-living resources of sea bed and subsoil, plus sedentary species.

The rise is the start of the common heritage of the seabed to humankind.



Continental rise and EEZ

Illustration Geoscience Australia

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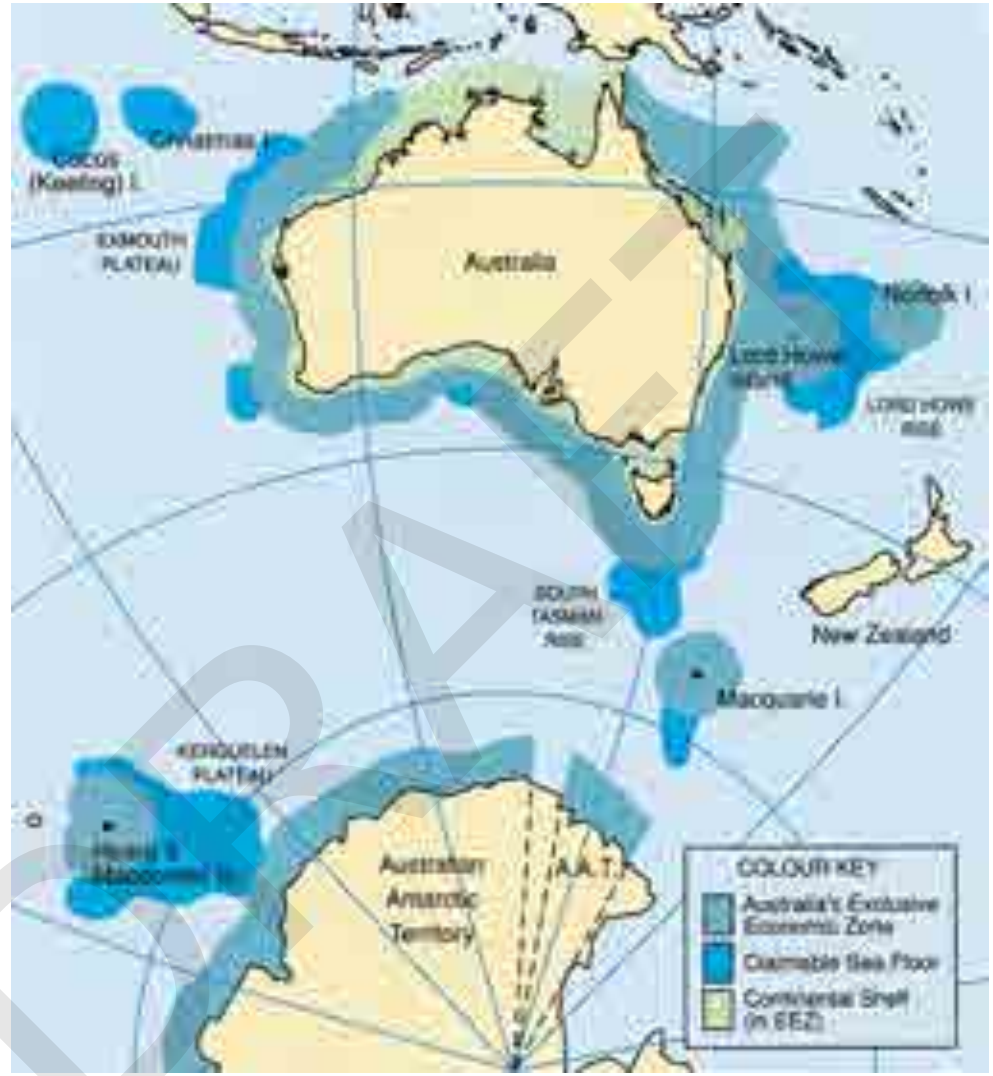
This is important because permanent maritime boundaries can be established.



Australia EEC

Illustration Geoscience Australia

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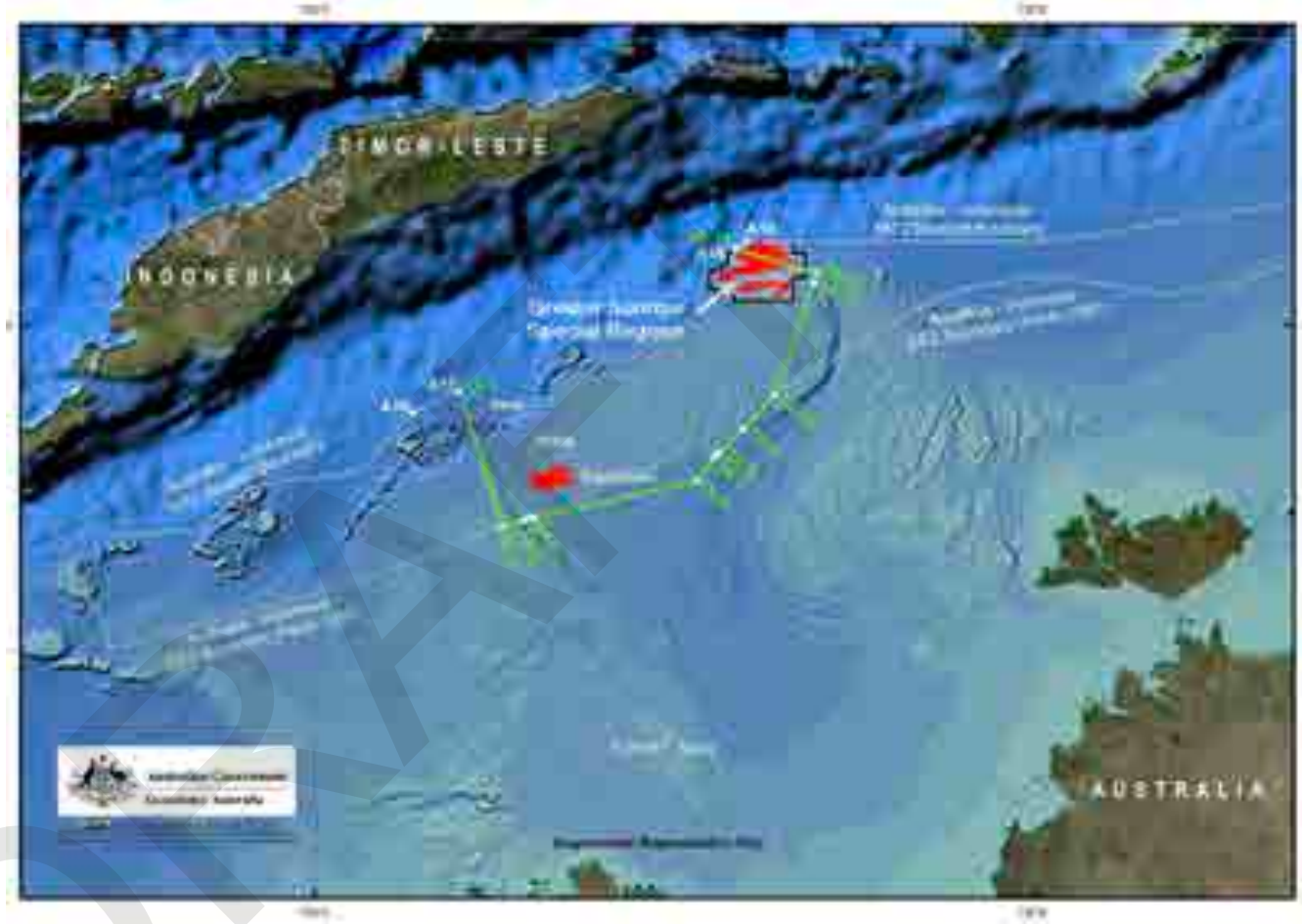
For example the Timor Sea oil and gas Treaty.

The Treaty provides for both countries to develop the Greater Sunrise gas fields together and share in the benefits.

This recognises both Australia and Timor-Leste have legitimate sovereign rights as coastal states under UNCLOS.



Timor Sea agreement

Illustration Geoscience Australia

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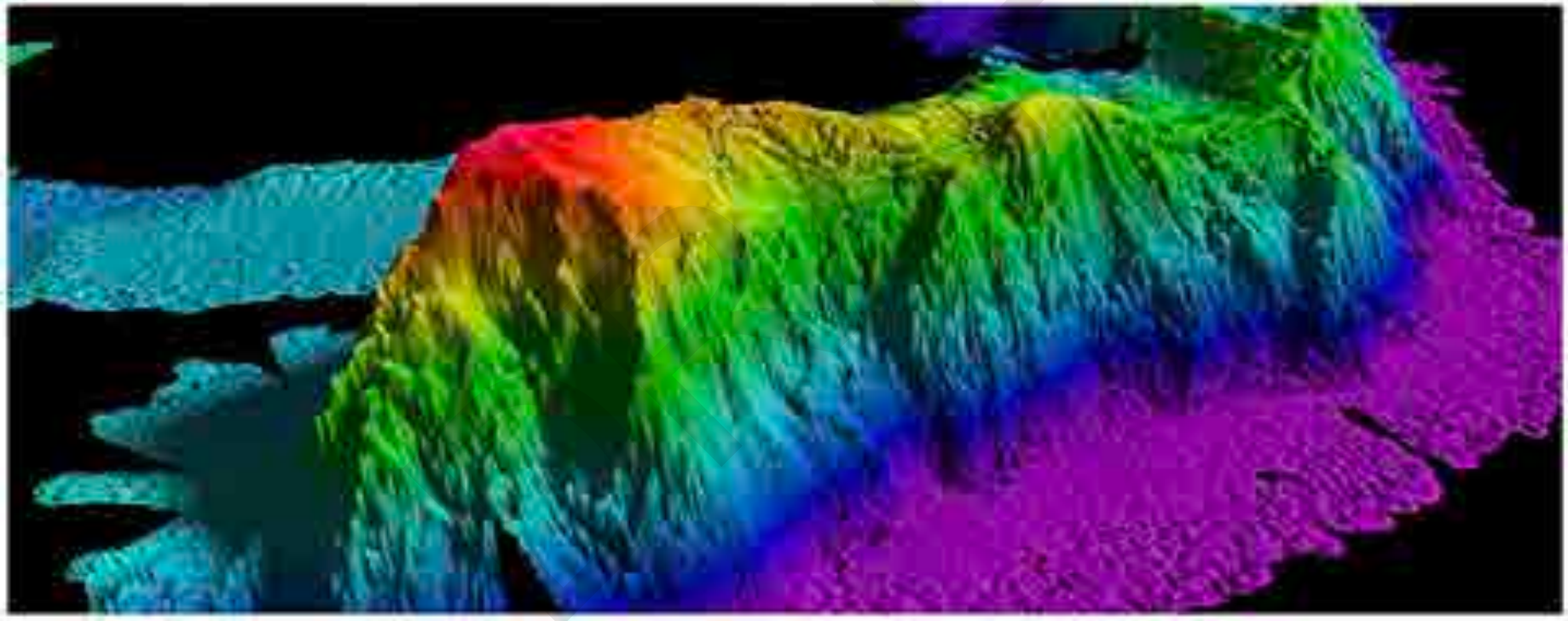
Seamounts

Seamounts are undersea mountains formed by volcanic activity.

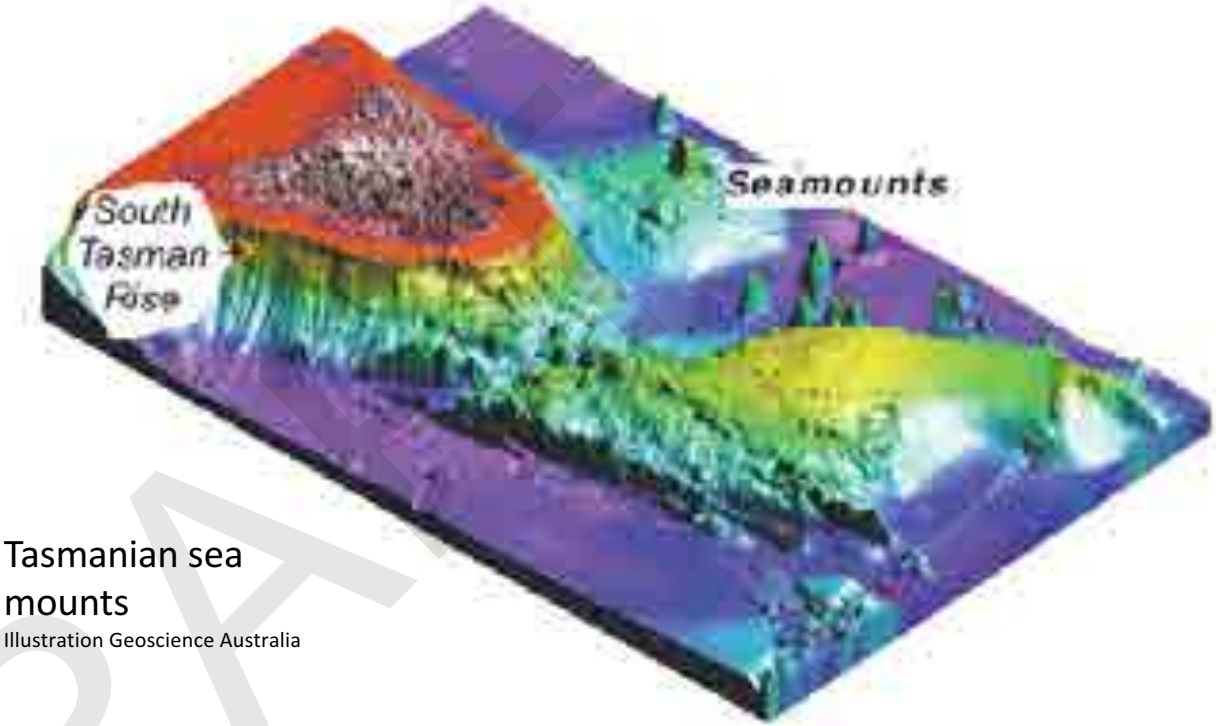


Seamount model created using multibeam echo sounder

Credit: NOAA What is a seamount. https://oceanservice.noaa.gov/facts/seamounts.html

Thanks to the steep slopes of seamounts, nutrients are carried upwards from the depths of the oceans toward the sunlit surface, providing food for creatures ranging from corals to fish to crustaceans.

Major commercial fisheries for orange roughy occur south of Tasmania.



Tasmanian sea mounts

Illustration Geoscience Australia

Orange roughy

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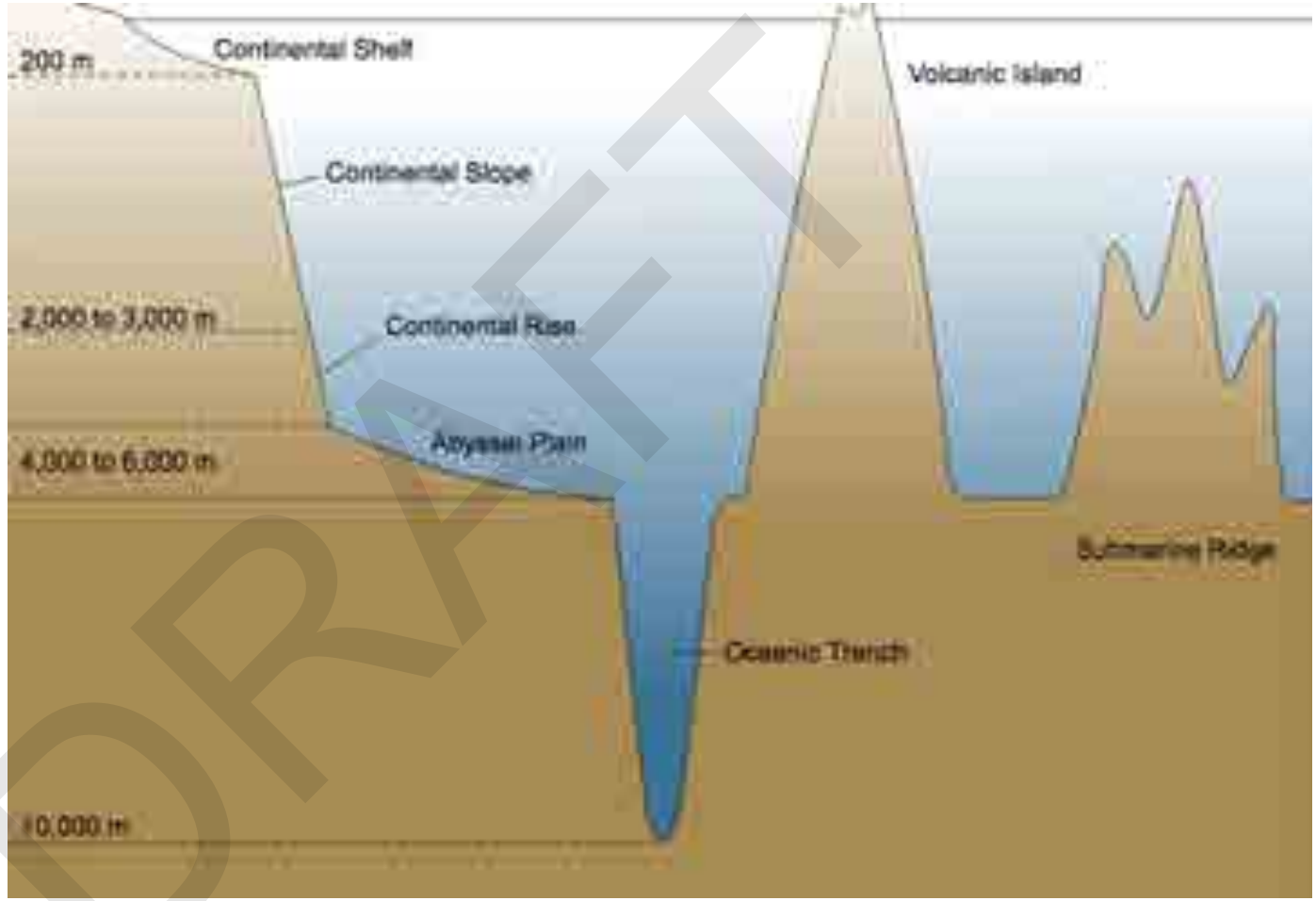
Volcanic (high) islands

These are islands of volcanic origin.



Oceanic divisions with high island

Illustration By Chris_huh (Own work) [Public domain], via Wikimedia Commons

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In some places, tall islands poke out from the ocean floor

For example in Australia, Balls Pyramid near Lord Howe Island.

Balls Pyramid and Lord Howe Island

Image courtesy Lord Howe MuseumMap: By edited by M.Minderhoud (own work based on PD map) [Public domain or Public domain], via Wikimedia Commons

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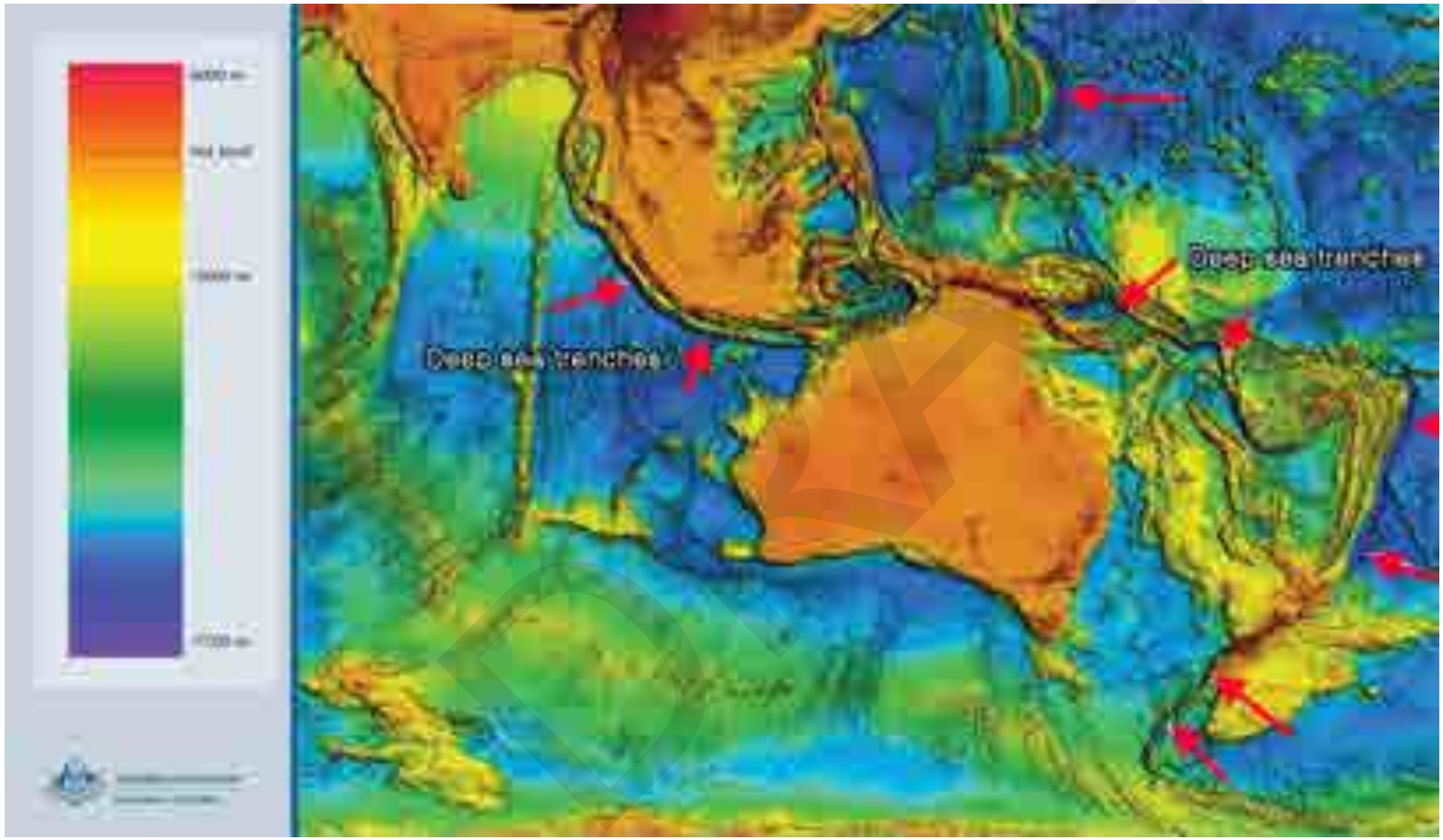
Deep sea trenches

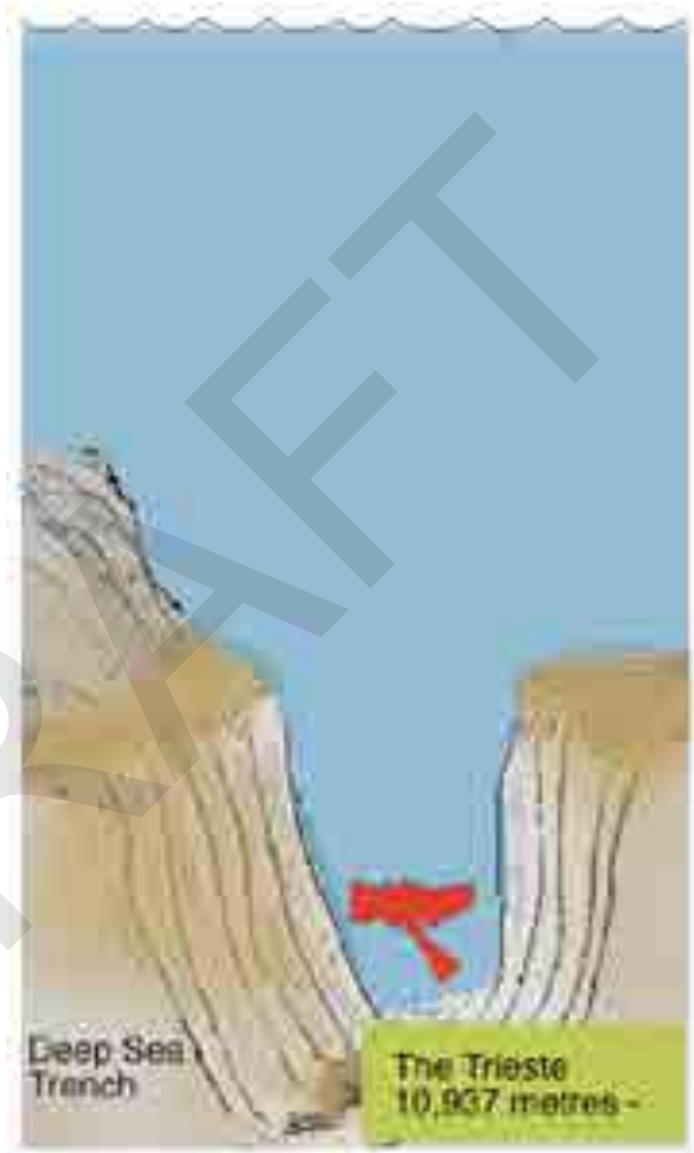
The continental slope in some places leads into deep V-shaped sea trenches.



Geoscience map with deep sea trenches

Illustration Geoscience Australia

They can be up to 160 km long, 50 km wide and range in depth from 6,000 - 11,000 m.



Deep sea trench

Illustration Bob Moffatt

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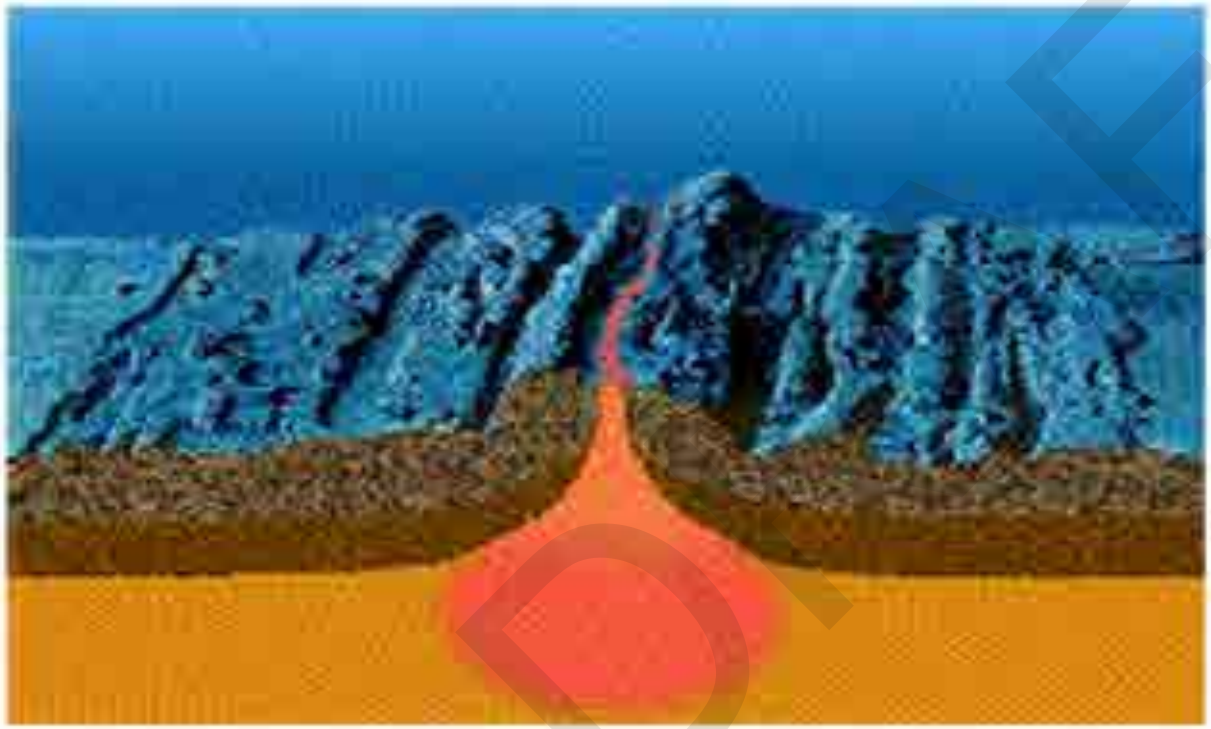
Mid-ocean ridges

- occur in all the major oceans and make up 23% of the earth, surface
- are mountain chains up to 1,000 km wide in places and
- mostly occur in the middle of the oceans.



Mid ocean ridge

Image (LEFT) By NASA/GSFC/Robert Simmon - http://earthobservatory.nasa.gov/Study/Tectonics/tectonics_3.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=358818
(RIGHT) By USGS - http://geomaps.wr.usgs.gov/parks/animate/index.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=13424851

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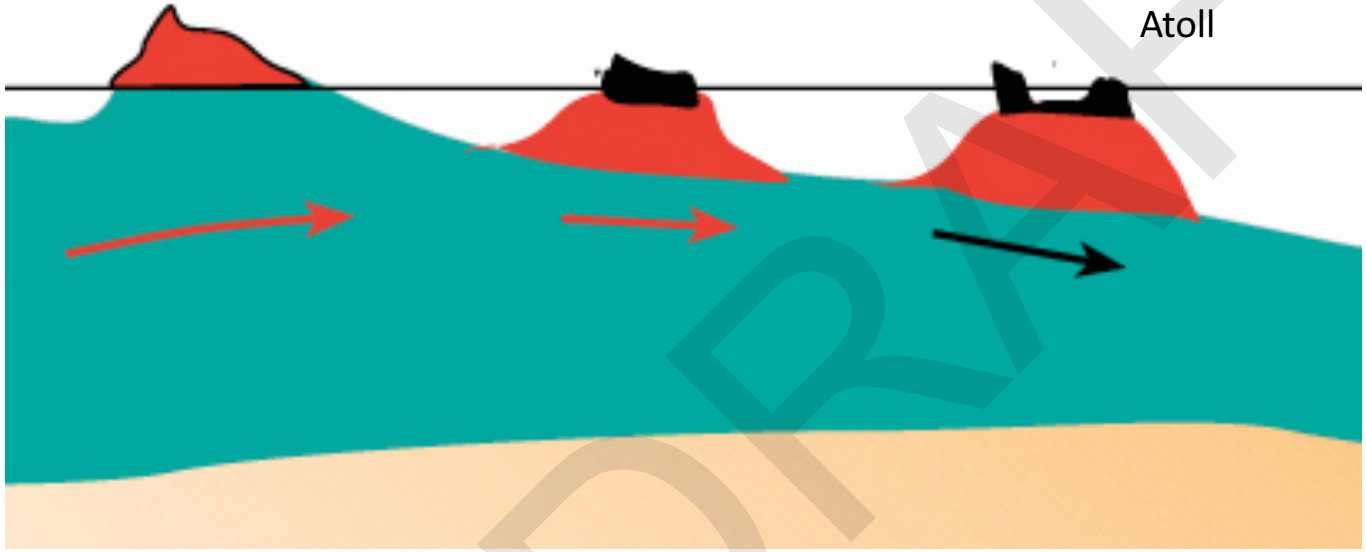
Atolls

Atolls form when an extinct seamount or volcano has eroded or subsided partially beneath the water.



Atoll formation
Illustration Bob Moffatt

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They are ring-shaped coral reef including a coral rim that encircles a lagoon partially or completely.

Coral atoll in the Maldives

By B166-er (Self-photographed) [Public domain], via Wikimedia Commons

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For the atoll to persist, continued erosion or subsidence must be at a rate slow enough to permit reef growth upwards and outwards to replace the lost height.

Atoll from space

By NASA/Johnson Space Center, Image Science & Analysis Laboratory [Public domain], via Wikimedia Commons

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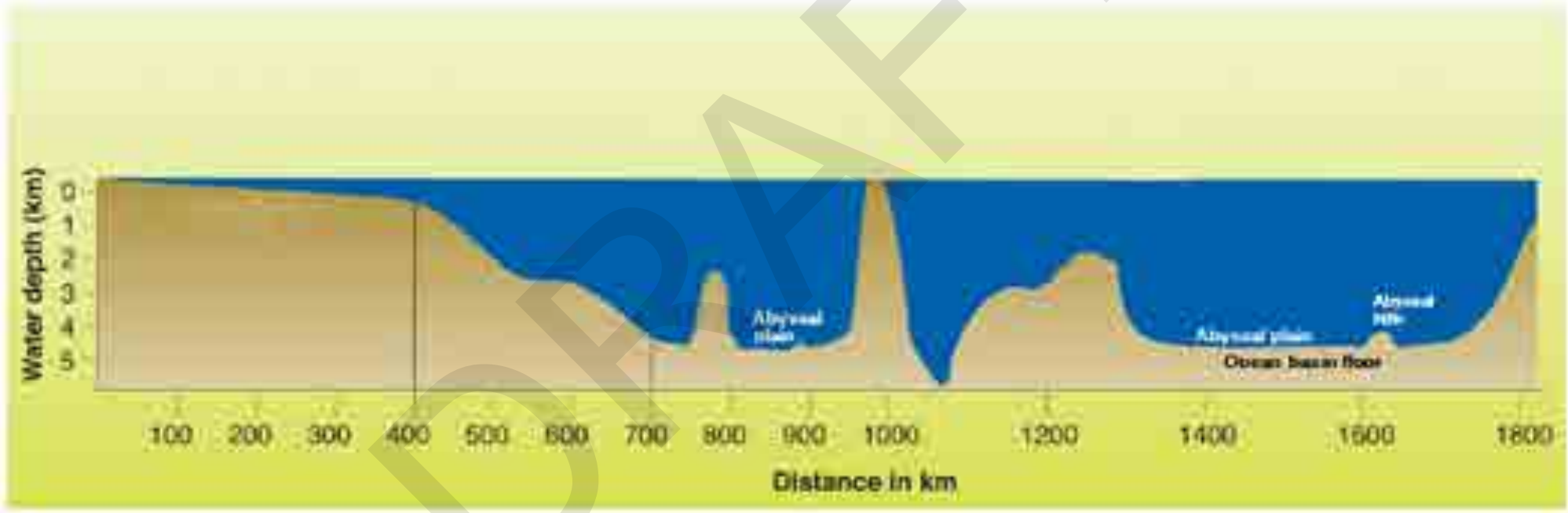
Ocean basin floor, including abyssal plain and hills

Two regions of the ocean- basin floor are the abyssal plain and the abyssal hills.



Abyssal plain and ocean basin floor

Illustration Bob Moffatt

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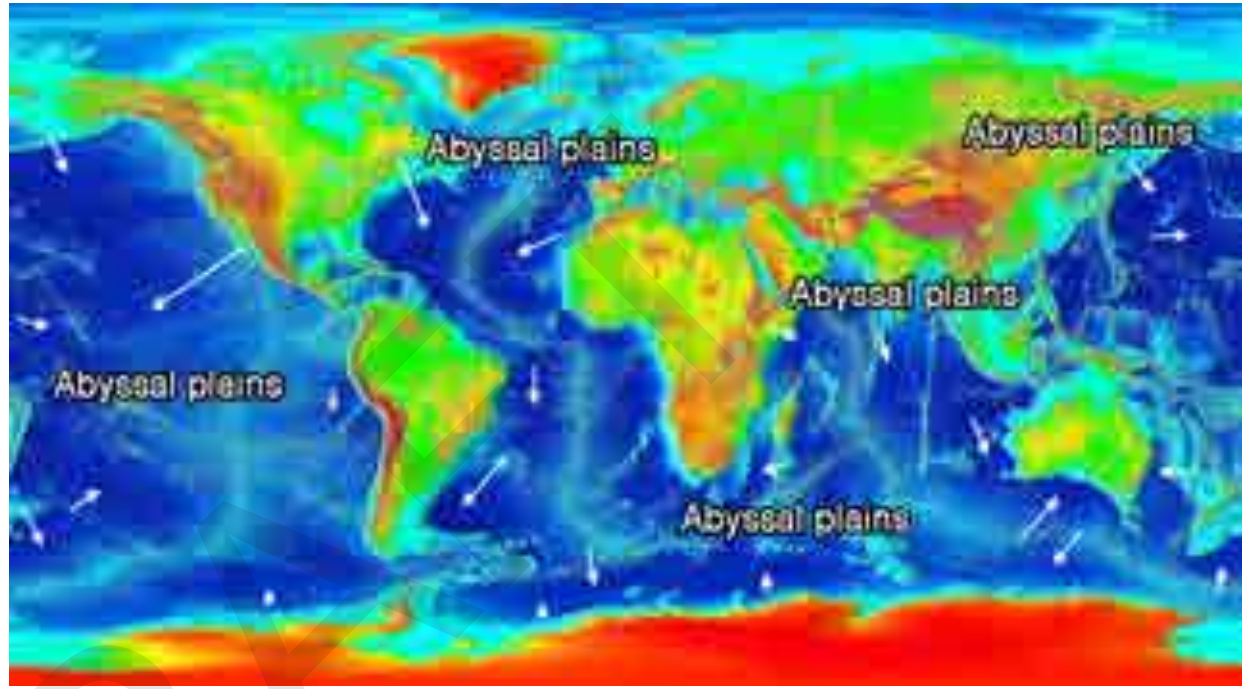
All oceans contain abyssal plains and these are interrupted by mountain chains or hills called abyssal hills.

An abyssal hill is a small hill that rises from the floor of an abyssal plain.

They are the most abundant geomorphic structures on the planet Earth, covering more than 30% of the ocean floors.

Abyssal hills have relatively sharply defined edges and climb to heights of no more than a few hundred meters



Global continental shelf, highlighted in dark blue
Public Domain, https://commons.wikimedia.org/w/index.php?curid=617528

You can read more at
[Abyssal plain]
[Abyssal hill]

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Abyssal plains are as flat and smooth with a gradient of 1:10,000, and cover extensive areas.

An abyssal hill is a small rise from the floor of an abyssal plain.

Abyssal hills have relatively sharply defined edges and climb to heights of no more than a few hundred meters.

Abyssal plane NOOA

Image - National Oceanic and Atmospheric Administration

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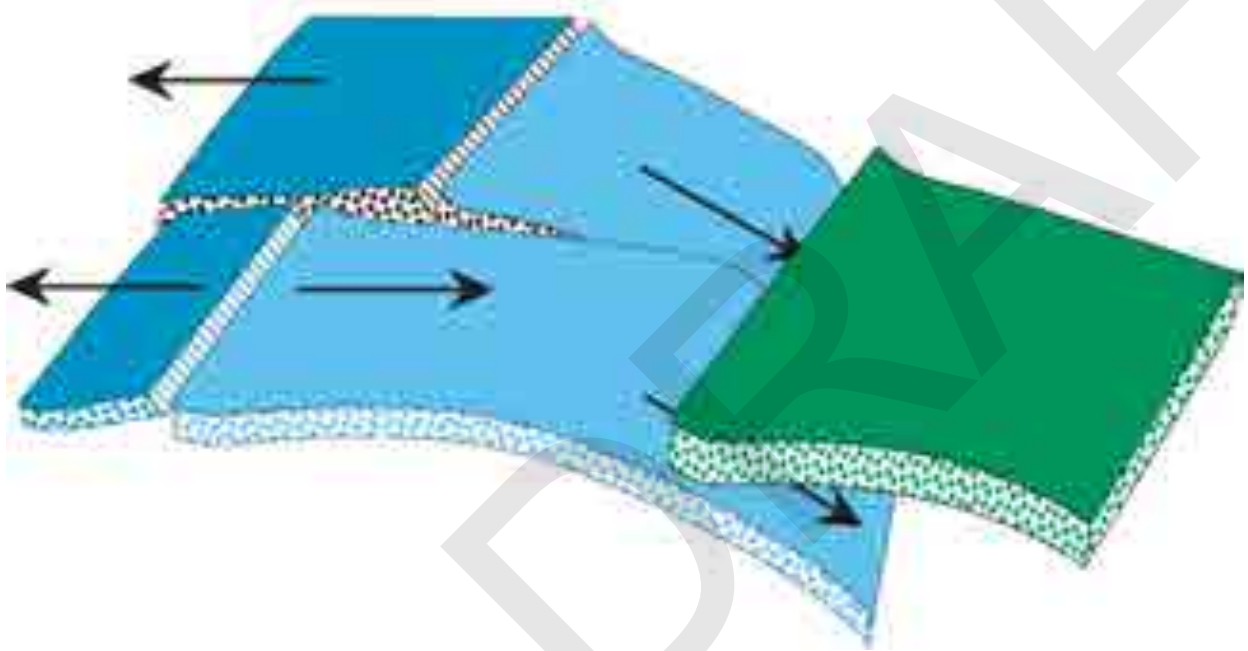
T002 Marine geology models



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Wet Paper

Syllabus statement

The syllabus says ... you should be able to

apply models to understand the geological features of the Earth for example, sea floor modelling, tectonic plate movements, coastal landforms, stratigraphy

Understand - recall, remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind

Apply - use knowledge and understanding in response to a given situation or circumstance; carry out or use a procedure in a given or particular situation

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Questions

Use geological models to explain the following geological Earth features

A: Plate tectonic movement
B. Continental drift
C. Atoll formation
D. Volcanoes
E. Mountain building
F. Earthquakes
G. Island chains

Apply geological Earth modelling to explain how the following Australia features formed.

H. Ancient limestone reefs in the Northern Territory
I. Great Dividing Range
J. Queensland coal deposits and marine dinosaurs
K. Fringing reefs, patch reefs and coral cays
L. Coastline stratifications

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Definitions

Models explain observations and predict future observations.

They can be drawings, graphs, equations, three-dimensional structures or words.

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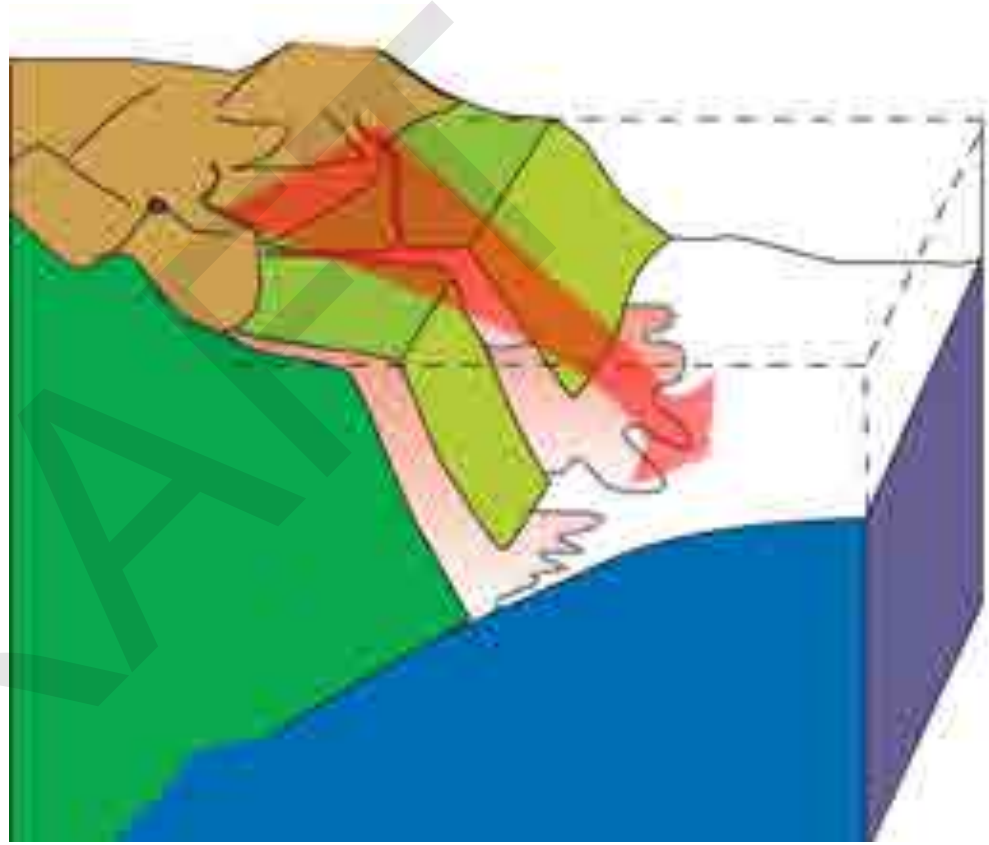
A drawing can show how sediments run off the land



Model sediments run off land

Illustration Bob Moffatt

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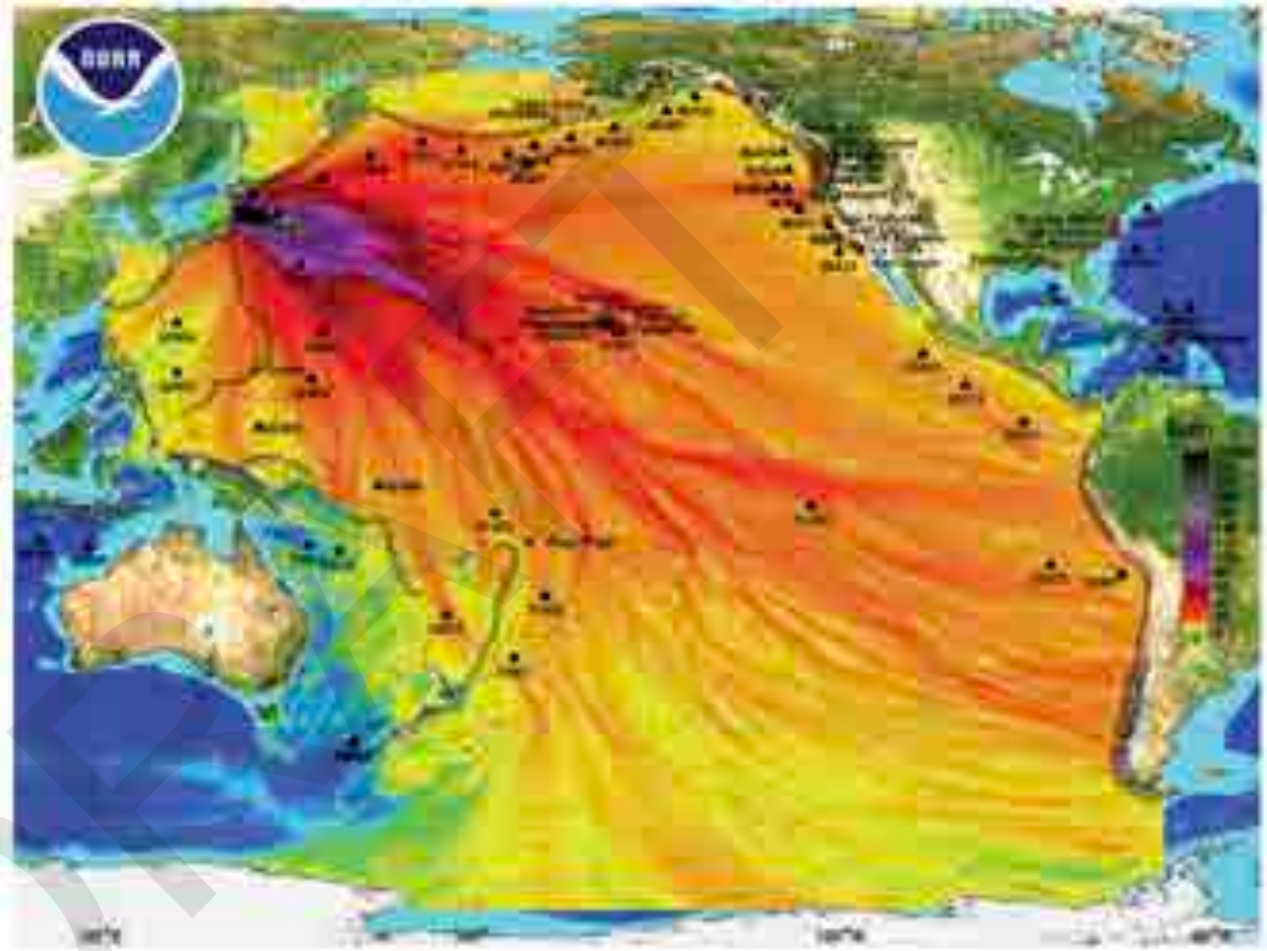
A map can model tsunami wave height following an undersea for earthquake.



NOAA tsunami map Japan 2011

Map prepared by the U.S. National Oceanic and Atmospheric Administration depicting the tsunami wave height model for the Pacific Ocean following the March 11, 2011, earthquake off Sendai, Japan.

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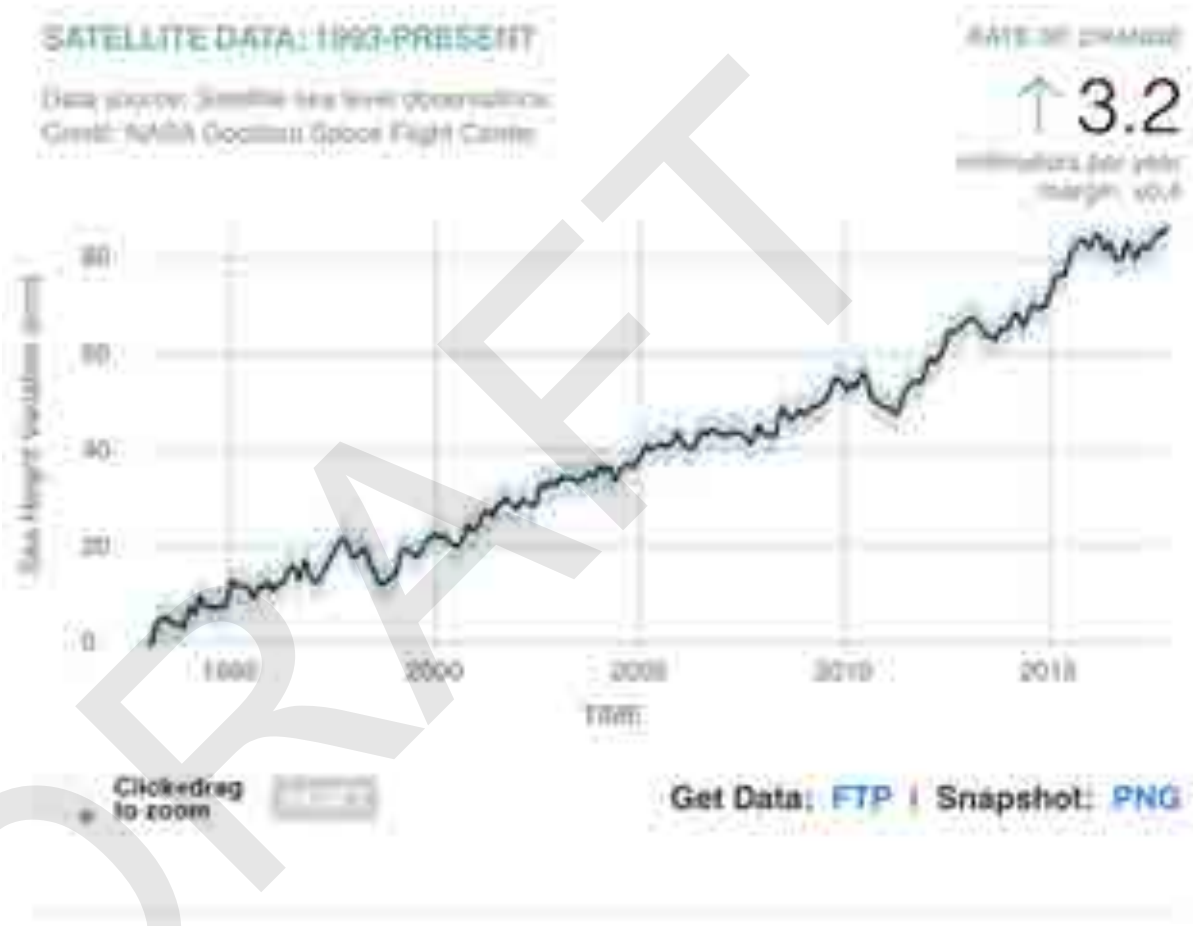
A graph of sea level rise based on mathematical calculations can be used to explain climate change.



Graphs based on mathematical calculations

Source NASA

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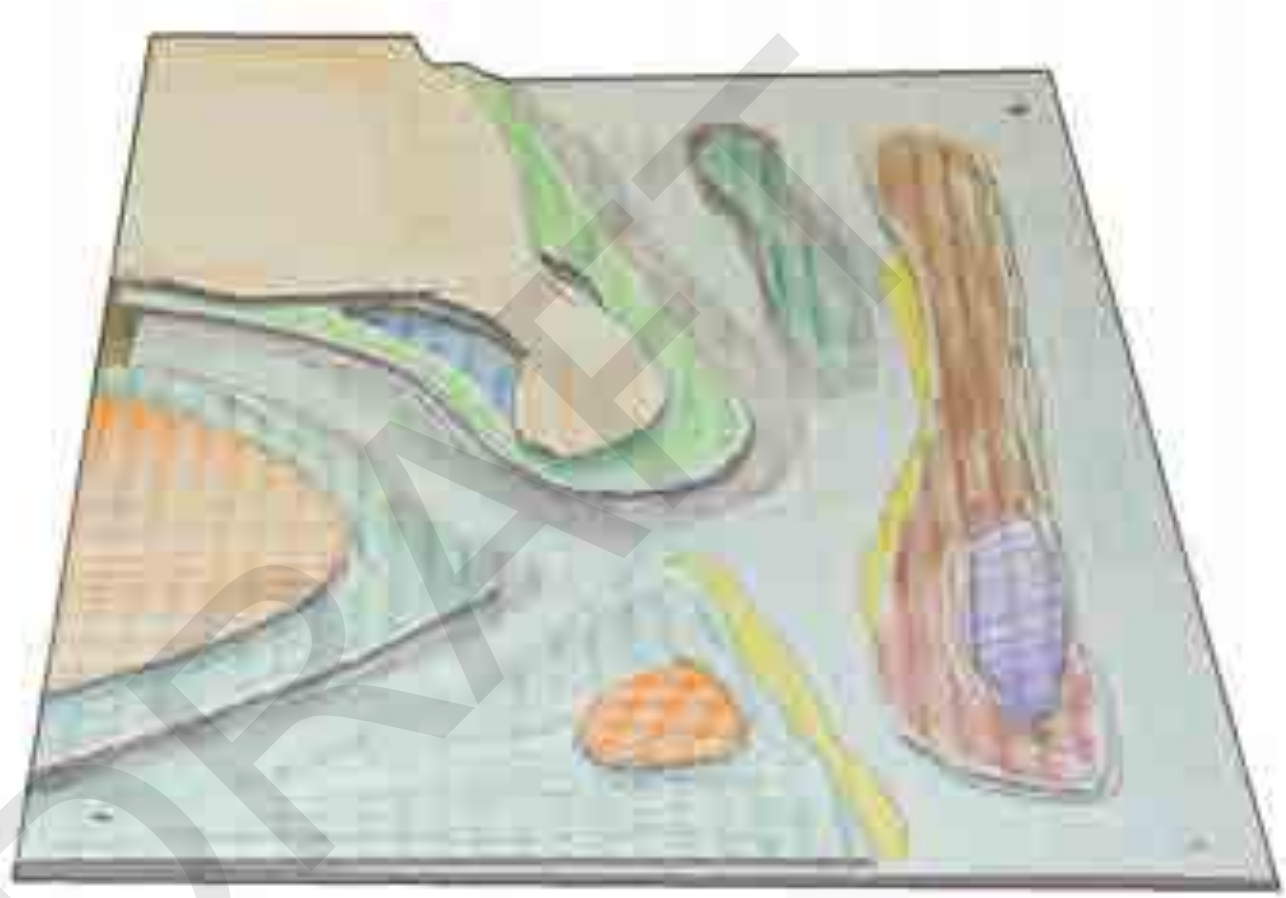
A three dimensional model of as mangrove habitat can explain water velocity movement and sediment deposition.



Model three-dimensional structure

Model by Bob Moffatt

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Words can be used to describe how oceanic plate movements form seamounts.

“As tectonic plates move outwards from mid-ocean ridges, they can carry volcanic islands.
In time, these islands gradually sink firstly forming atolls and then seamounts.”

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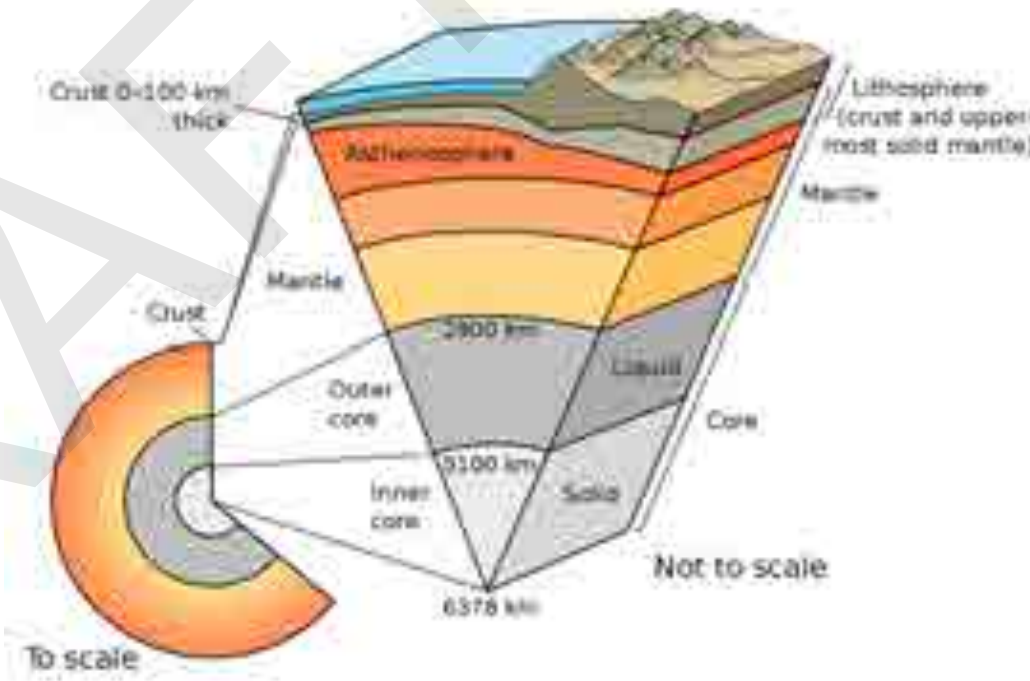
Movement of the lithosphere

Drawings show that our earth is composed of 3 layers. An

- outer layer called the crust.
- inner layers are called the mantle and core

The core contains hot lava called magma.



Earth model layers

By derivative work: Anasofiapaixao Earth_internal_structure.png: USGS (Earth_internal_structure.png) [Public domain], via Wikimedia Commons

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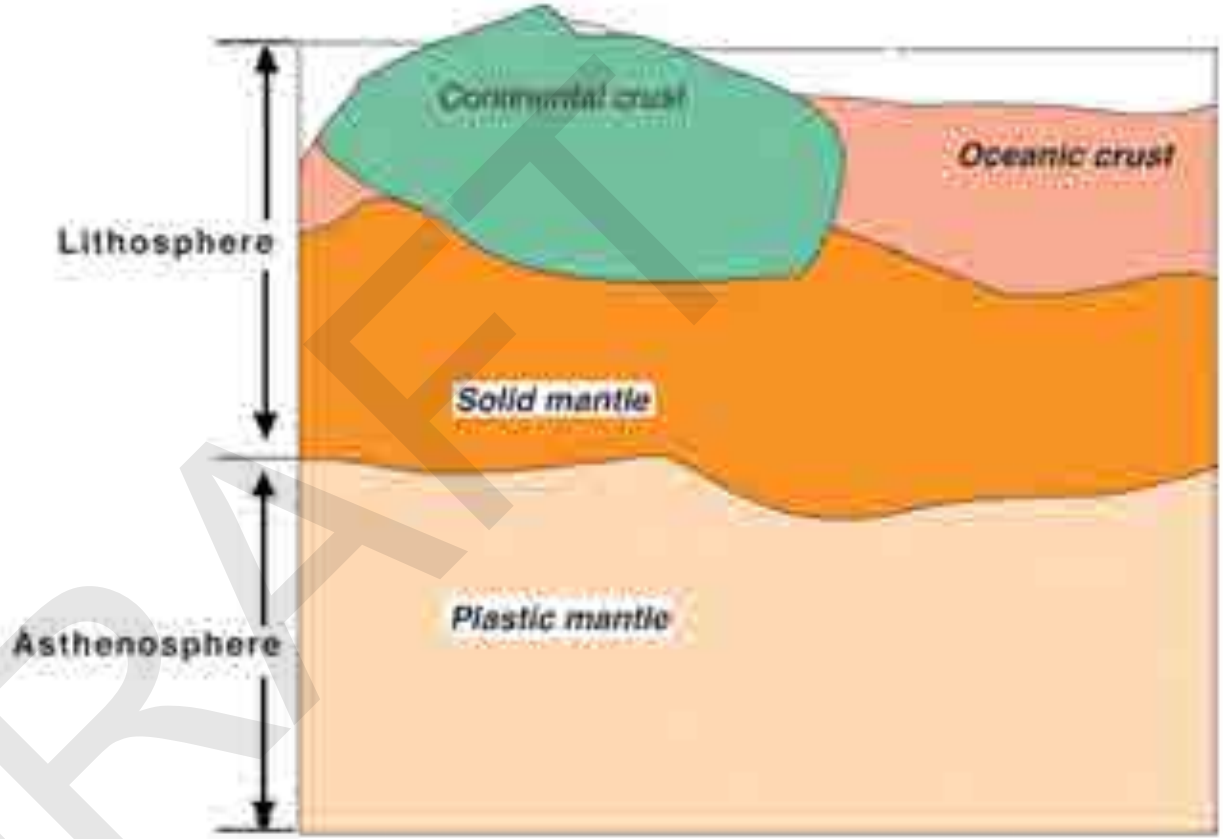
The crust and mantle are divided into the

- Lithosphere and
- Asthenosphere.

The lithosphere consists of the

Continental crust
Oceanic crust and
Solid mantle.



Lithosphere and asthenosphere A
Illustration Bob Moffatt

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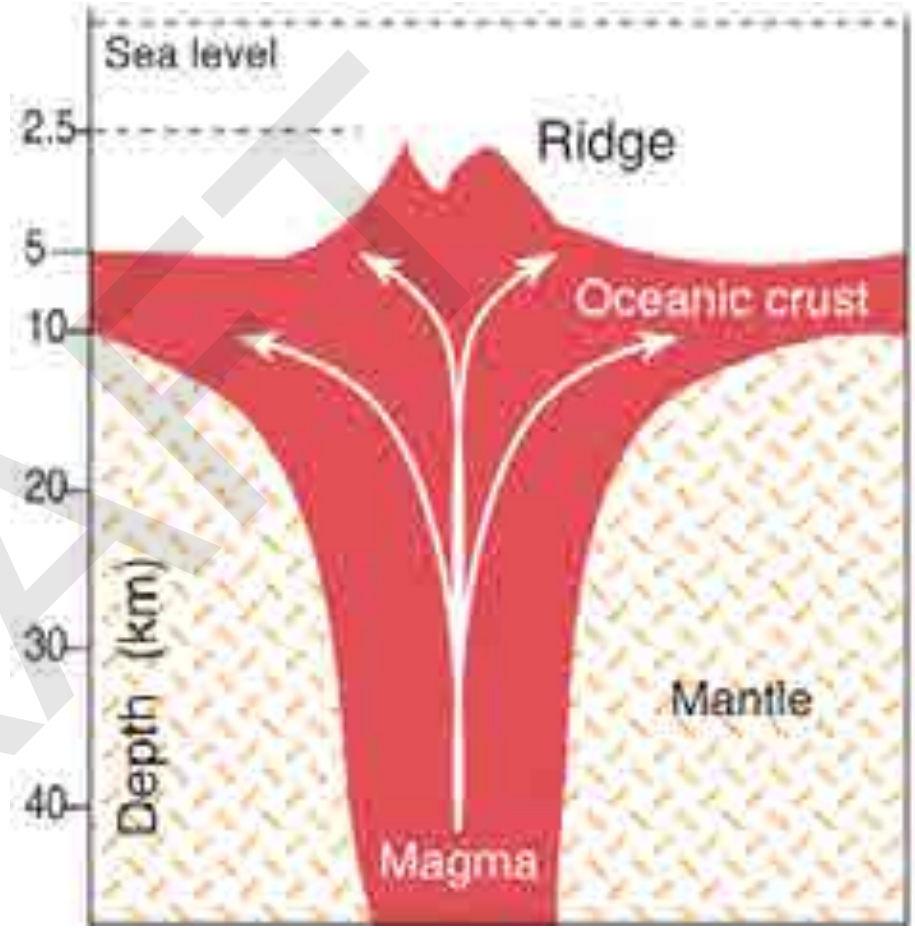
The lithosphere is brittle, cracks and fractures when subject to large forces from within the Earth.

The mantle contains weak spots which allows magma to flow upwards exerting great forces on the oceanic crust.



Magma rising through mantle

Illustration Bob Moffatt

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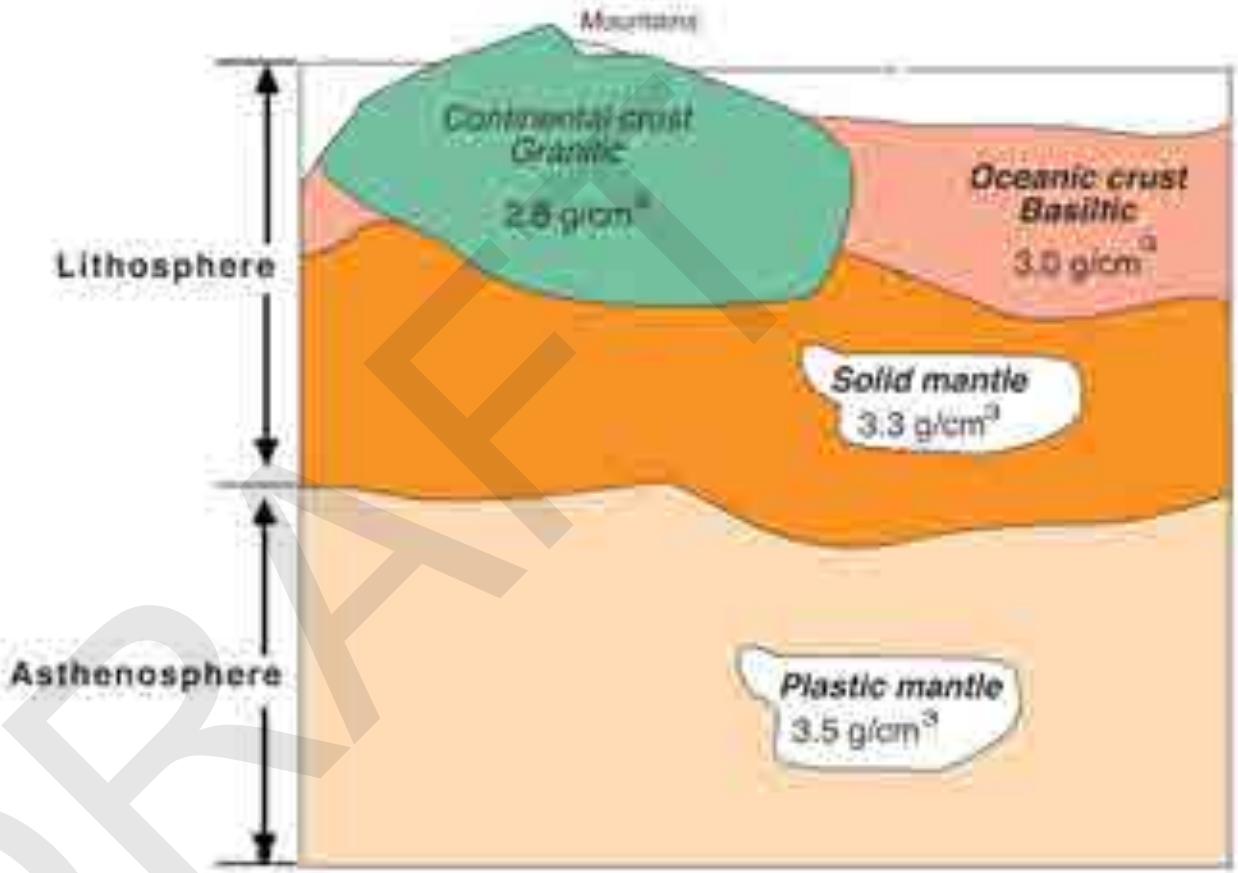
The asthenosphere is below the lithosphere.

It has relatively low resistance to movement where convection of core lava is thought to occur.

It comprises the plastic mantle and is a zone of weakness.



Lithosphere and asthenosphere

Illustration Bob Moffatt

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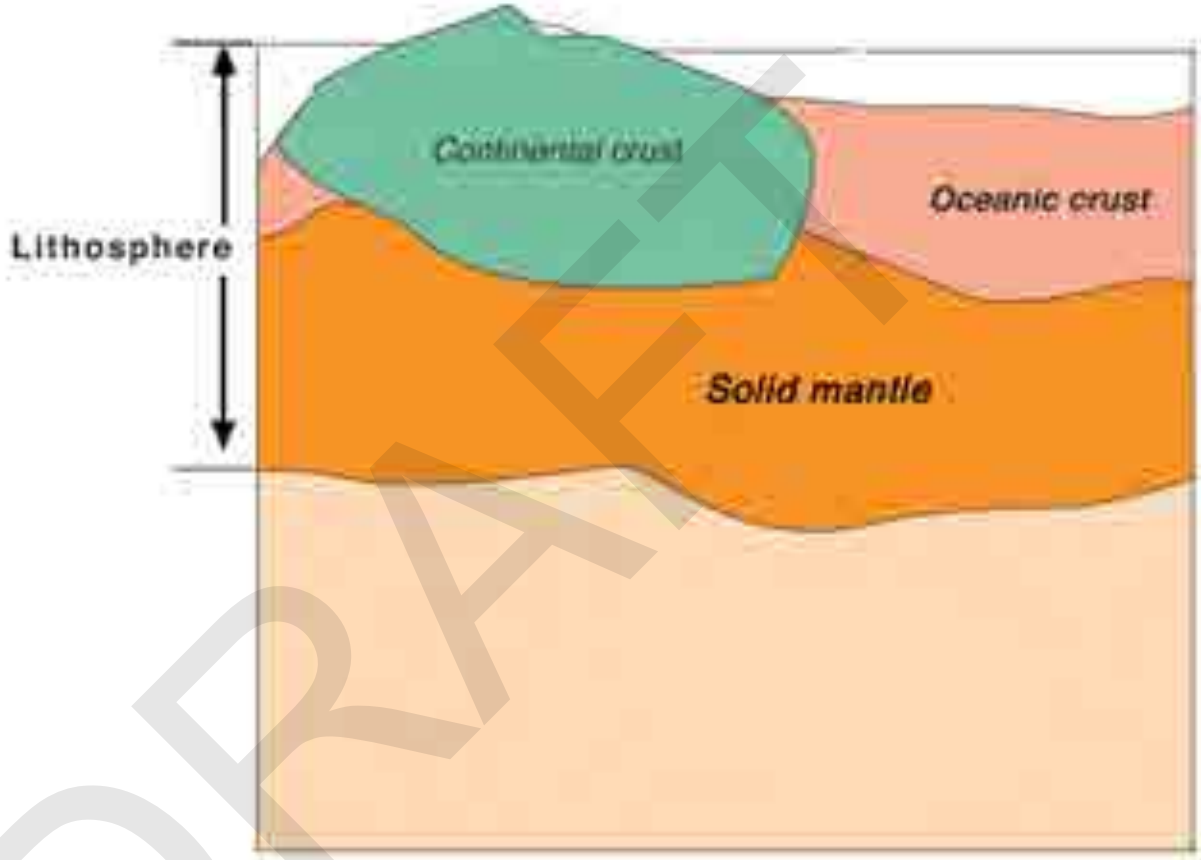
The lithoshpere is above the asthenoshpere.

It has continental crust, oceanic crust and solid mantle.



Lithosphere

Illustration Bob Moffatt

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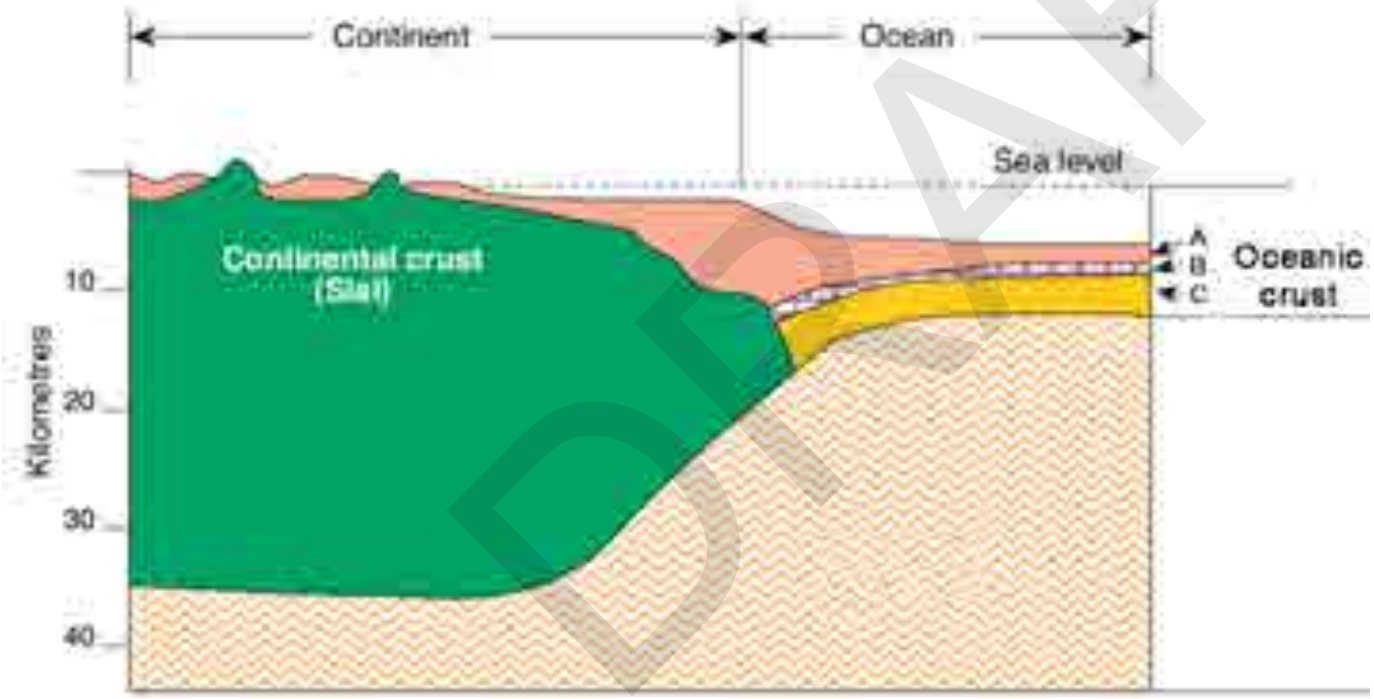
Continental crust is composed of low density granitic types of rock.

Oceanic crust is composed of high density basaltic rock and has three layers which are
- made of sediment eroded from the land.
- mixed with lava and sediment.
- made up of basalt.



Oceanic crust has three layers A, B and C

Illustration Bob Moffatt

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If these parts are moved under great pressure, they will fold and fracture.

Oceanic crust showing movement
Illustration Bob Moffatt

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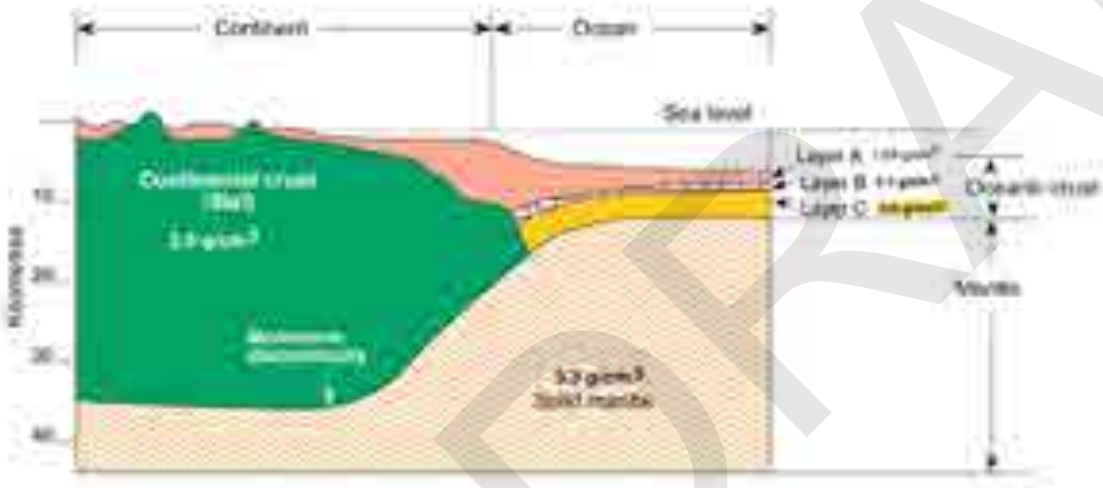
We can see this if we look at our coastline if we were to sail around Australia.

Nares Point Kimberley folding and fracturing
Photo Ian Morris

So here is an example of how a geological model can be applied to explain a coastal geological feature.

Here is the model



Here is the model applied

Model application to mantle folding

Illustration Bob Moffatt Photo Ian Morris

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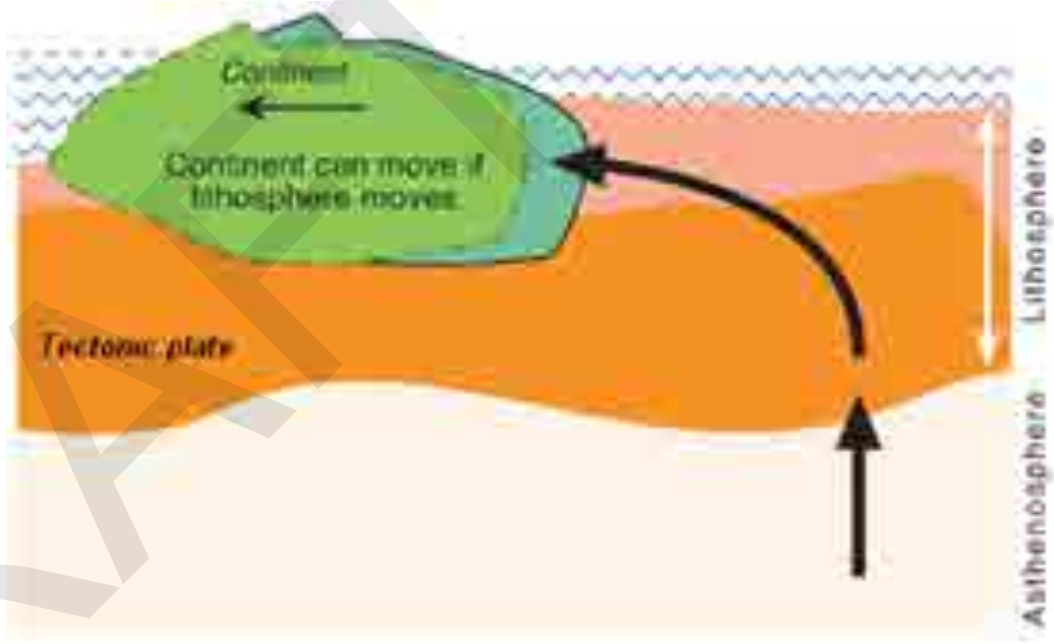
Continental drift and plate tectonics

The two sub-layers of the earth's crust (lithosphere) can move, float, and sometimes fracture.

These parts are called tectonic plates.



Continents can move on tectonic plates

Illustration Bob Moffatt

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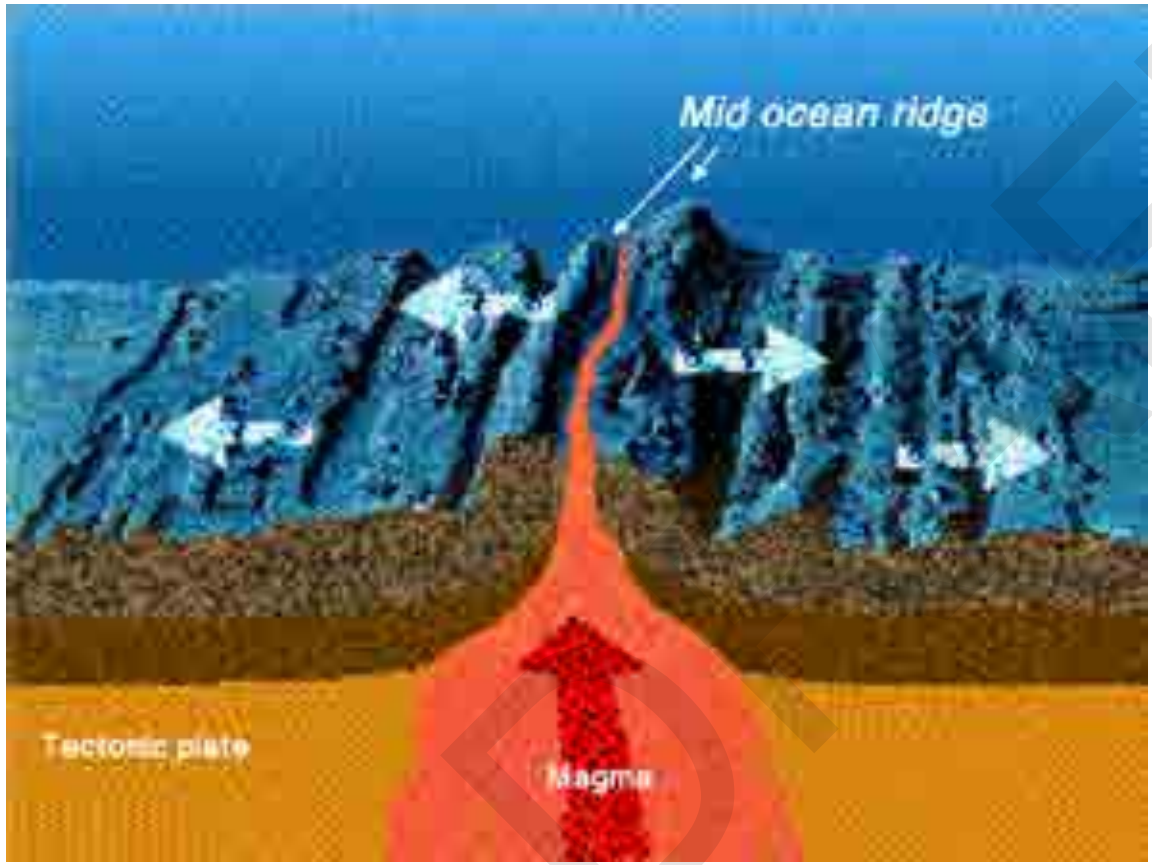
Forces generated by magma rising in mid-ocean ridges can cause these plates to move.



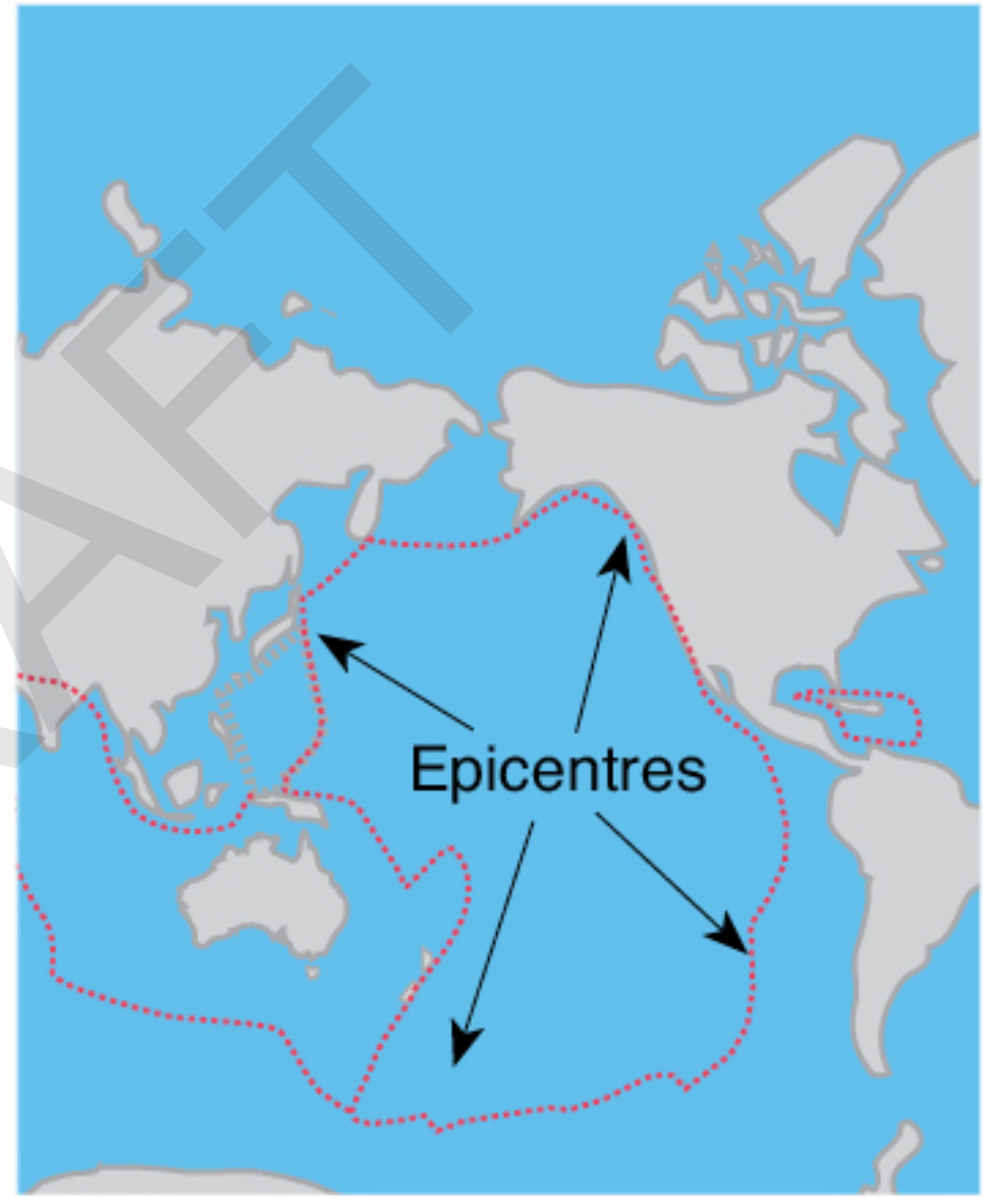
Mid ocean ridge

By USGS [Public domain], via Wikimedia Commons

DRAFT

If we study the incidences of earthquakes from 1963 in the Pacific region, a pattern emerges as shown below

This lead scientists to conclude that these were the edges of tectonic plates.



Pacific Ocean earthquake records

Illustration Bob Moffatt

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The major plates of the Earth can be sumarised in an illustration.

Earth tectonic plates

Illustration NASA/GSFC/Robert Simmon [Public domain], via Wikimedia Commons

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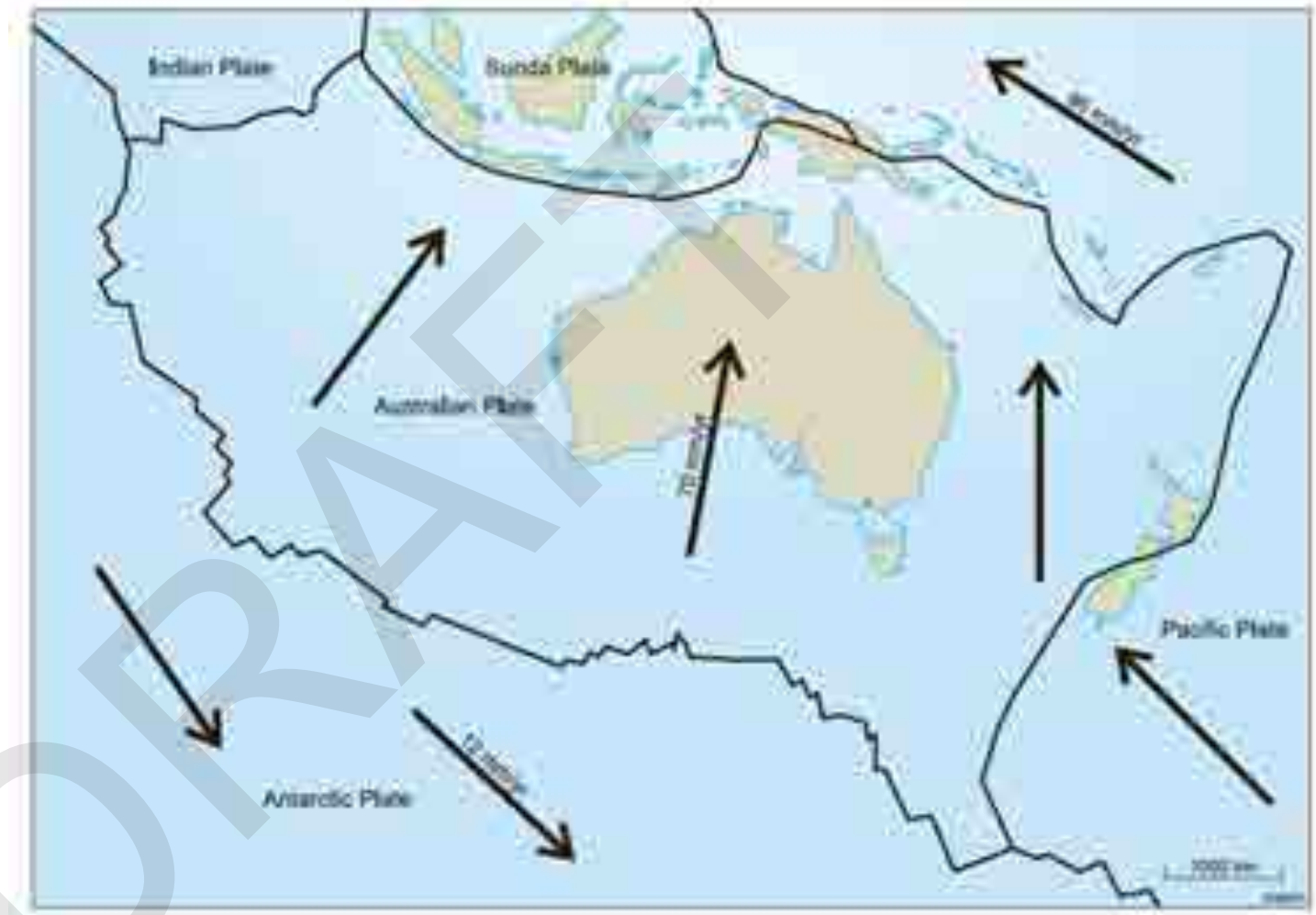
The Australian plate is moving north at a rate of 2 cm per year or the rate at which your fingernail grows.



The Australasian tectonic plate. Arrows show movement of the plates relative to each other, with numbers indicating velocities (millimetres per year) calculated using GPS stations (Source: J. Parr, CSIRO)

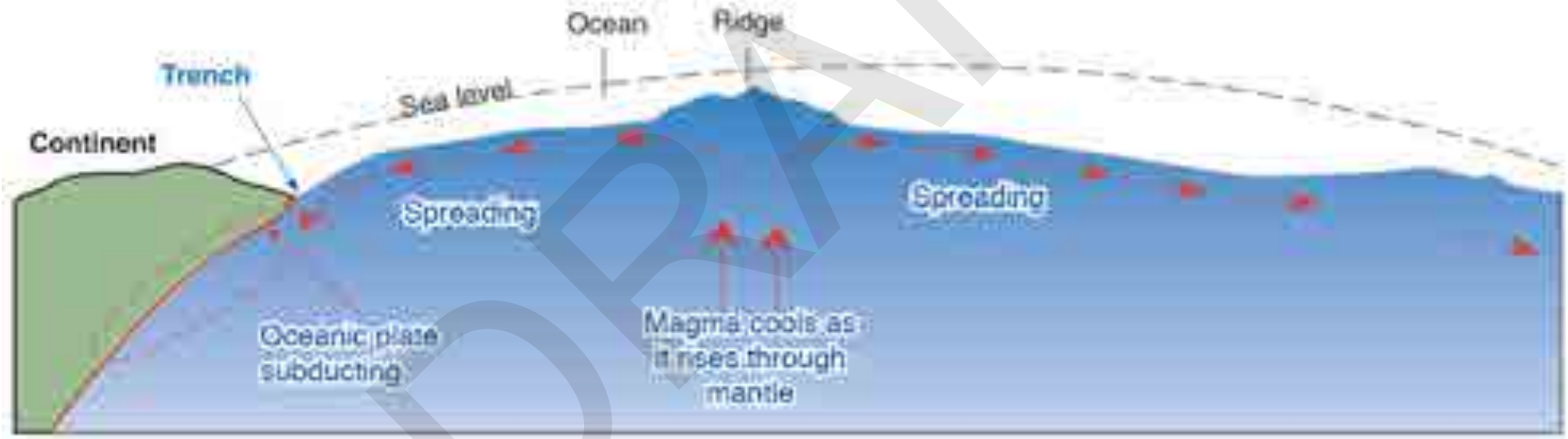
Australian plate by CSIRO

Illustration by CSIRO J Parr

DRAFT

Places where earthquakes occur can be related to deep ocean trenches and are described as places where one plate collides and slides under another.

Places where magma rises and forces the plates to move are called ridges.



Ocean plate movements

Illustration Bob Moffatt

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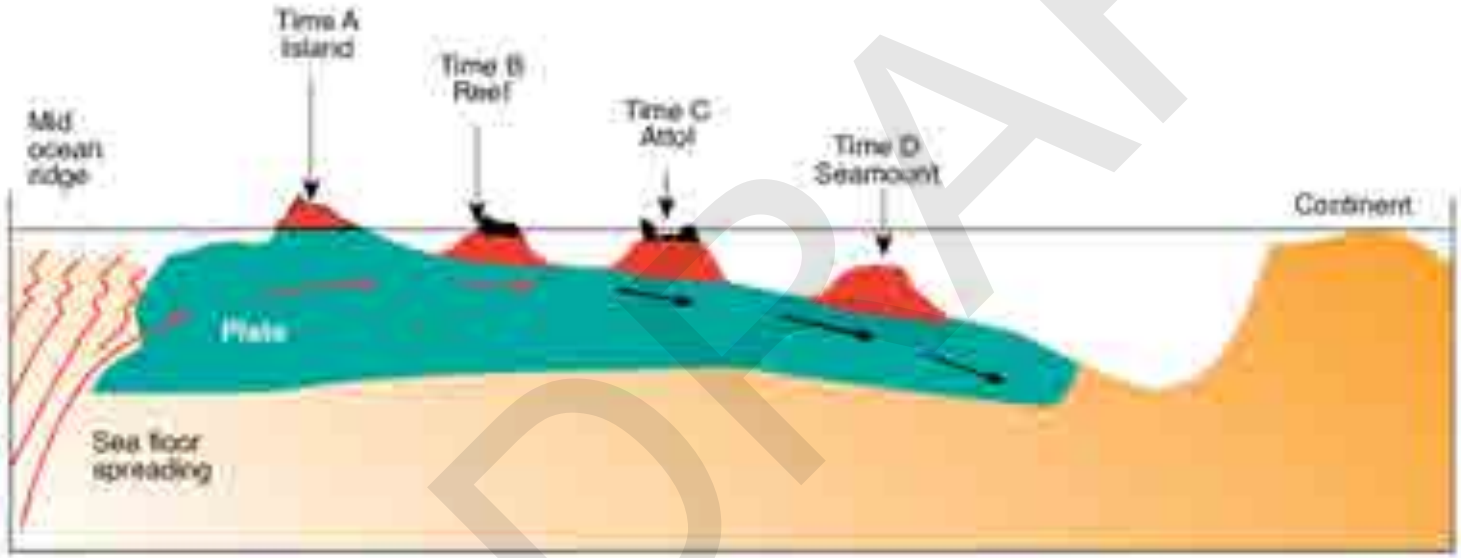
As plates moves in the lithosphere and as they move outwards from ridges, anything on them such as islands or continents, moves as well.

Consider an island moving on a plate.
In time the island will change to a reef, then an atoll and finally a sea mount.



Island movements on a plate
Illustration Bob Moffatt

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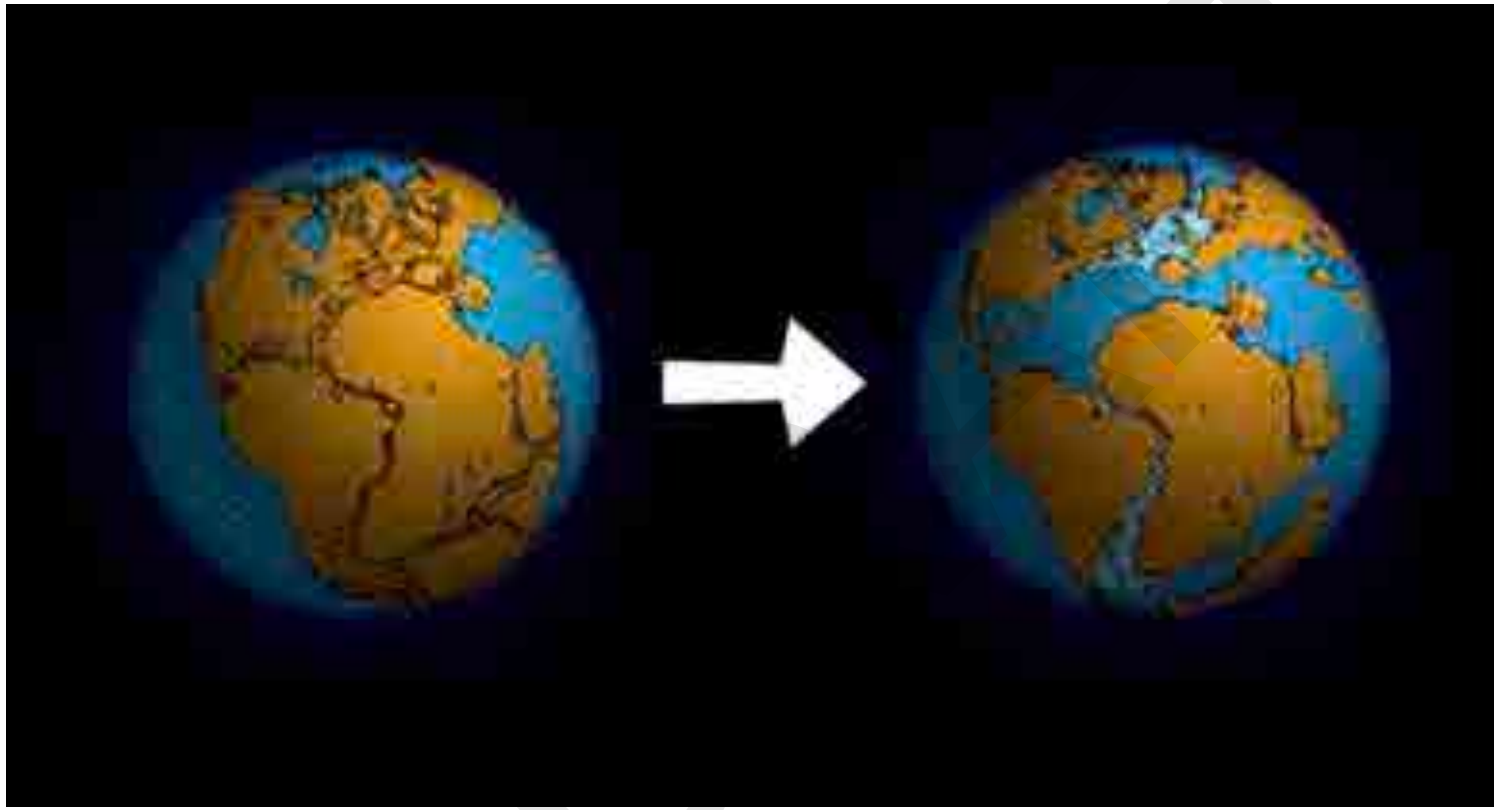
Scientists apply this understanding to explain that over millions of years continents must have moved over the crust of the Earth in a process called continental drift.

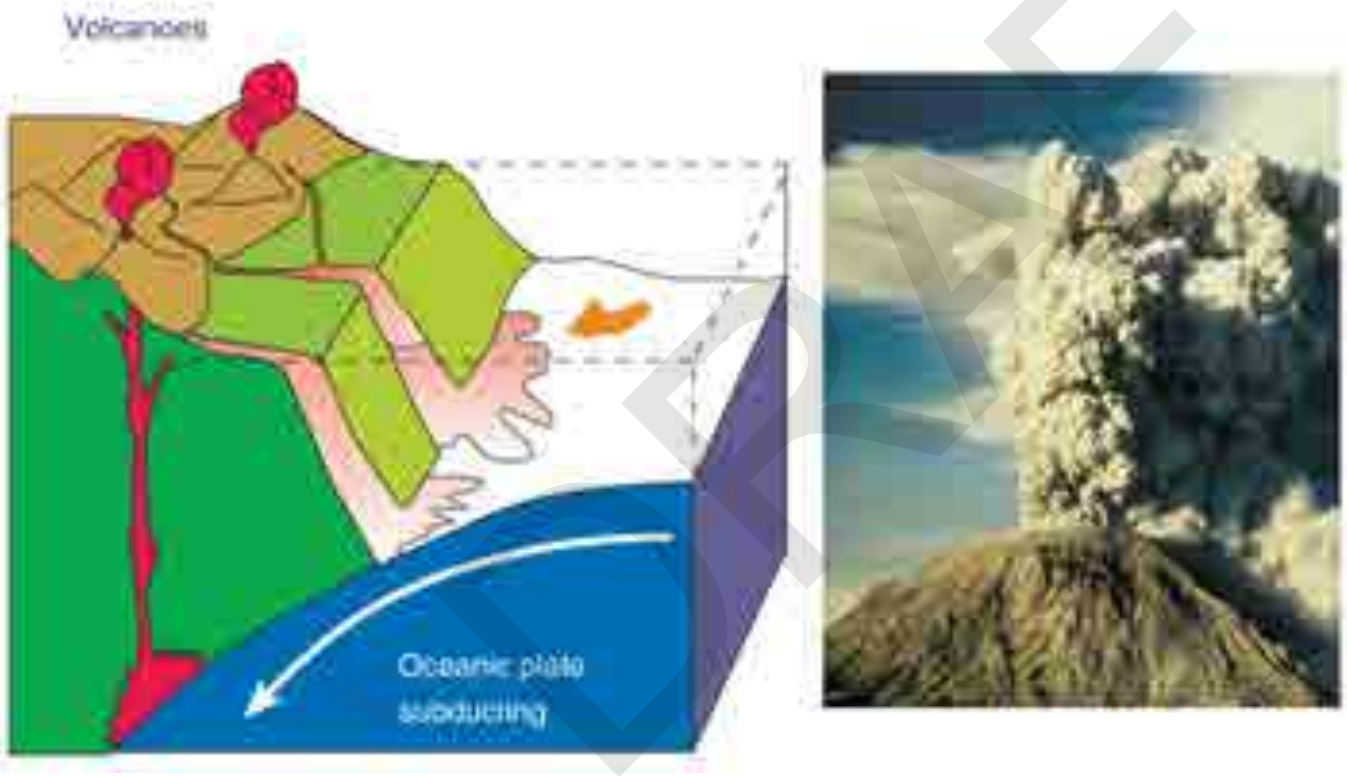


Continental drift

https://en.wikipedia.org/wiki/Continental_drift#/media/File:Pangea_animation_03.gif

Volcanoes and mountain building

The movement when a plate subducts (moves under another plate) results in earthquakes and volcanoes.



Ocean plate subduction and volcano

Illustration Bob Moffatt Volcano AAP

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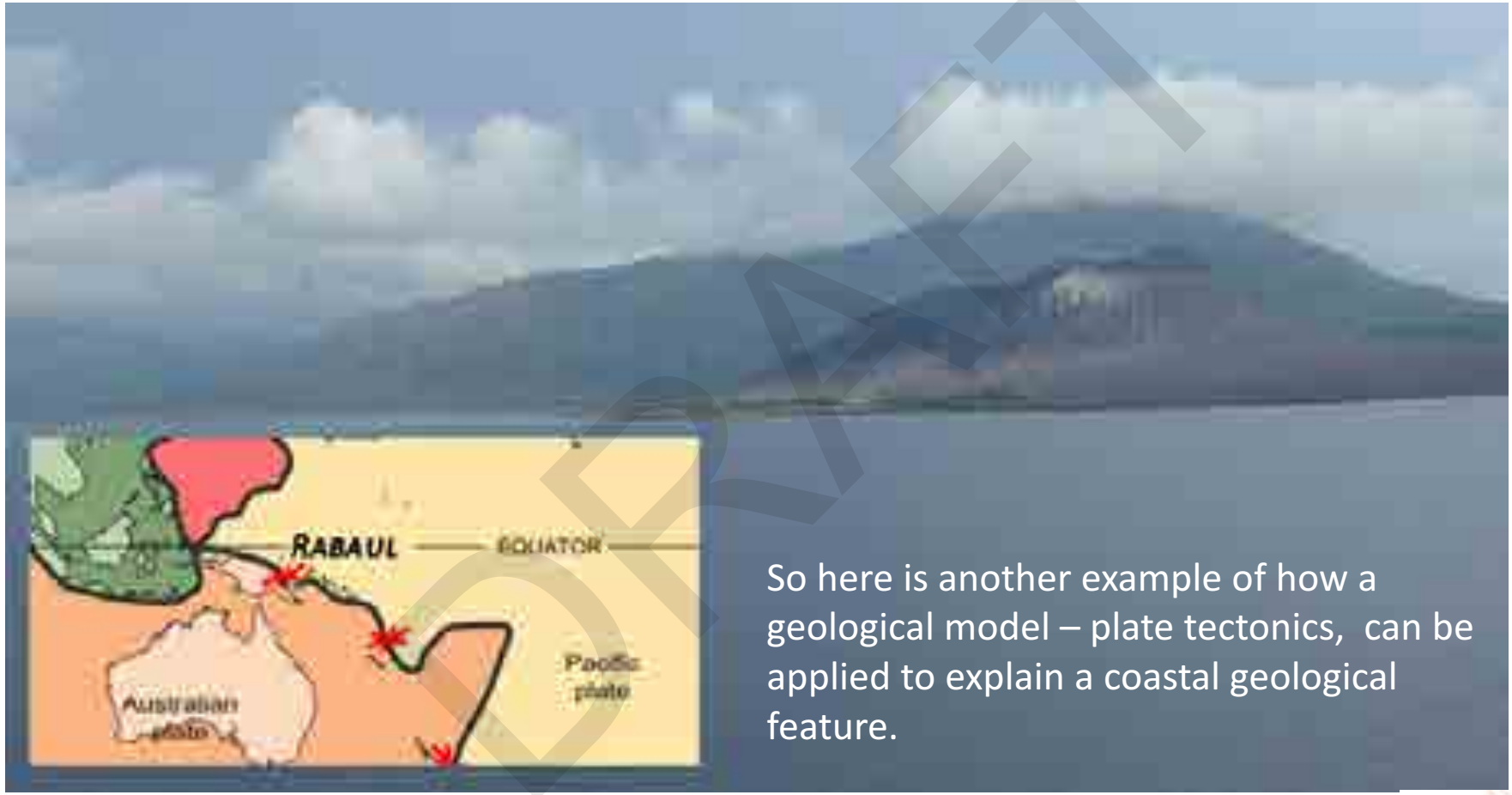
Just north east of New Guinea lies the active Rabaul volcano where the Pacific plate subjects beneath the Australian plate.



So here is another example of how a geological model – plate tectonics, can be applied to explain a coastal geological feature.

Rabaul volcano and map

Photo Bob Moffatt Illustration NASA/GSFC/Robert Simmon [Public domain], via Wikimedia Commons

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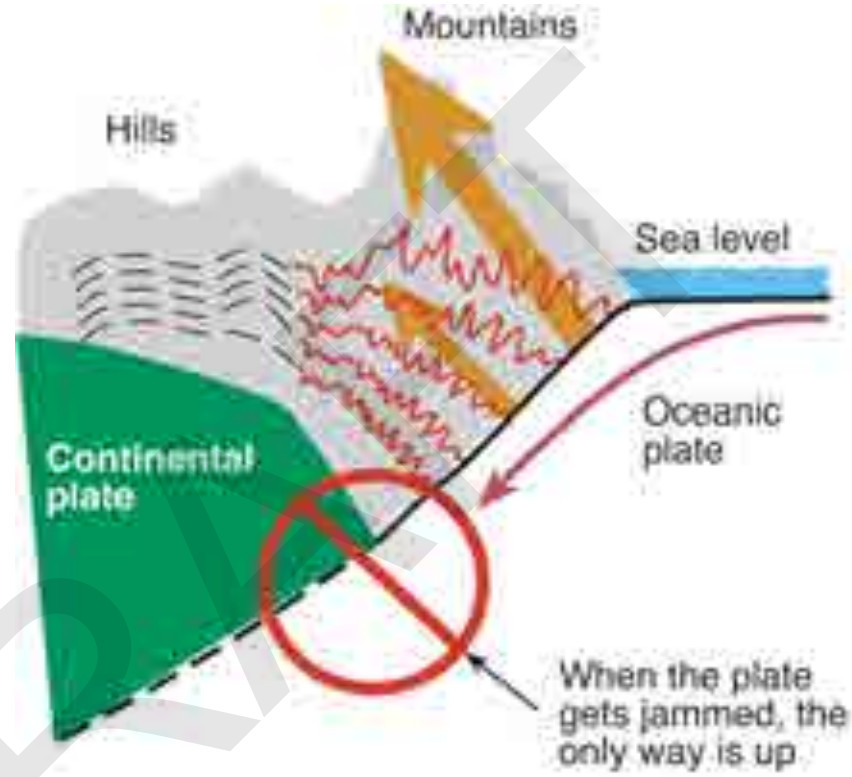
When plates move, they take with them continental crust.

When these plates collide the continental crust is pushed up into mountain ranges.



Mountain building model

Illustration Bob Moffatt

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An example is the Great Dividing Range.

Great dividing range in Victoria and Queensland

Photos Bob Moffatt

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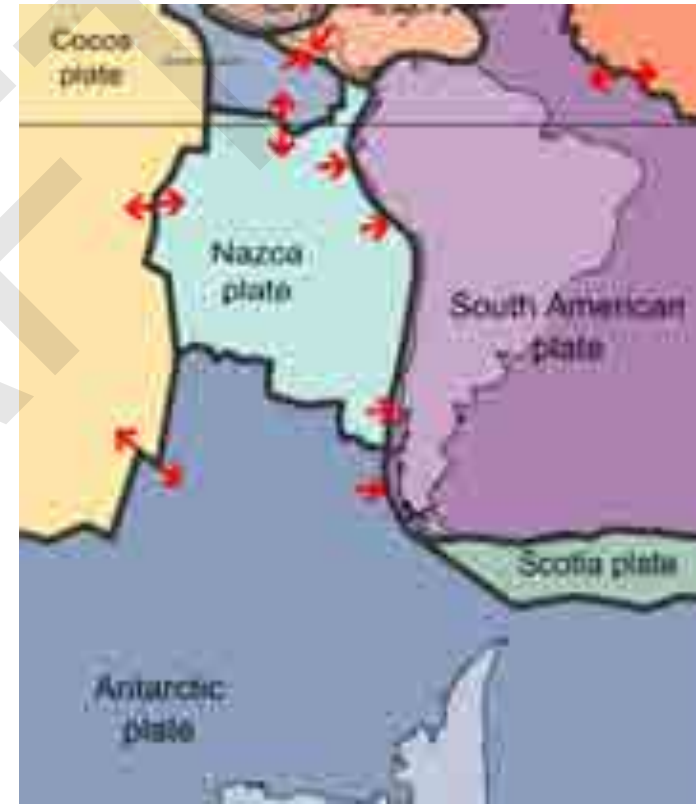
In South America the Andes mountain range extending for most the west coast has been pushed up by the collision of the Nazca plate and the South American plates.

Andes mountains South America
Photo Bob Moffatt



Nazca plate
Illustration NASA/GSFC/Robert Simmon [Public domain], via Wikimedia Commons

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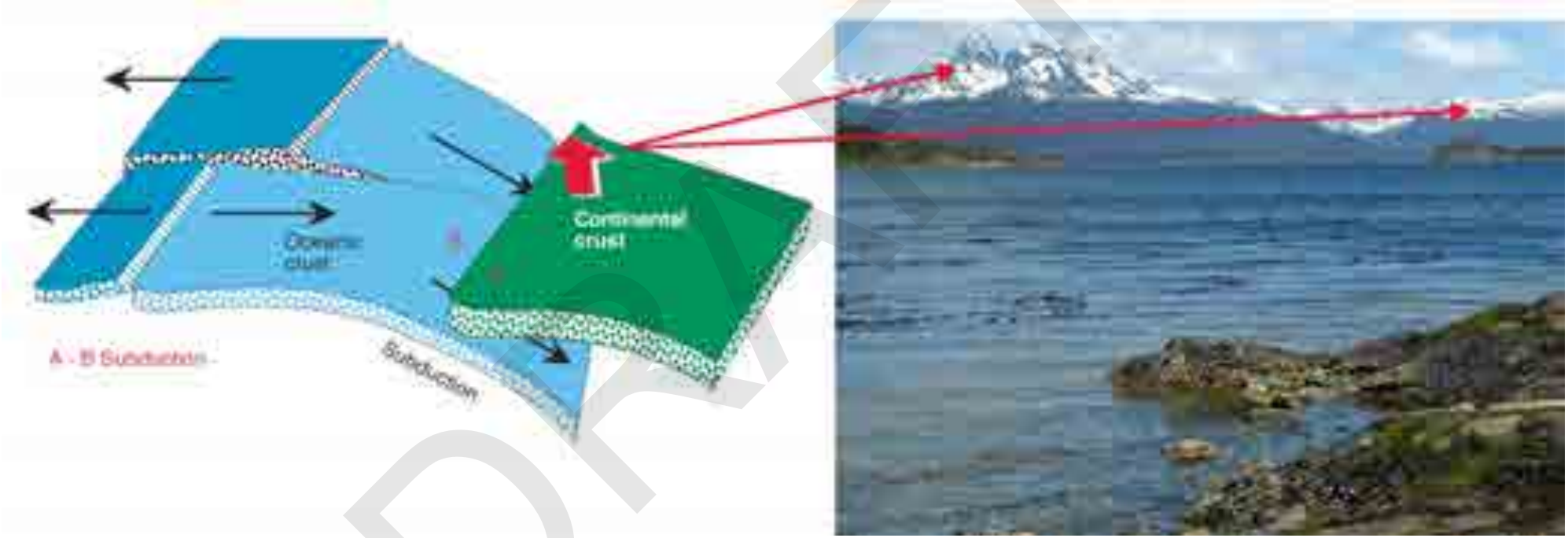
So the **model of plate subduction** is used to explain how mountains are made.



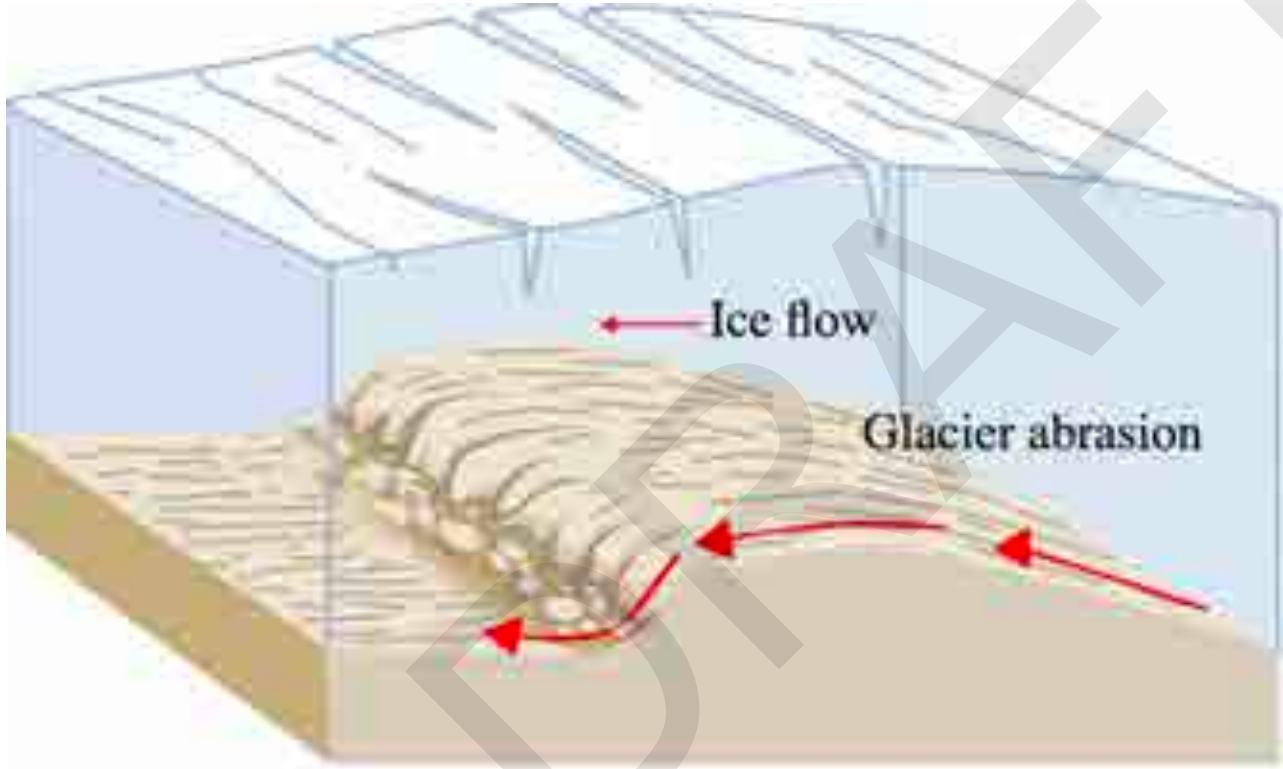
Model shows Andes mountain formation

Illustration and photo Bob Moffatt

DRAFT

The shaping of mountains and coastlines is affected by many forces.

Glaciation is one such force resulting in enormous erosion of mountains causing deep cuts.



NZ glacier and fiord

Illustration Luis María Benítez from es [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons

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Major glaciers occurred in New Zealand's South Island resulting in fiords.

The fiords or sounds are so deep that large ocean liners cannot anchor when they bring in tourists.

NZ glacier and fiord

P{hotographs Bob Moffatt

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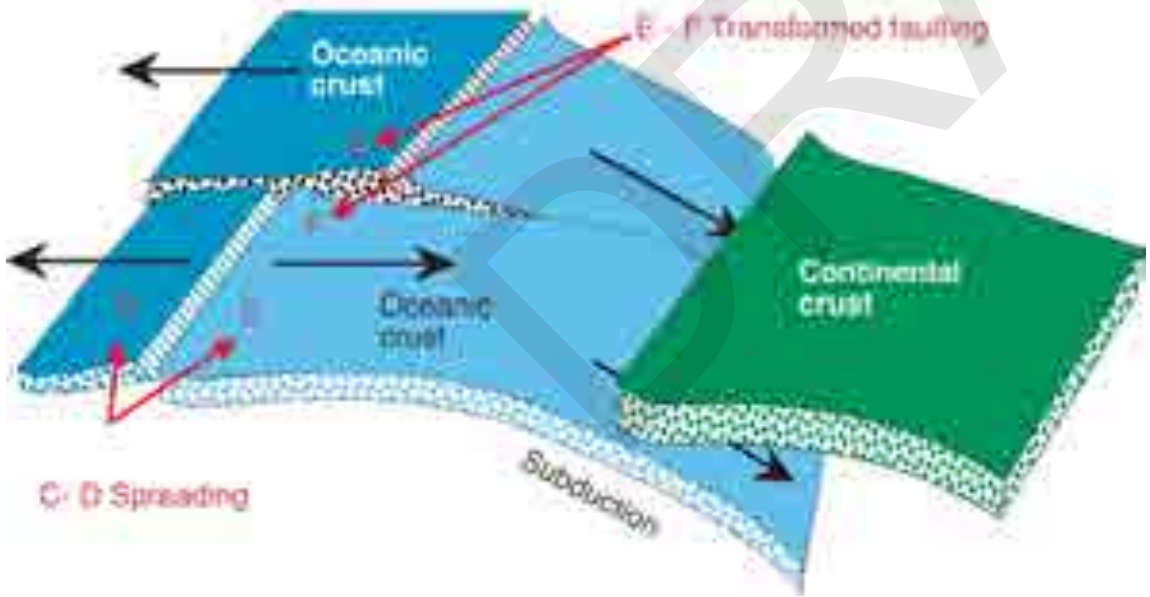
Earthquakes

As one boundary of an oceanic plate is pushed downwards into the asthenosphere by subduction, new oceanic crust is being formed at the opposite end by magma rising from the asthenosphere.

The process is called Sea floor spreading (C-D).

Transverse faults (E – F) can also occur as plates tend to break into two sections.



Subduction summary

Illustration Bob Moffatt

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This model is used to explain Earthquakes.

Effect of an Earthquake

Photograph Sherwood Maynard University of Hawaii (copyright)

San Andreas Fault

Illustration Bob Moffatt

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Island chains

Volcanic island chains of the Pacific show movement of the ocean's floor.

When the new crust is being produced at the mid-oceanic ridge, a volcano can form.

The source of the magma remains constant, and as the plate moves over the hot spot.

Mt Kilauea is the example.

Hawaii Islands

Illustration Bob Moffatt

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Mt Kilauea is not a dangerous volcano and people can walk up to the crater and watch it erupt.

But the crater will move as the island moves over the hot spot.

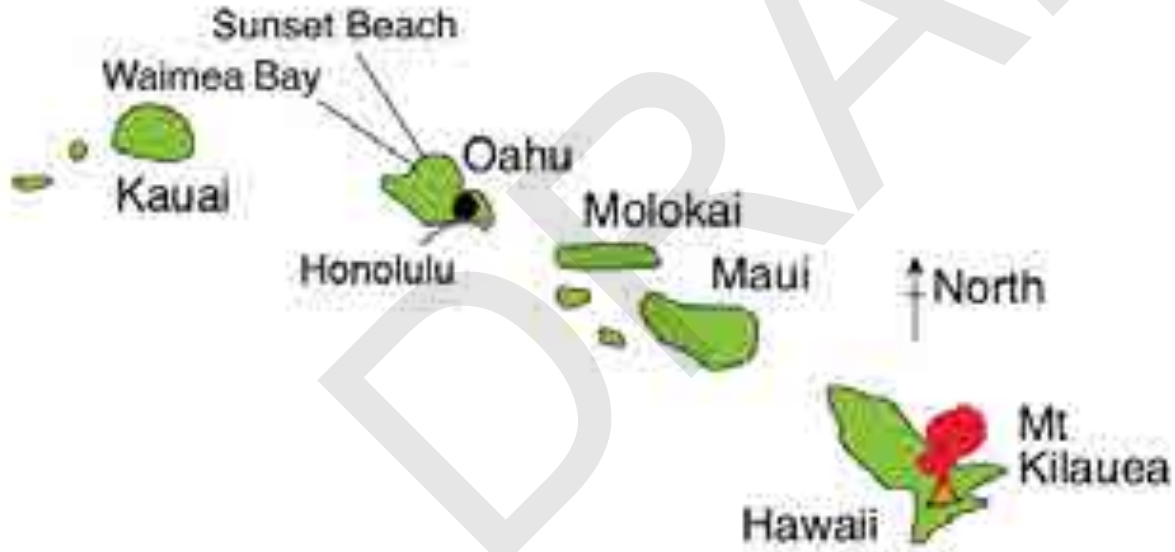
Mt Kilauea Hawaii

Photograph By Puu_Oo_looking_up_Kilauea.jpg: USGS derivative work: Avenue (Puu_Oo_looking_up_Kilauea.jpg) [Public domain or CC0], via Wikimedia Commons

It can be seen that the other islands in the Hawaiian group have been formed in this way.

One of the most famous Ohau, has a north shore famous for large surfing waves.
Other island chains in the Pacific have been formed this way.

Western Samoa has very flat volcanic cones. The islands of Fiji, Tahiti and Tonga all formed from volcanoes.



Hawaiian islands
Illustration Bob Moffatt

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Year 12 External exam type question

Analyse evidence to identify patterns of understanding for the movement of tectonic plates

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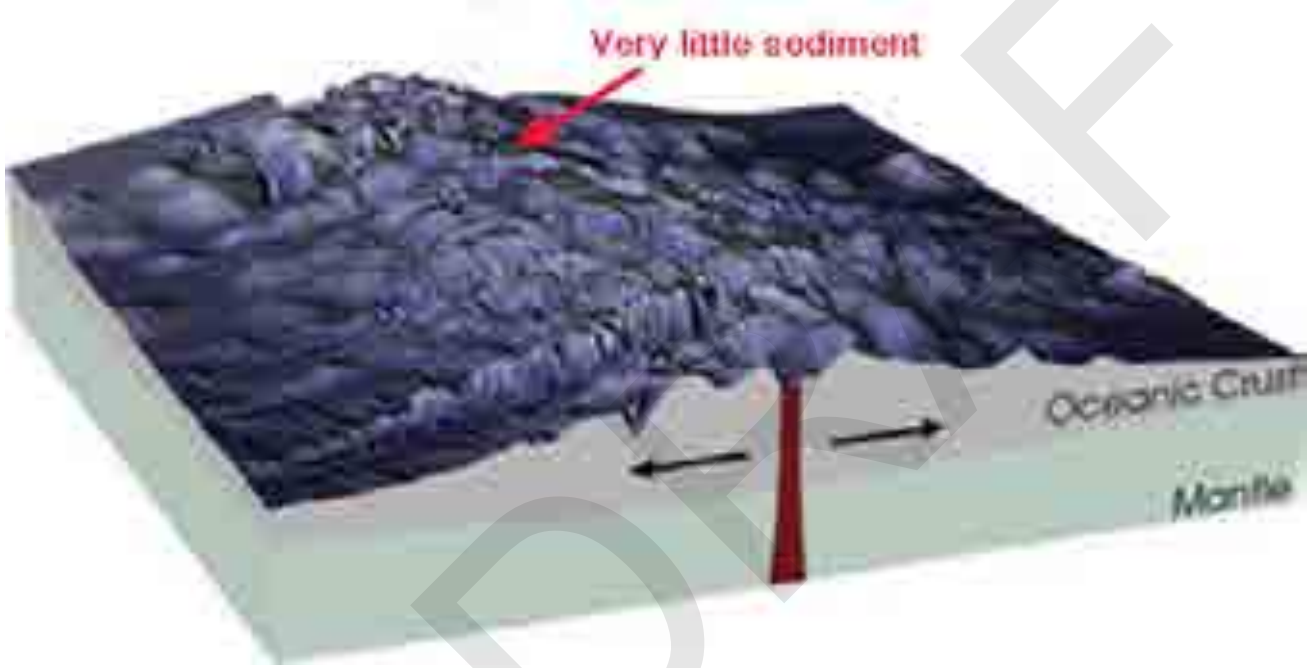
The ocean floor in the area of the ocean ridges has very little sediment built up on them.

This is the area where the ocean floor is spreading and the new crust is being formed.



Mid ocean ridge

By NASA/GSFC/Robert Simmon - http://earthobservatory.nasa.gov/Study/Tectonics/tectonics_3.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=358818

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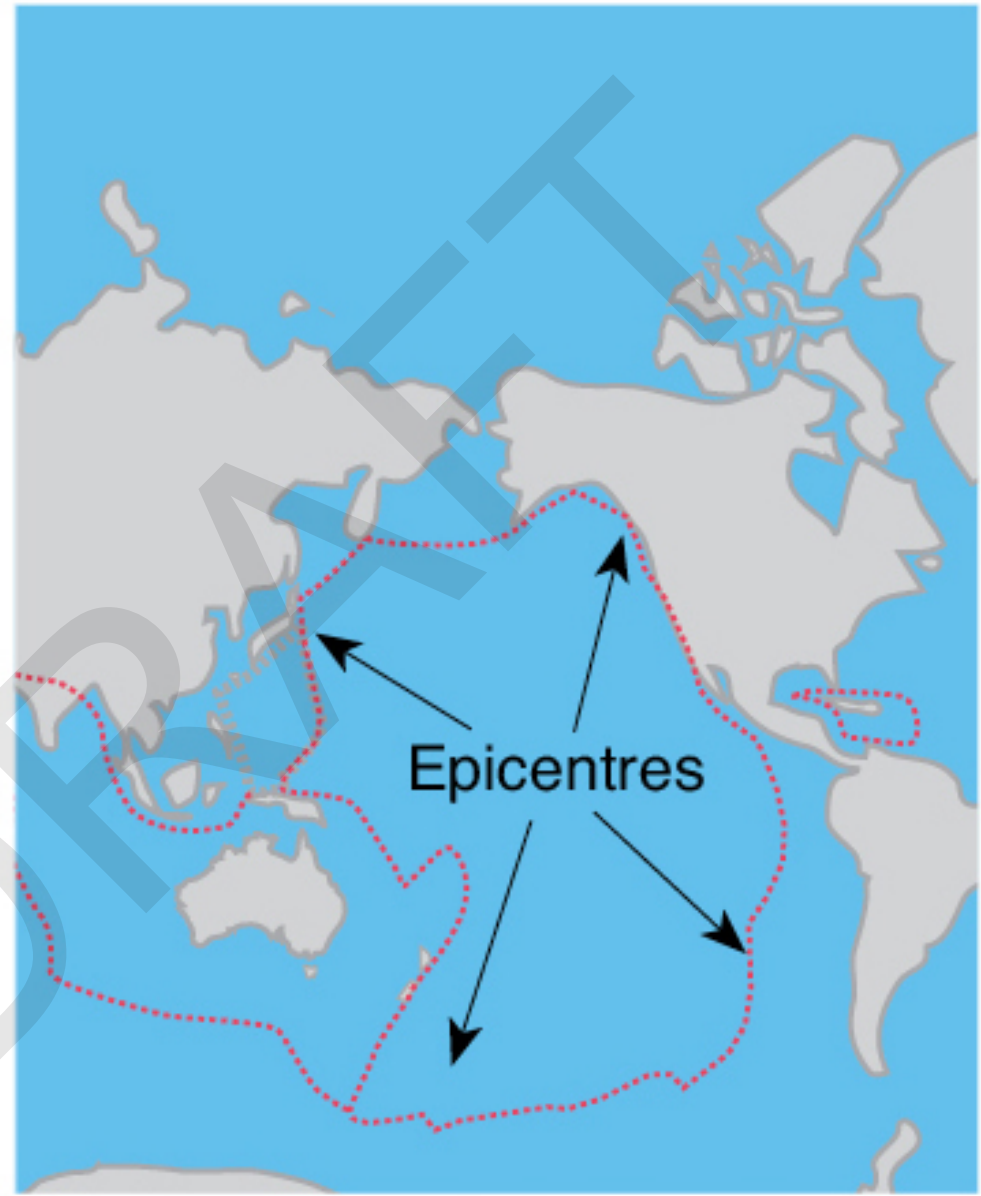
The fact that most of the Earth's earthquakes originate in the areas where the plates collide.



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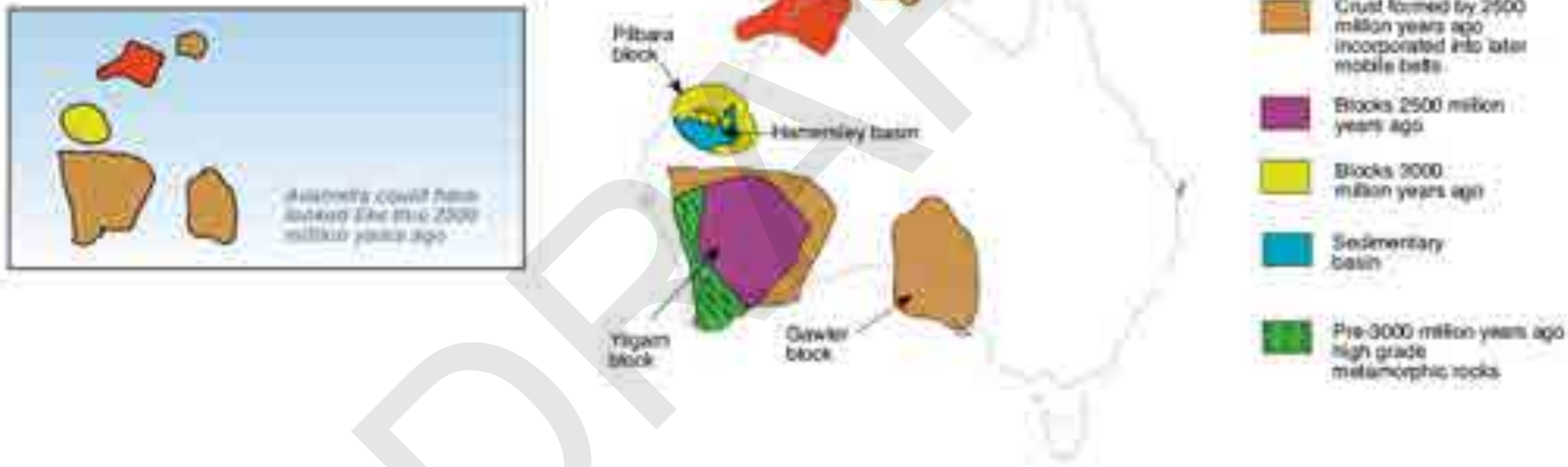
Ancient limestone reefs in the Northern Territory

2500 million years ago Australia had five blocks of content surrounded by sea.



Australia 2500 MYO

Illustration Bob Moffatt (after Perspectives of the Earth)

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These blocks were at the bottom of a super continent called Gondwana.

A shallow sea, with coral reefs separated another supercontinent Laurasia to the north.

On either side was a vast ocean.

Gondwana

Illustration Bob Moffatt

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A geologic time scale (GTS) is used by scientists to describe the timing and relationships of events that have occurred during Earth's history.

Geological Time Scale

Era	Geological period	Approx time	Important events applicable to Australia
Cenozoic	Recent	18 mya	Coral growth continental shelf
	Oligocene	35 mya	Specialisation of mammals, sediments flowed from rivers onto continental shelves
	Eocene	55 mya	Australian plate still moving north and fracturing
Mesozoic	Paleocene	70 mya	Expansion of mammals, coral sea forms, cato trough forms, foundations for Bowen Basin laid down
	Cretaceous	100 mya	Dinosaurs became extinct, Australia still joined to Antarctica
	Jurassic	200 mya	First mammals and birds
Palaeozoic	Triassic	230 mya	First Dinosaurs
	Permian	285 mya	Expansion of primitive reptiles
	Carboniferous	350 mya	Expansion of sharks and fish
	Devonian	400 mya	First insects
	Silurian	430 mya	First land plants
	Ordovician	500 mya	First fish
Precambrian	Cambrian	600 mya	First marine invertebrates
	Precambrian	4600 mya	The beginning of life in the Sea

Geological time

Illustration Bob Moffatt

DRAFT

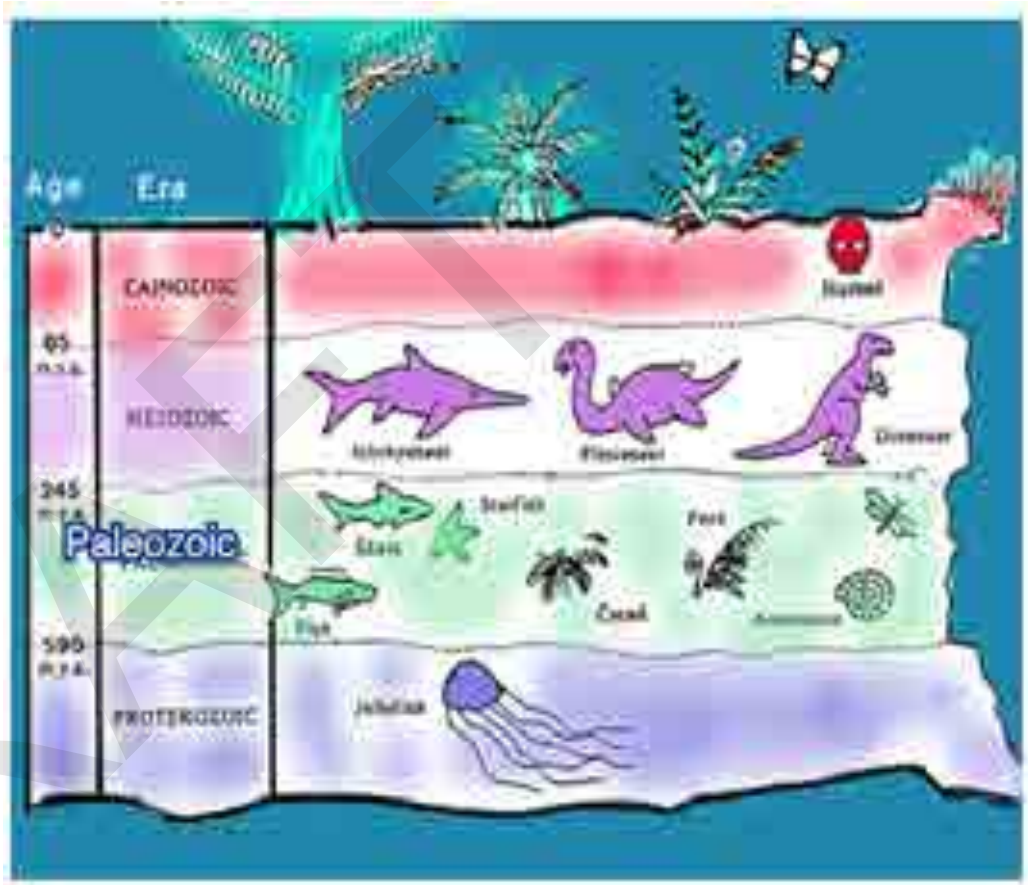
Stratigraphy is the branch of geology concerned with

- the order and relative position of strata and their relationship to the geological timescale,
- the analysis of the order and position of layers of archaeological remains

or

- the structure of a particular set of strata.

An example would be in a road cutting you could see ichthyosaur remains higher up in the cutting than fish or sea stars.



Stratigraphy

Illustration Queensland Museum

DRAFT

Other examples can be found in ancient reefs in the north of Western Australia.

Devonian reef Kimberley region

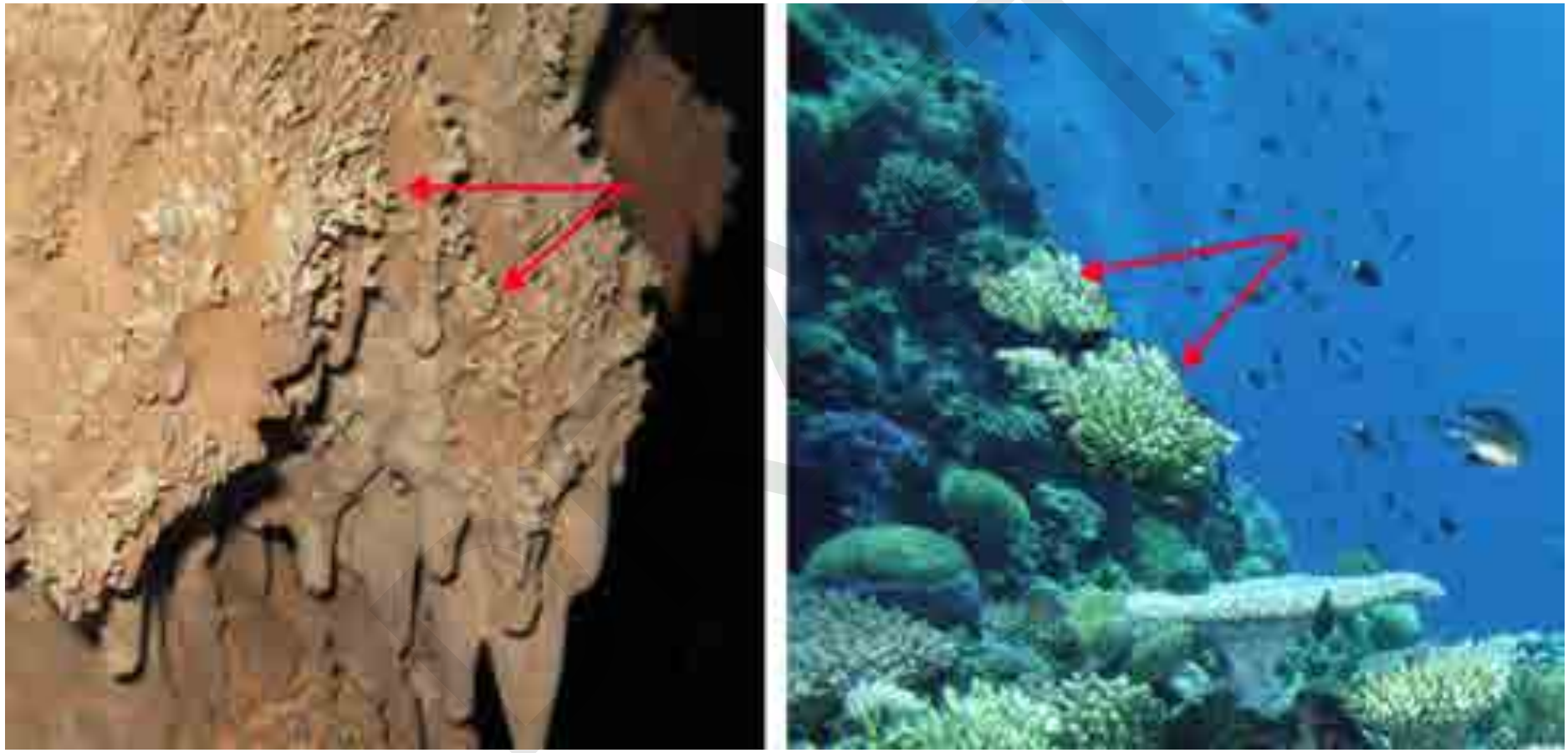
Photo Bob Moffatt

DRAFT

Solid limestone reefs containing a huge variety of fossils laid down as they died in the ancient seas.
The fact it is now on land suggests that it must have been pushed up out of the water by plate subduction.

Devonian reefs in the Kimberley region of Western Australia
Illustrations Bob Moffatt WA National Park

Here you can walk through the ancient Devonian reefs and see many of the fossil invertebrate and plant remains from this period of time.



Devonian reef and reefs today

Photo Bob Moffatt Illustration WA National Parks

Examples you can see are fossil nautili.

Windjana George and fossils

Photo Bob Moffatt

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The Great Dividing Range

In the Paleozoic era, two thirds of the Australian crayton had formed and was joined to a super continent called Gondwana.

Gondwanaland

Illustration Bob Moffatt

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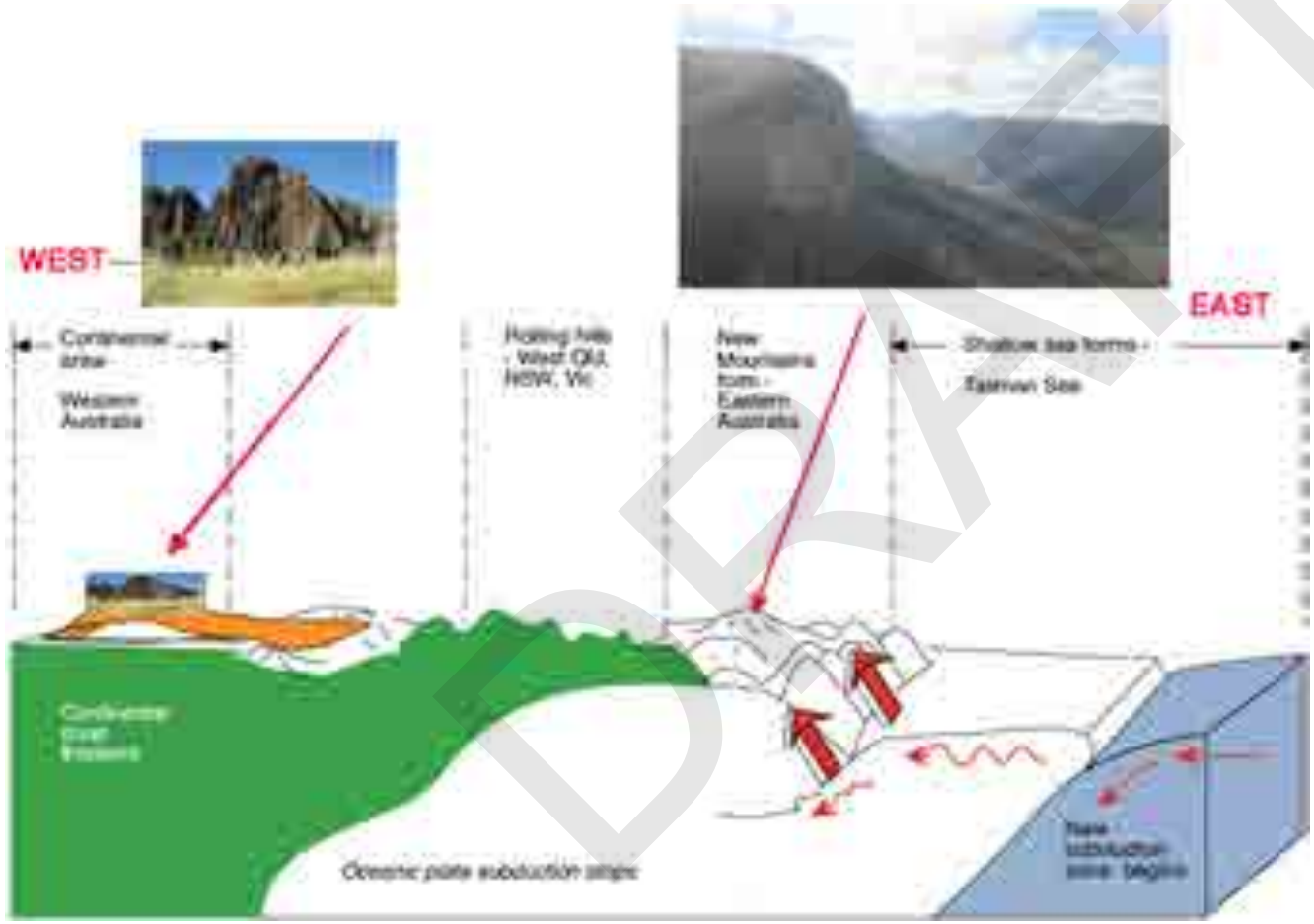
During this time an oceanic plate was subducting under what now is South Australia and a marginal sea lay between it and an island chain which was to become the Great Dividing Range.



- To the east of this volcanic range lay a deep ocean trench with oceanic crust subducting in the Tasman Sea area.
- To the west lay our ancient reefs

Aus 600 - 400 MYO East west comparison

Illustration and photos Bob Moffatt

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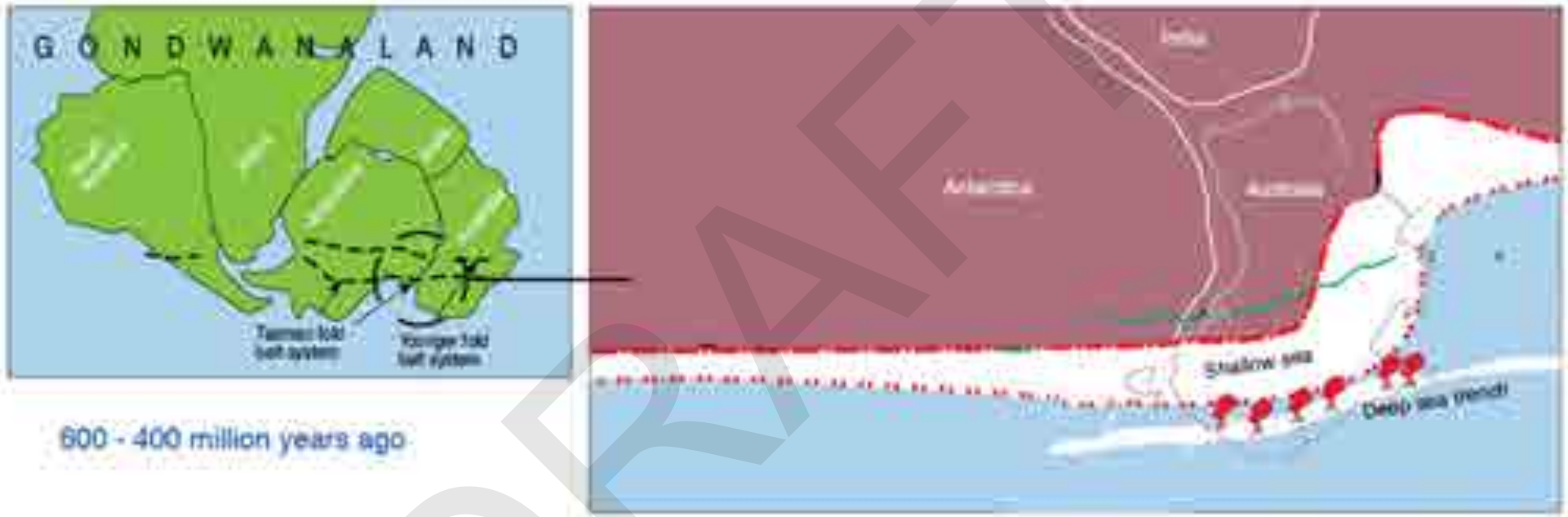
To the south Tasmania was splitting from Antarctica and a new deep sea trench was forming.

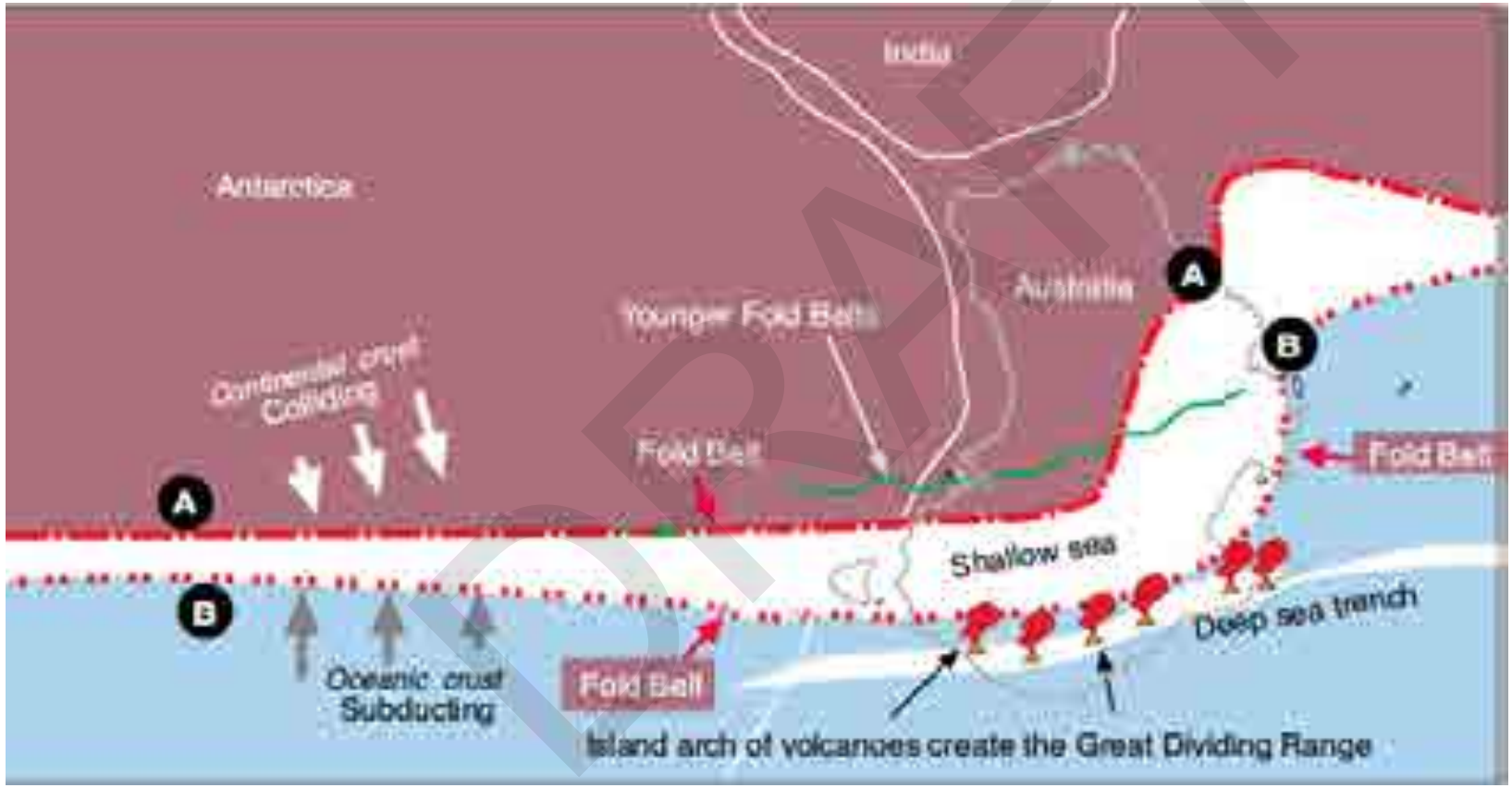


Australia 600 - 400 MYO Island arc

Illustration Bob Moffatt

DRAFT

As the oceanic plate pushed under the Australian plate massive fold belt systems, carrying with them sedimentary, metamorphic and igneous rocks from millions of years under the sea.



Australia 600 - 400 MYO fold belt systems

Illustration Bob Moffatt

DRAFT

The shallow sea was uplifted and became the rolling hills west of the great divide.

The volcanoes of the arch crumbled as sedimentary rocks from the deep ocean trench were thrust into the old mountain range.

Blue mountains NSW

Photo Bob Moffatt

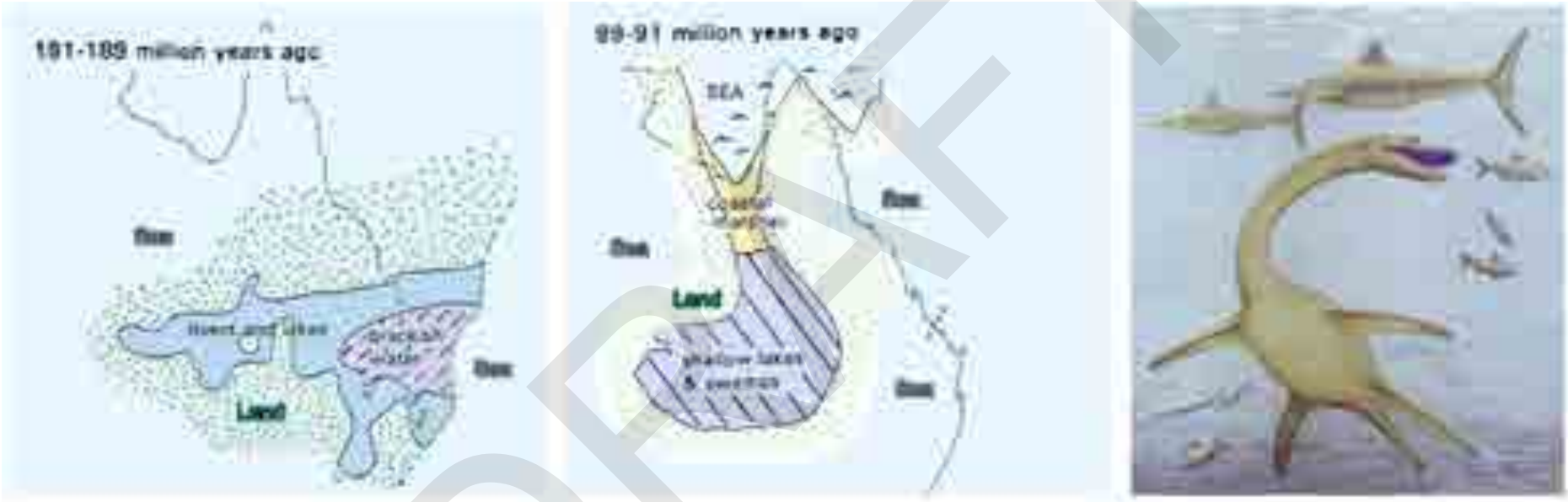
DRAFT

Queensland coal deposits and marine dinosaurs

This was also the time the massive coal deposits were laid down in the Bowen basin in Queensland

Coal deposits in Queensland
Photo Australian Mining Council

In Queensland inland seas had formed and the Queensland Museum Geosciences and Australian Age of Dinosaurs Museum have been actively excavating dinosaurs from western Queensland, near the township of Winton, since 2001.



Ancient Queensland seas

Illustrations Queensland Museum

DRAFT

Barrier Reef formation

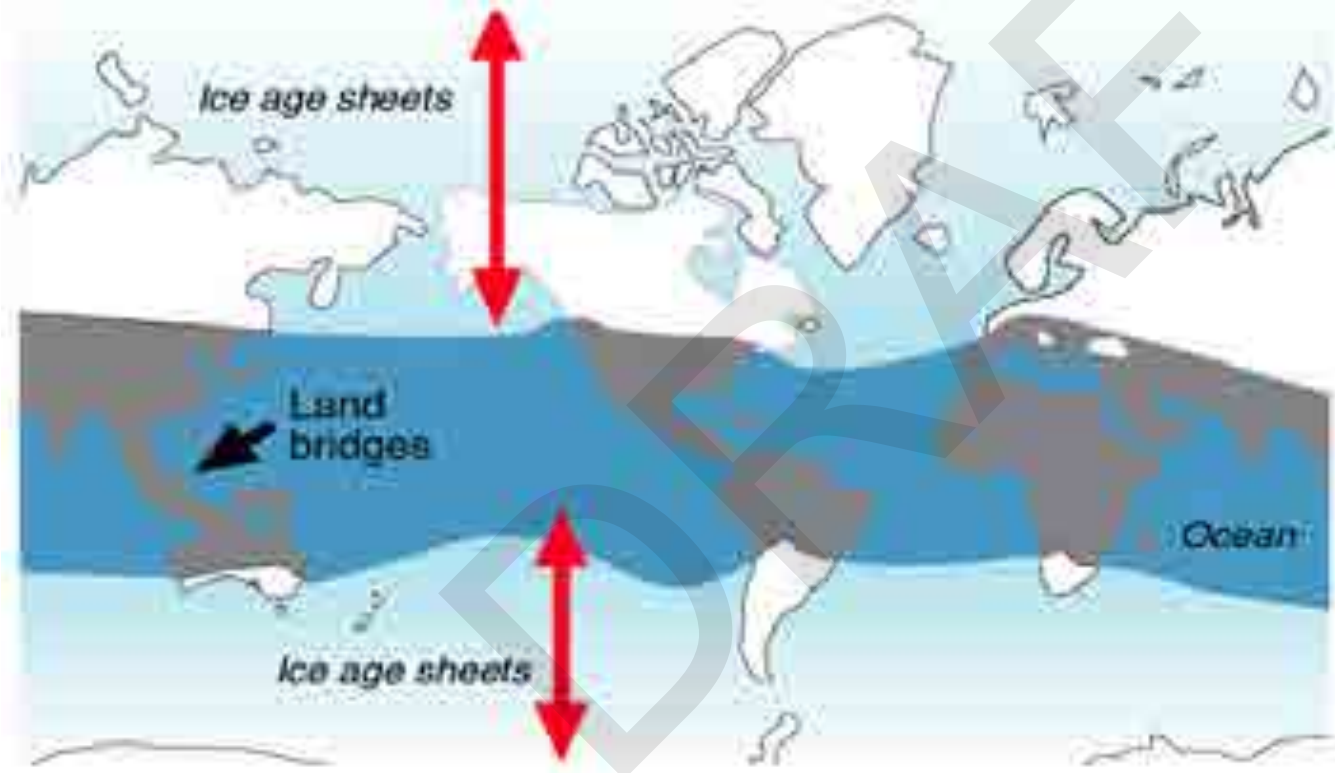
From 50 mya to present a series of ice ages engulfed the earth during this period.

When an ice age occurs, vast amounts of water become trapped in the polar ice caps and the depth of the ocean decreases.

Ice age Earth

By Ittiz (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons, modified by Bob Moffatt under Wiki licence 2.0.

Shallow seas drain and land bridges form that allows movements of human populations as well as other animal and plant life.



Ice age seas
Illustration Bob Moffatt

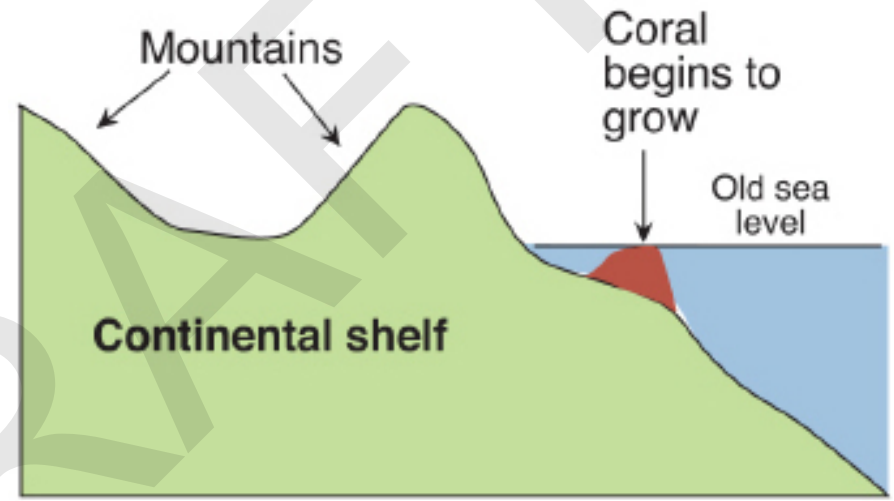
These ice ages contributed to the development of present day Australian coastal landforms as well as offshore islands and reefs.

DRAFT

About 18 mya a sequence of events that started reefs growth began as Australia was at a latitude that promoted coral growth at a rapid rate.

As the sea levels rose corals began to grow in large numbers, forming reefs on the outside of the continental shelf

There were still mountains and plains on the continental crust as the age of the mammals increased.



Reef development pre-ice age A

Illustration Bob Moffatt

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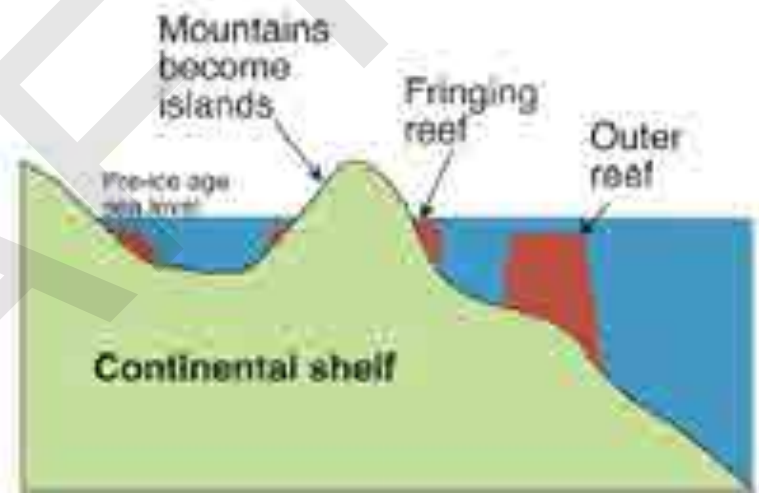
As the sea level rose further, so did the reefs forming fringing reefs around the new islands and outer reefs on the edge of the continental shelf.

- Life abounded in the seas and the islands became separated by large expanses of water.
- Populations of birds may have developed because of the absence of natural predators such as snakes or dingoes.
- Turtles could nest and form rookeries also with the absence of larger predators.



Pre ice-age reefs
Illustration Bob Moffatt

DRAFT

Then followed a series of ice ages.

The sea level fell about 150 metres.

Continental shelf areas were now subjected to river systems and erosion.

Limestone caves under and around old limestone cliffs were possibly the homes for our early Aborigines.

Predators returned to offshore islands

Sediments built up at the bottom of rivers.

Ice age reefs

Illustration Bob Moffatt

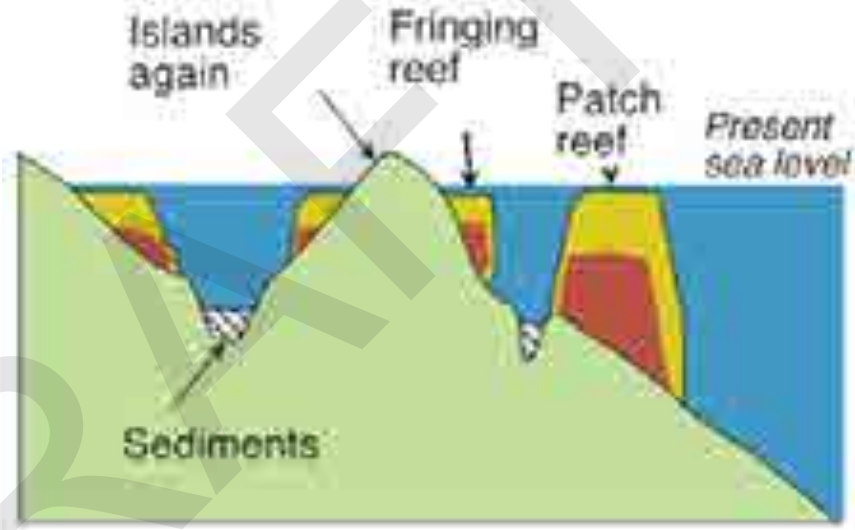
DRAFT

About 18,000 years ago ice caps from the last ice age began to melt and water level gradually rose.

Coral grew up and thickened over old reefs.

Modern reefs are therefore a thin veneer on ancient reefs.

Drilling cores into them can reveal valuable information about past climatic events.



Modern reefs

Illustration Bob Moffatt

DRAFT

On the reefs we see today are layers of new coral growth, about 15 metres deep, covering the old fossil reefs.

Two types of reef found in Queensland can be found at Lizard Island and North West Island.

Fringing reef (L) Patch reef (R)

Photos Great Barrier Reef Marine Park Authority (L) Bob Moffatt(R)

DRAFT

Magnetic Island is an example of a continental island with a fringing reef.

Magnetic Island
Photo Tourism Queensland

DRAFT

West coast islands and reefs

Reefs formed off the coast of Western Australia in much the same way as just previously described.

The shape of the continental shelf is different as are the ocean currents.

Fringing reefs WA
Photo CALM

DRAFT

Coastline stratification

About 50 mya Australia had began to separate from Antarctica.

The Great Australian Bight serves as a reminder of where Antarctica once was joined.

Great Australian Bight

Photographs Bob Moffatt

DRAFT

Stratification of marine sediments is clearly visible on the Victorian coastline beside the Great ocean road.

Victorian coastline

Photograph Tourism Victoria

Massive folding and faulting can be seen on our rocky shores.

Thick and thin beds of rock can be tilted vertically then faulted so they do not line up, then shaved off at the top.

Rocky shores in Southern Queensland show wiggly lines indicate that the beds have been folded and pushed around.

Rocky shore tectonics

Photo Bob Moffatt

DRAFT

During ice ages, sand can be deposited in layers and then when exposed to wind, carved into coloured layers.

The coloured sands at Frazer island are examples of this.

Coloured sands Frazer Island

Photo Bob Moffatt

DRAFT

T003 Biogeochemical cycles

DRAFT

Syllabus statement

The syllabus says ... you should be able to

describe the processes of the water, carbon and oxygen cycles

Describe - give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something

DRAFT

Question

Explain the term cycle and give a written account of the **processes** involved in the water, carbon and oxygen cycles.

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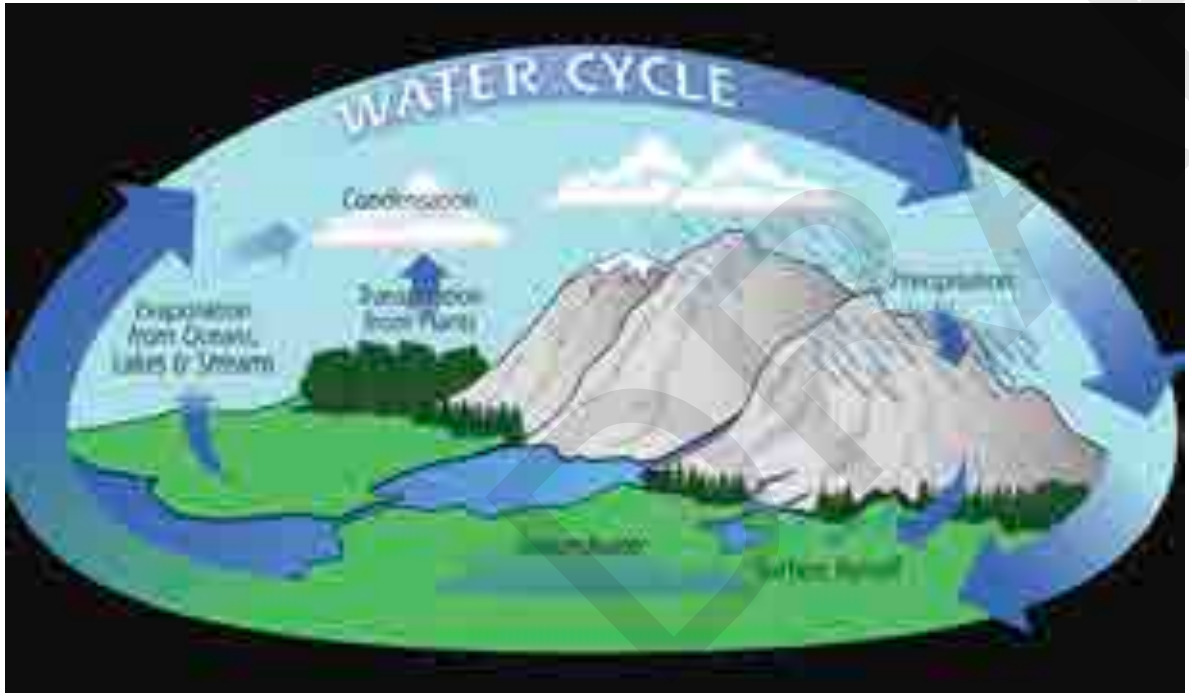
Definition

A **cycle** is a series of changes which comes back to the starting point and which can be repeated.

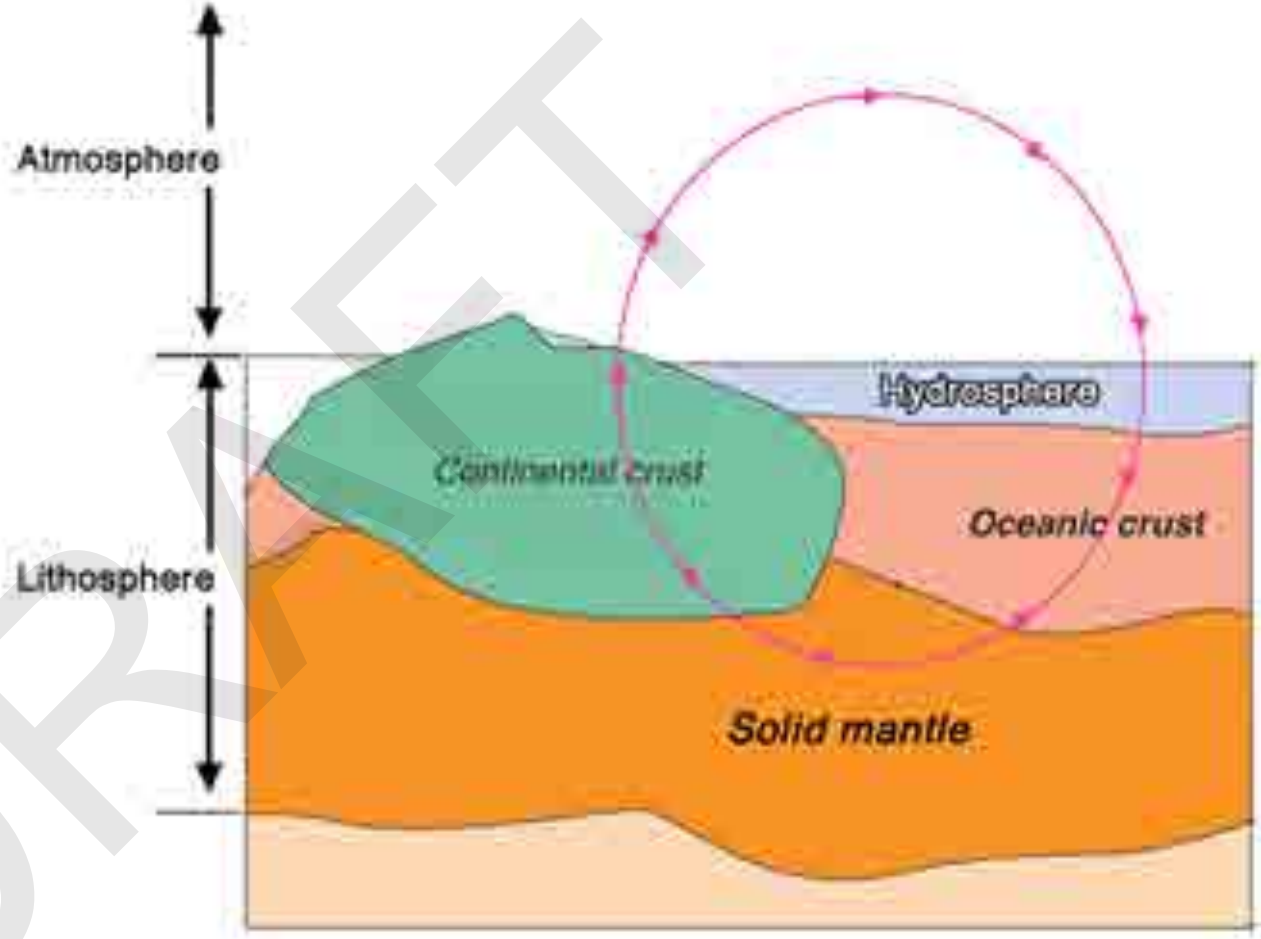
Water, for example, is always recycled through the water cycle, which undergoes evaporation, condensation and precipitation, before falling back to Earth.



Water cycle

Ref: https://pmm.nasa.gov/education/water-cycle

Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another through biogeochemical cycles.



Cycle - lithoshpere atmosphere hydrosphere

Illustration Bob Moffatt

DRAFT

In some cycles there may be places (called reservoirs), where the element is accumulated or held for a long period of time (such as an ocean, coal deposit or rainforest.

Coal deposits

Photo Australian mining council

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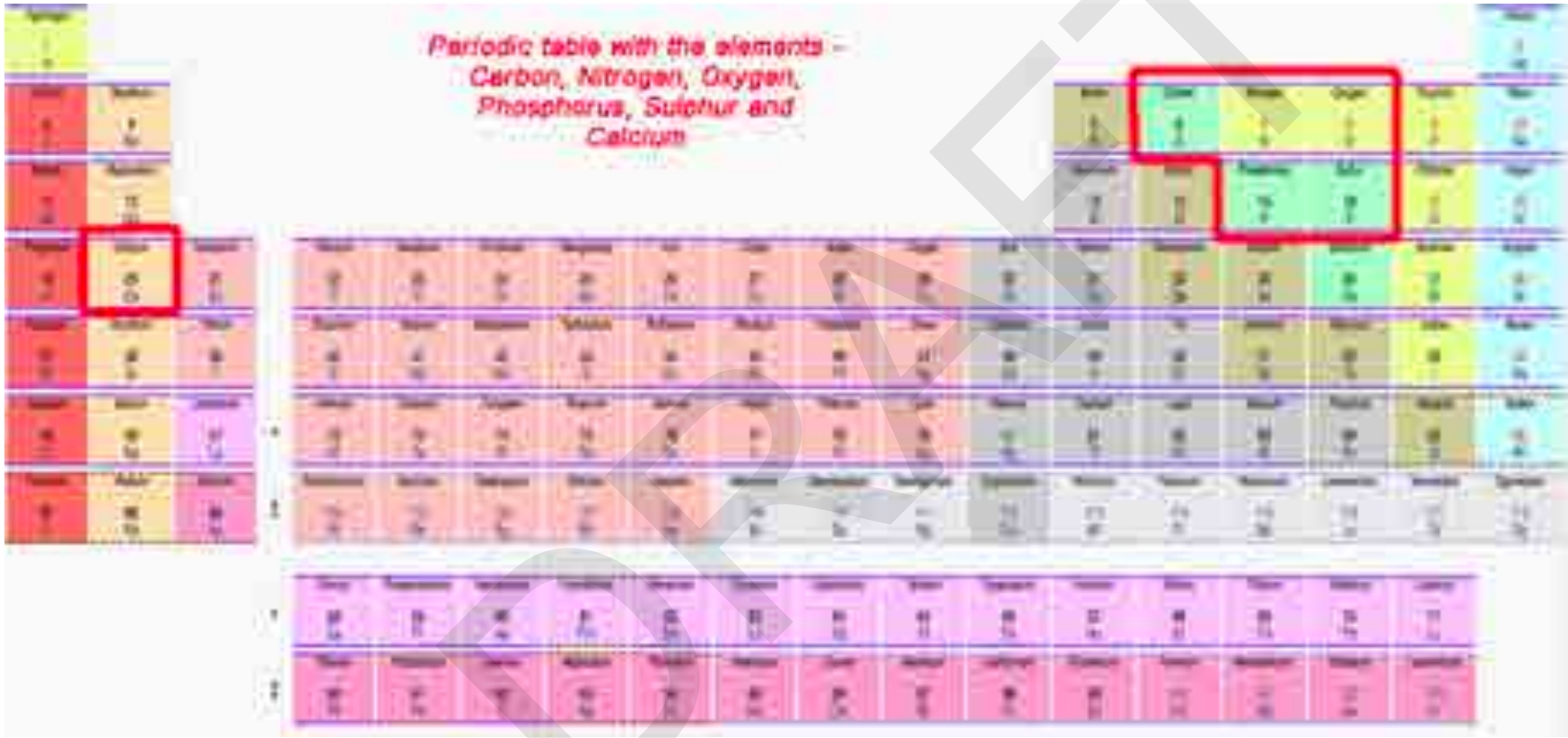
Cycles involve the elements and compounds.
Important elements are nitrogen, oxygen, phosphorus, sulphur and hydrogen.



Periodic table with the elements carbon, oxygen, nitrogen, phosphorus, calcium and sulphur
By Offnfopt (Own work) [Public domain or CC0], via Wikimedia Commons

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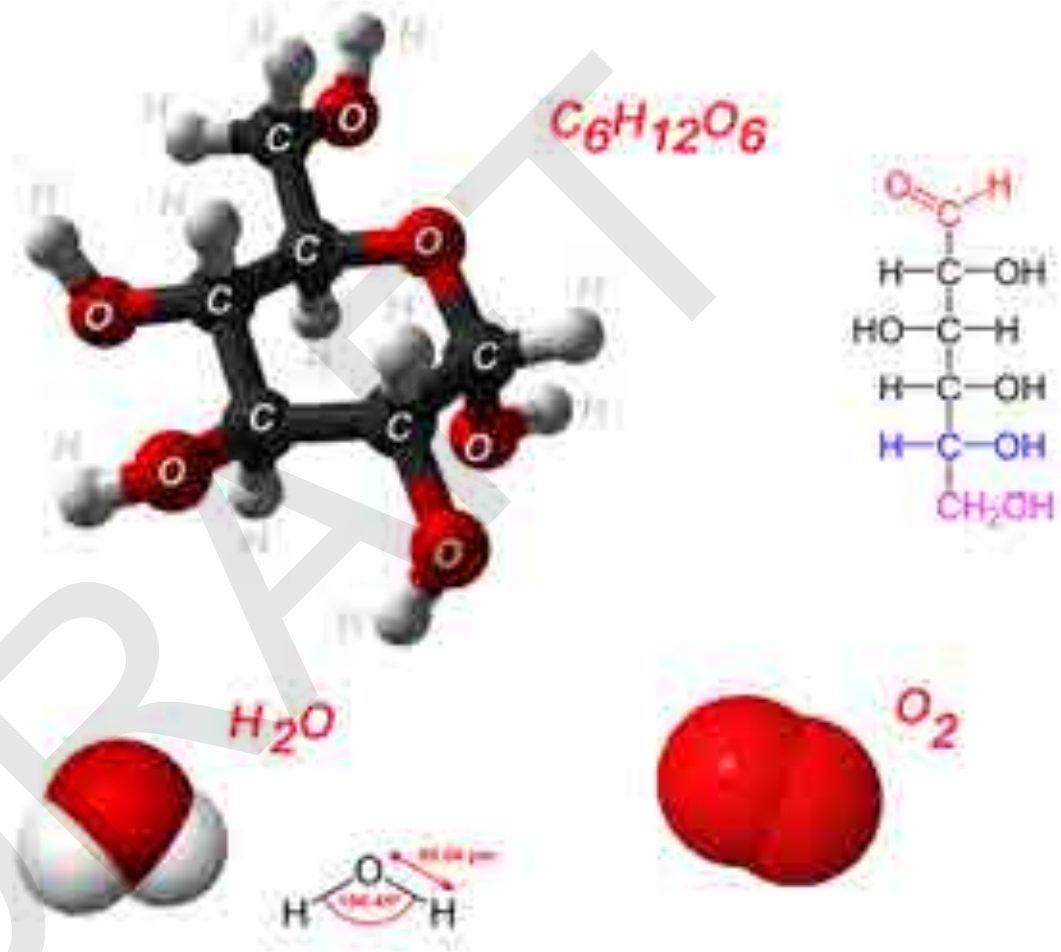
Cycles also involve molecules.

Sugar and water molecules are involved in the carbon, oxygen and water cycles



Sugar, water and oxygen molecules

Water by Dan Craggs (Own work) [CC0], via Wikimedia Commons
Glucose By Ben Mills (Own work) [Public domain], via Wikimedia CommonsOxygen By Ulflund - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=20317308

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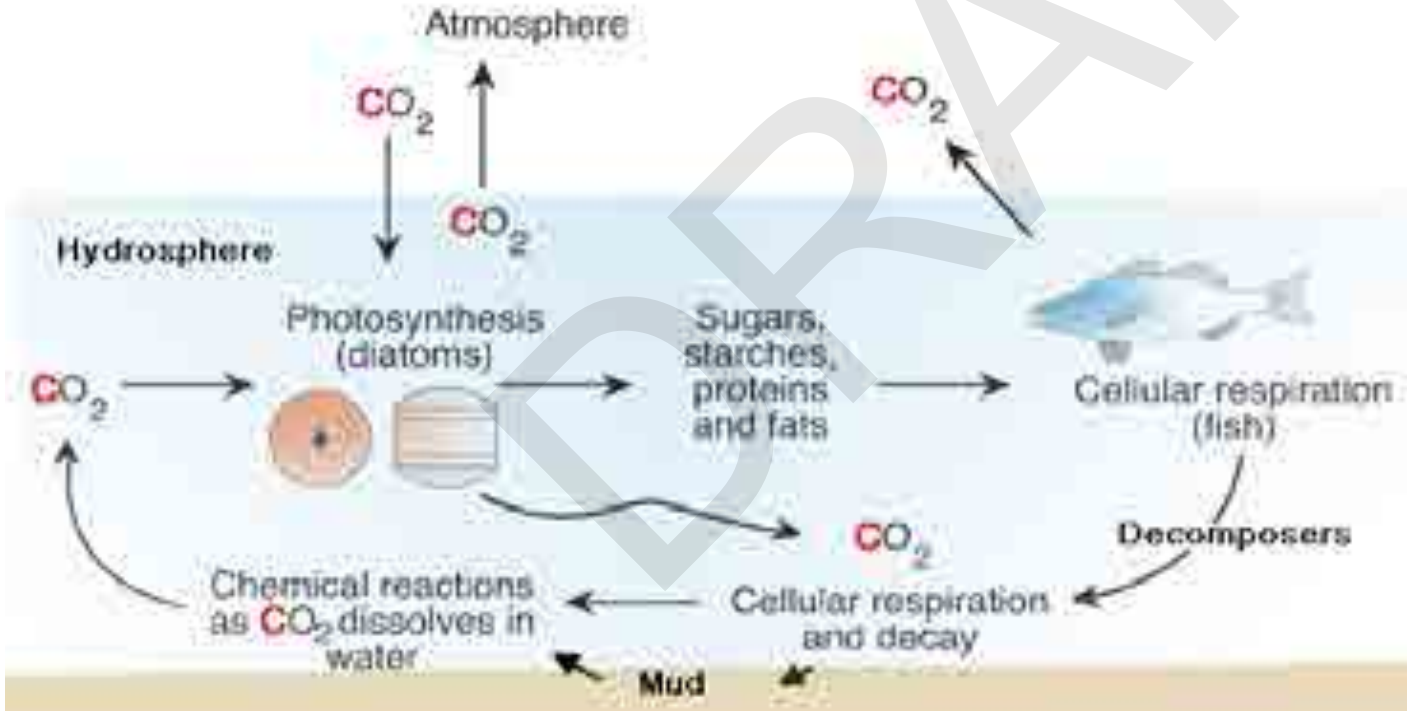
Definition -

A **biogeochemical cycle** is a pathway by which a chemical substance moves through both the biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere).

- Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another.
- For example in an estuary carbon passes through the air, water, plankton, fish, decomposer organisms and mud.



Estuarine carbon cycle

Illustration Bob Moffatt

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There are also human-induced cycles such as those for DDT and mercury.

DDT Nature article

By https://www.nature.com/news/2010/100107/full/news.2010.4.html

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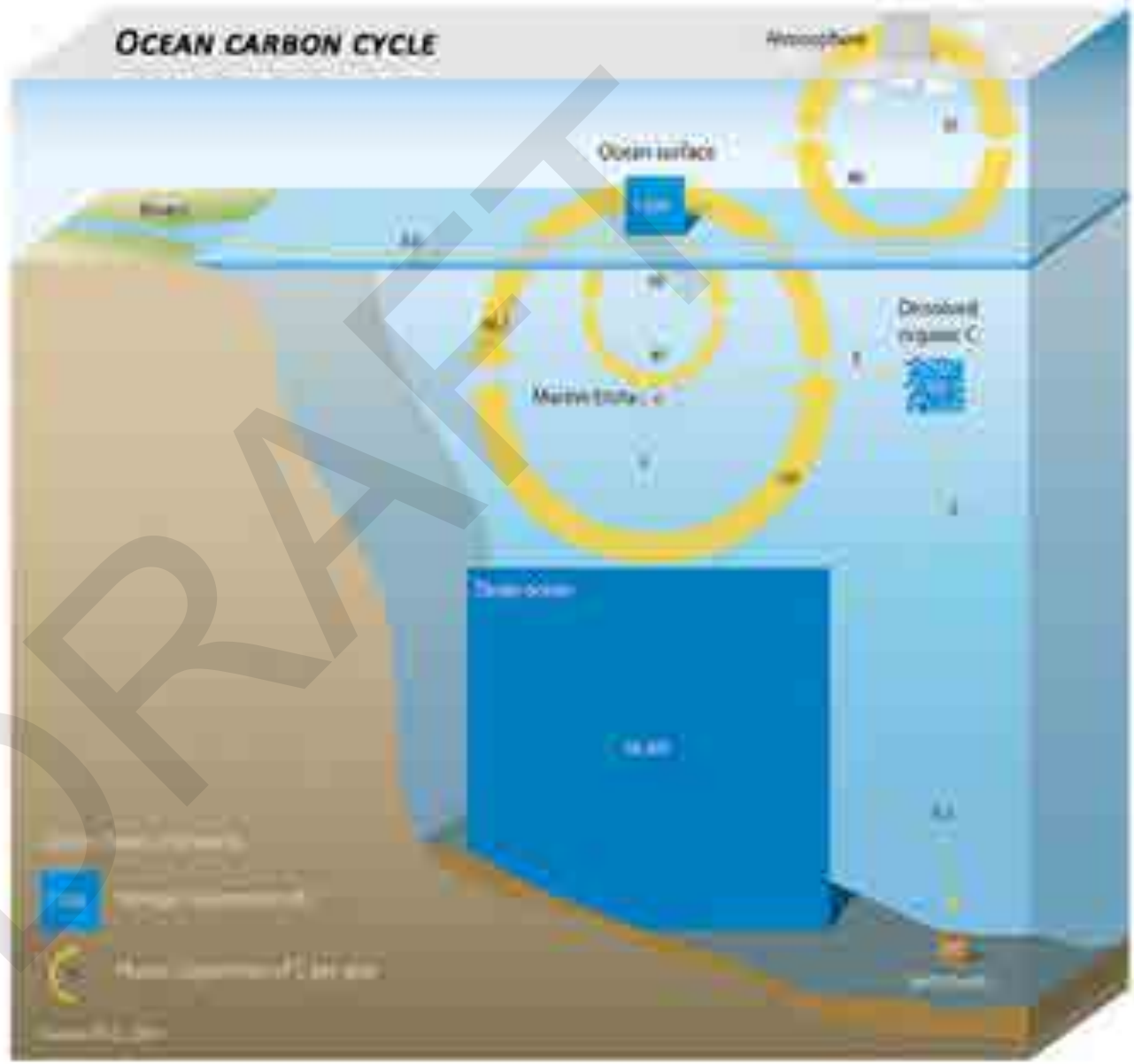
Carbon can also stay locked in layers of the deep ocean for a long time.



Ocean carbon cycle

By Offnfopt (Own work) [Public domain or CC0], via Commons

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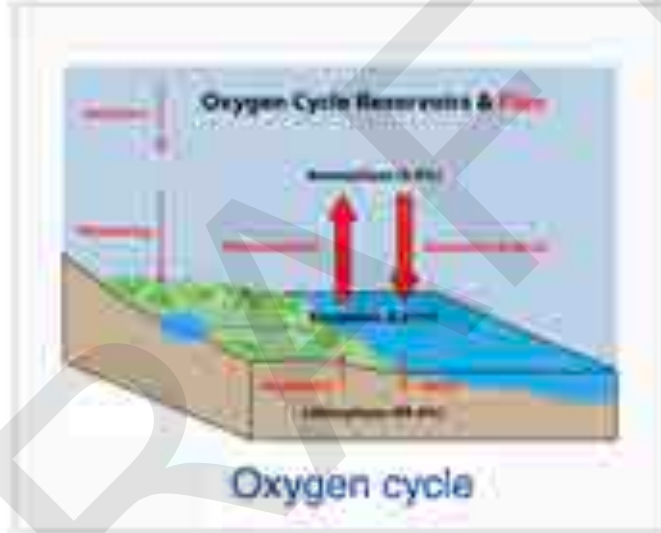
Common biogeochemical cycles are

Carbon

Oxygen

Water



Carbon, oxygen and water cycles

Carbon - By Carbon_cycle-cute_diagram.jpeg: User Kevin Saff on en.wikipedia Derivative work: FischX [Public domain], via Wikimedia CommonsOxygen - By Oxygen_Cycle.jpg: Cbusch01derivative work: Fred the Oyster - Oxygen_Cycle.jpg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9842362Water - By John M. Even / USGS [Public domain or Public domain], via Wikimedia Commons

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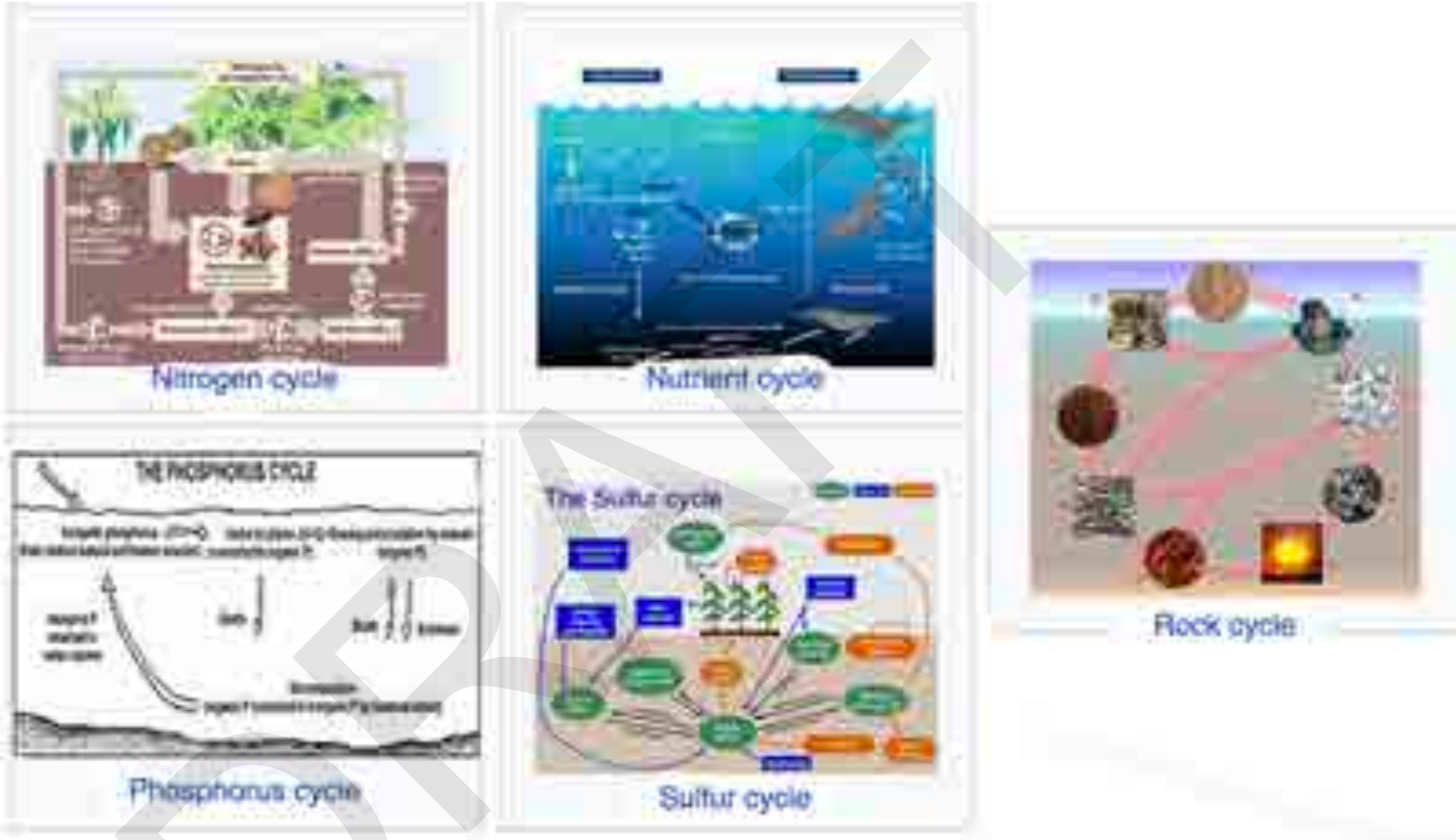
Others are
Nitrogen
Nutrient
Phosphorus
Sulfur and
Rock



Other cycles

Nitrogen - By Environmental Protection Agency (http://www.epa.gov/maia/html/nitrogen.html) [Public domain or Public domain], via Wikimedia Commons
Nutrient - By Roman J, McCarthy JJ [CC BY-SA 2.5 (https://creativecommons.org/licenses/by-sa/2.5)], via Wikimedia Commons
Phosphorus - EPA US Federal Government
Sulphur - Welcome1To1The1Jungle at English Wikipedia [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons
Rock - By Woudloper/Woodwalker (I photoshopped this) [Public domain, Public domain, GFDL (http://www.gnu.org/copyleft/fdl.html)

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Water cycle

The Earth is like a spaceship - nothing can enter or leave the system if life is to continue.

The amount of water remains constant, only its quality can change.

Earth by NASA

Illustration NASA

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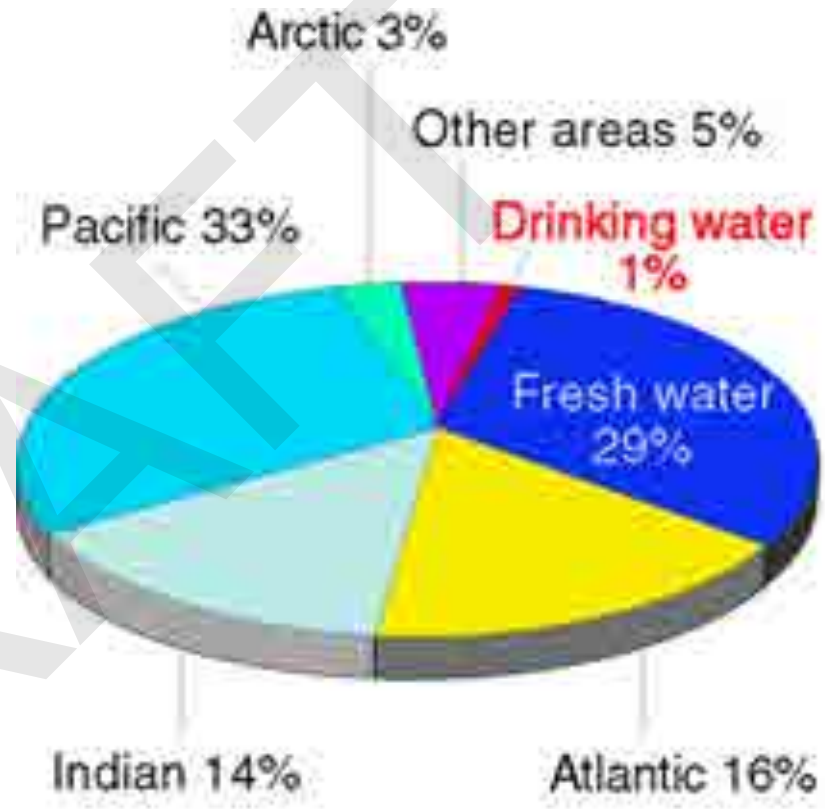
98% of water is contained in our oceans. Without water all life would not exist.

For us humans, only 1% of all water on the earth is available for drinking - making a great case for water conservation.



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The exchange of water between the ocean and the land is called the water cycle. Water evaporates from the sea or land water bodies, precipitates over land and then is returned to the sea above or below the land surface.

Water cycle in Caloundra

Illustration Bob Moffatt, Photo Viewfinder

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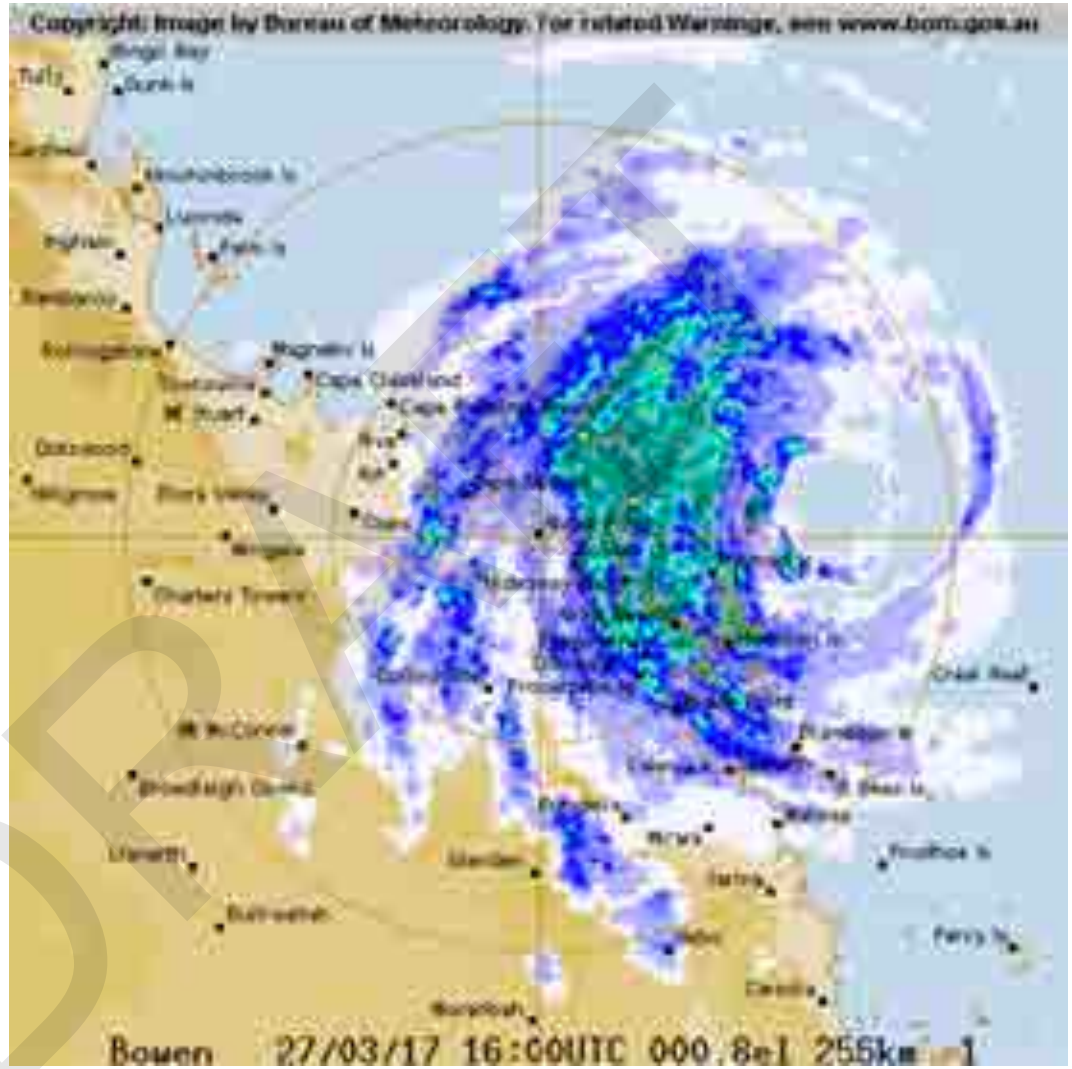
The volume of precipitation is determined by weather patterns with low pressure systems playing a major role.



Cyclone Debbie

Image copyright Bureau of Meteorology

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During these events large volumes of water can carry nutrients and sediments onto the great barrier reef.

Cyclone flood plume

AAP Image/James Cook University

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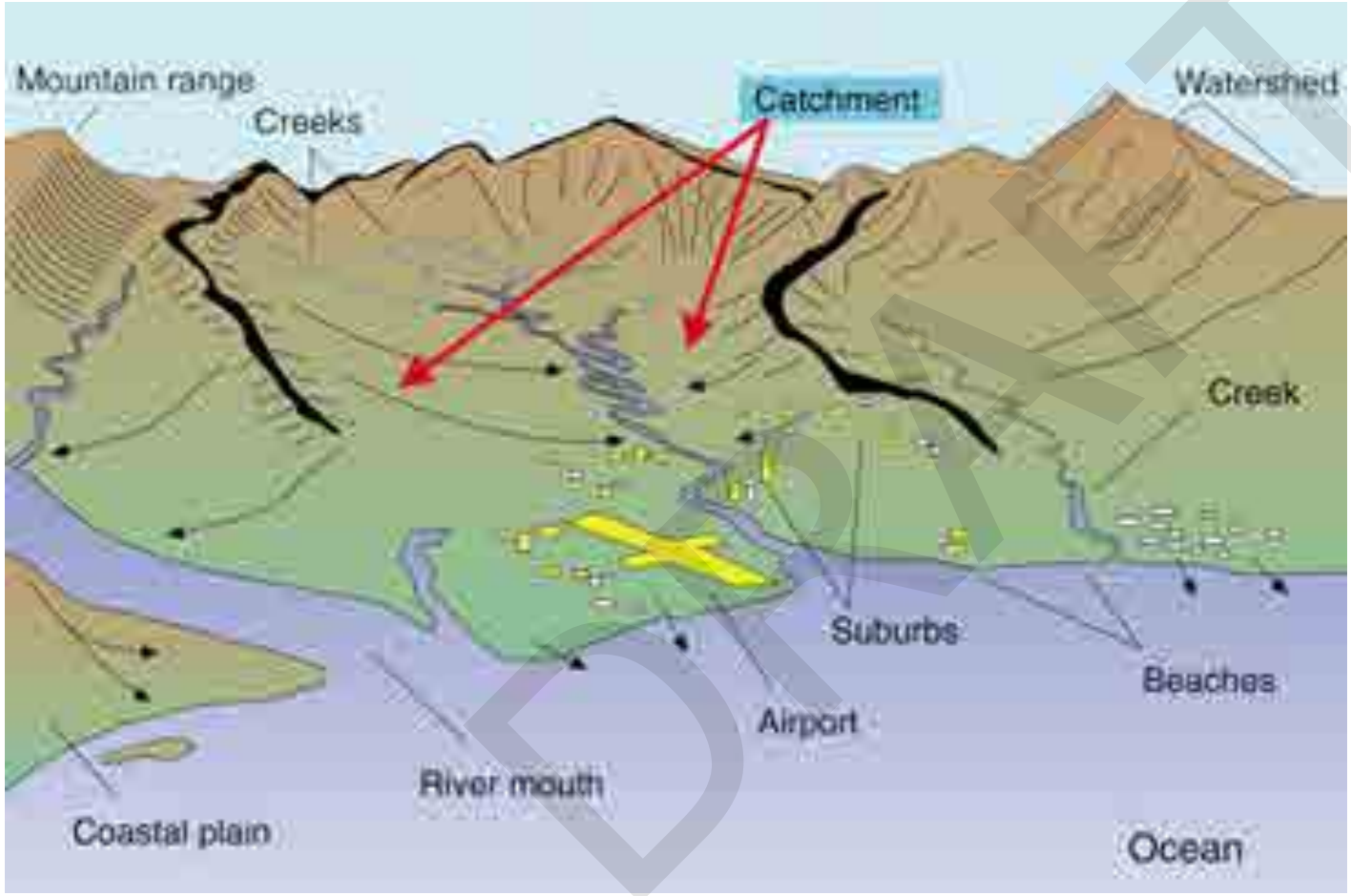
Water in the cycle erodes rocks in mountains, which roll down rivers to form sand, which ends up on our beaches and blows up into sand dunes to allow plants to grow.



Water catchment

Illustration Bob Moffatt

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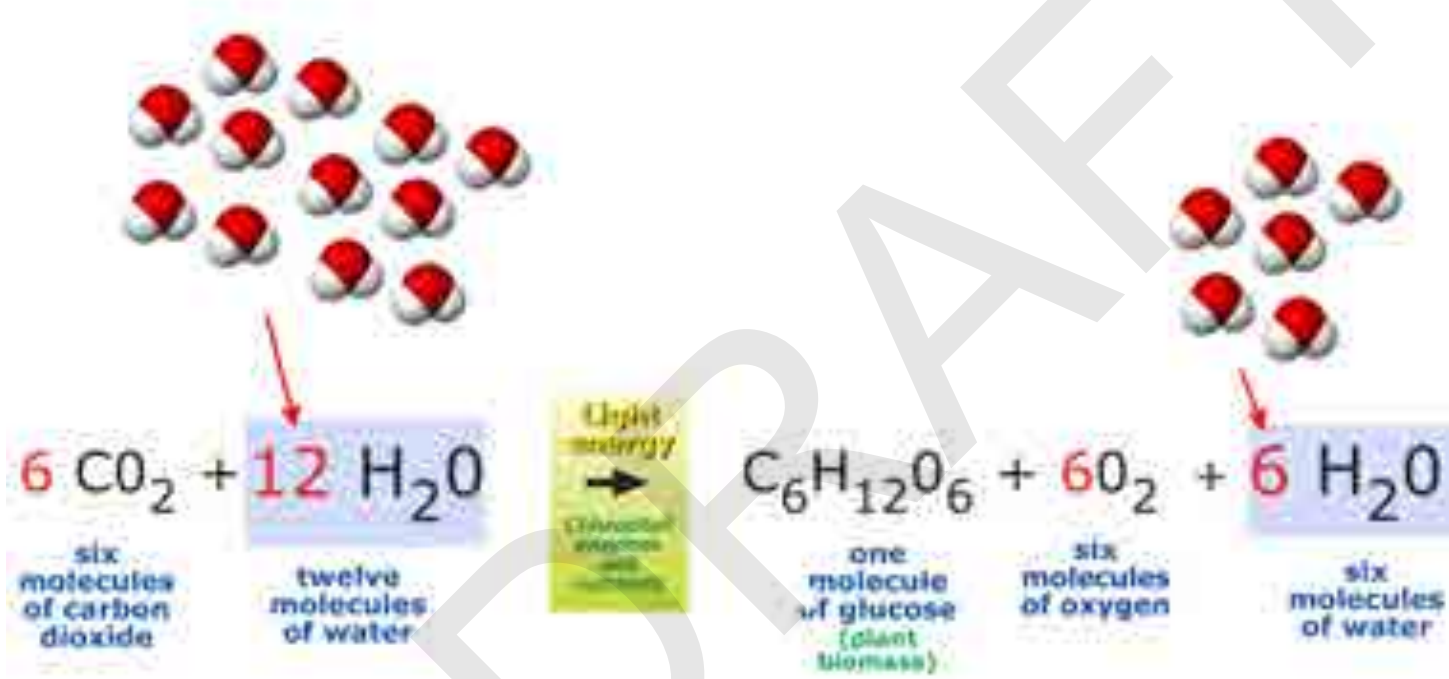
Water also cycles through storm water pipes that can greatly affect water quality

Storm water drain

Photo Bob Moffatt

Water molecules are an essential part of the process for plants to grow by photosynthesis



Photosynthesis equation involves water

Illustration Bob Moffatt, Water - By John M. Even / USGS [Public domain or Public domain], via Wikimedia Commons

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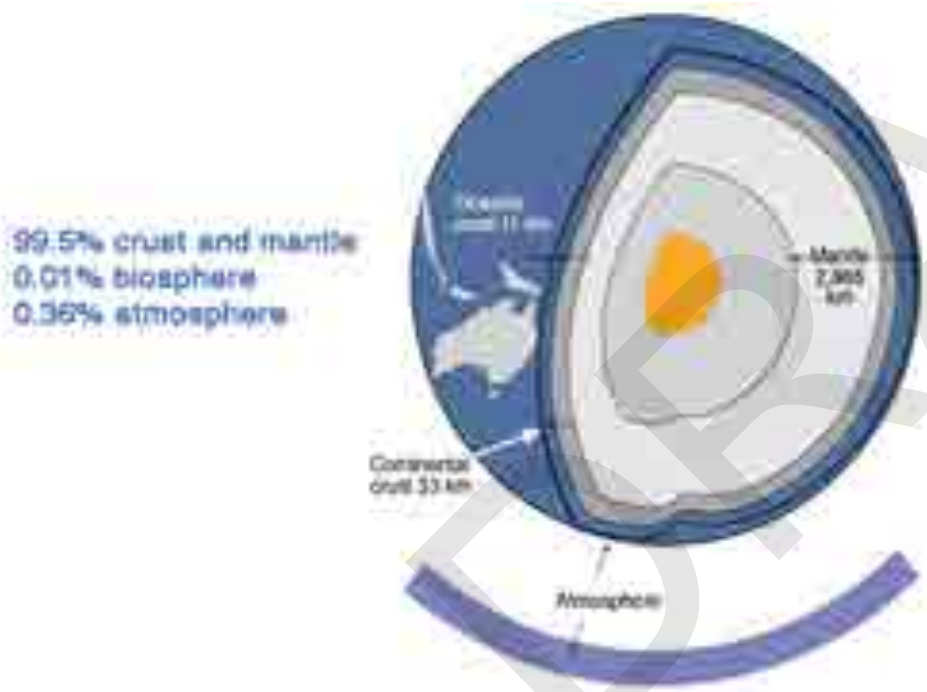
Oxygen cycle

The largest reservoir of Earth's oxygen is within the silicate and oxide minerals of the crust and mantle (99.5%). Only a small portion has been released as free oxygen to the biosphere (0.01%) and atmosphere (0.36%).



Available oxygen to planet Earth

Illustration Bob Moffatt

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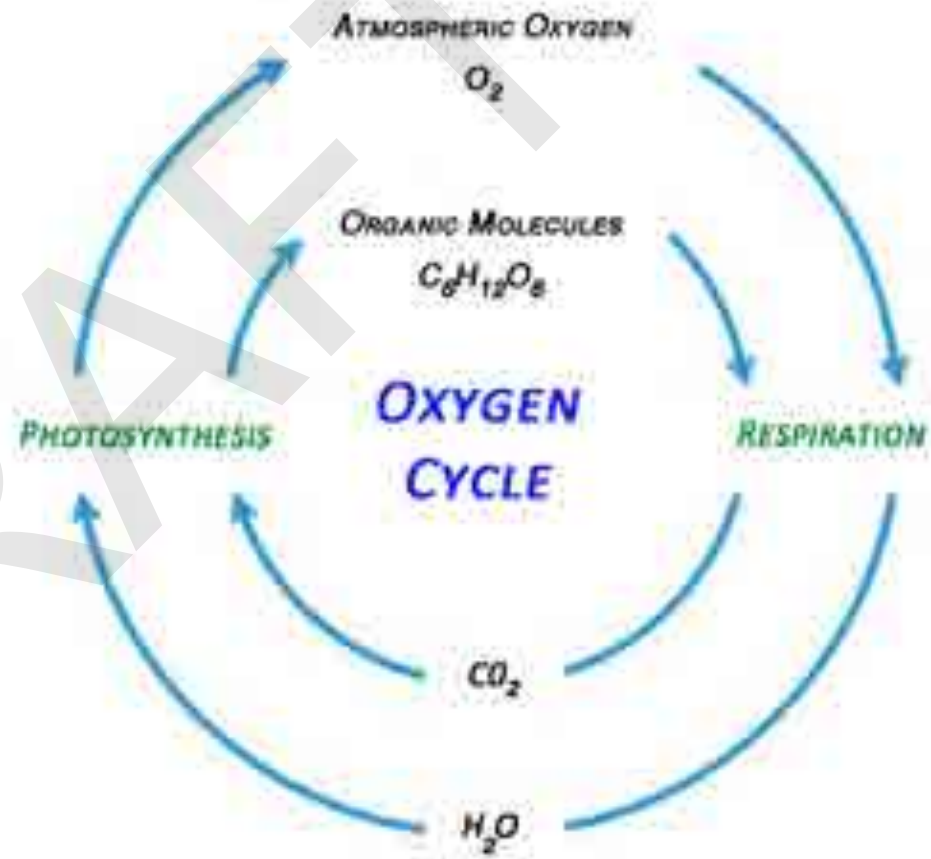
The oxygen cycle has three reservoirs: the atmosphere (air), the total content of biological matter within the biosphere (the global sum of all ecosystems), and the Earth's crust.

Photosynthesis and respiration are the two main processes of this cycle.



Oxygen cycle
Illustration Bob Moffatt

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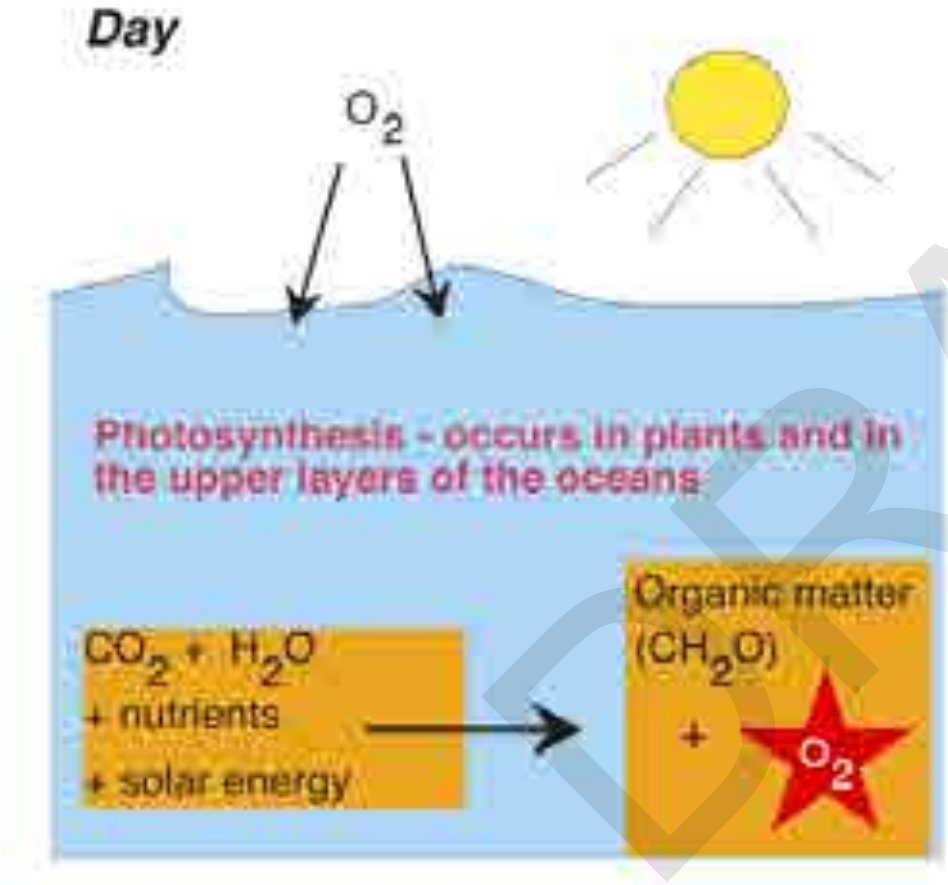
The processes involved in photosynthesis in daylight involve water combining with carbon dioxide to make sugar and oxygen and released into the atmosphere.



Photosynthesis day

Illustration Bob Moffatt

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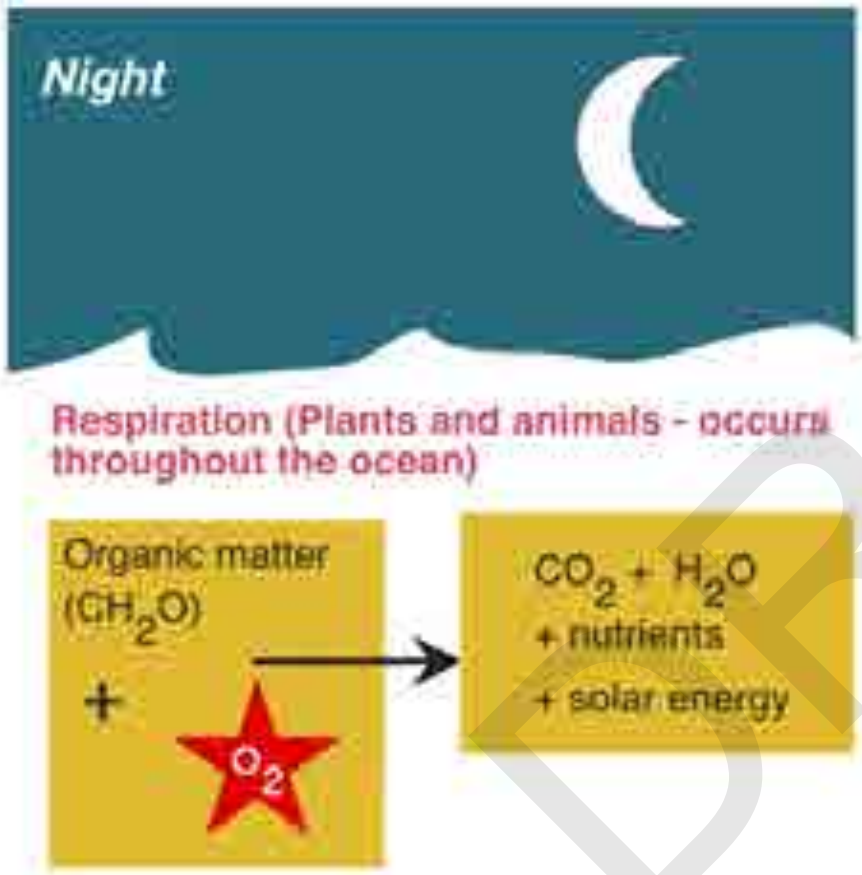
At night respiration then takes this oxygen out of the air, combines it with sugar making water and carbon dioxide and releasing energy.



Respiration night

Illustration Bob Moffatt

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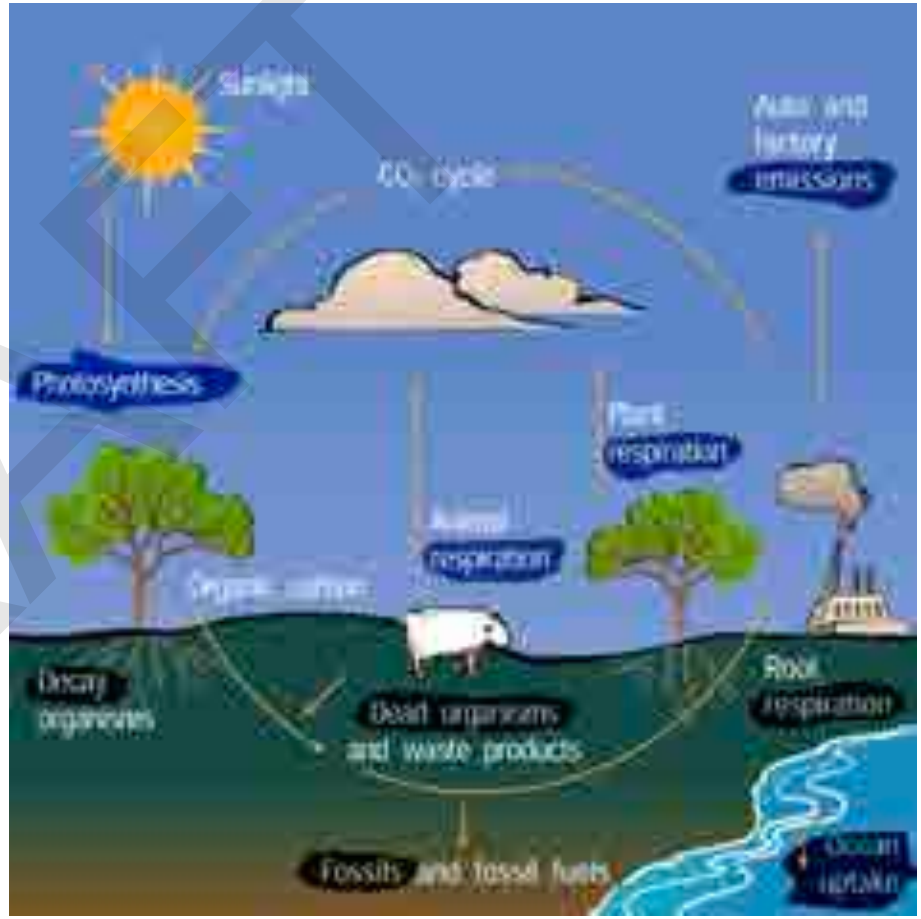
Carbon cycle

The carbon cycle process involves the way the element carbon moves between the Earth's biosphere, hydrosphere, atmosphere, and geosphere.

Some processes include

- Respiration
- Photosynthesis
- Diffusion
- Dissolving
- Death
- Decomposition
- Fossilization
- Burning (Wood, petrol in cars etc)
- Sedimentation



Carbon cycle basics

https://eo.ucar.edu/kids/green/cycles6.htm

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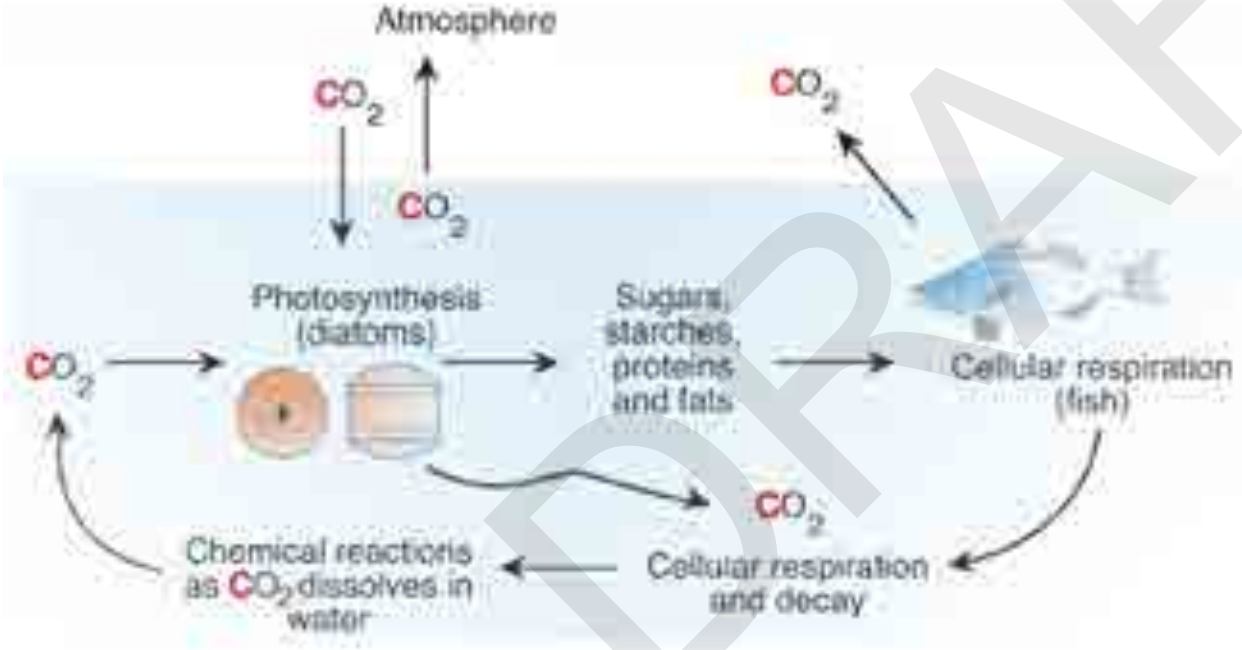
The original source of carbon is the carbon dioxide gas found in the atmosphere.
This carbon is removed from the air by green plants and phytoplankton while carrying out photosynthesis.
Once the carbon is in the form of carbohydrates in the plants it can then be passed along the food chain.



Carbon cycle photosynthesis and respiration elements
Illustration Bob Moffatt

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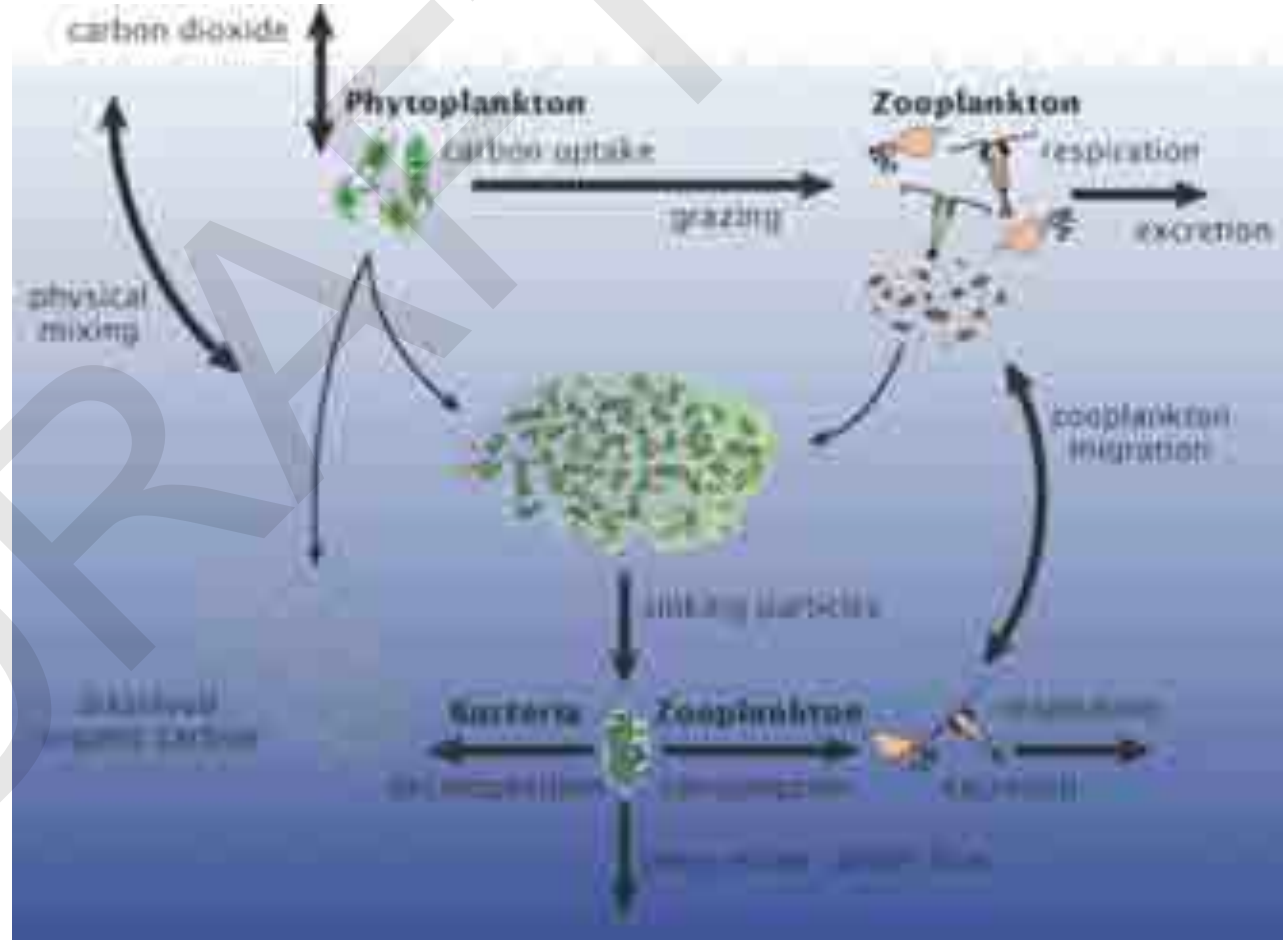
Marine organisms complete over one and a half times the photosynthesis of land plants.

Oceanographers estimate that phytoplankton form 85% of the carbon found in the ocean.



Plankton and the carbon cycle
By NASA
https://earthobservatory.nasa.gov/Features/Phytoplankton

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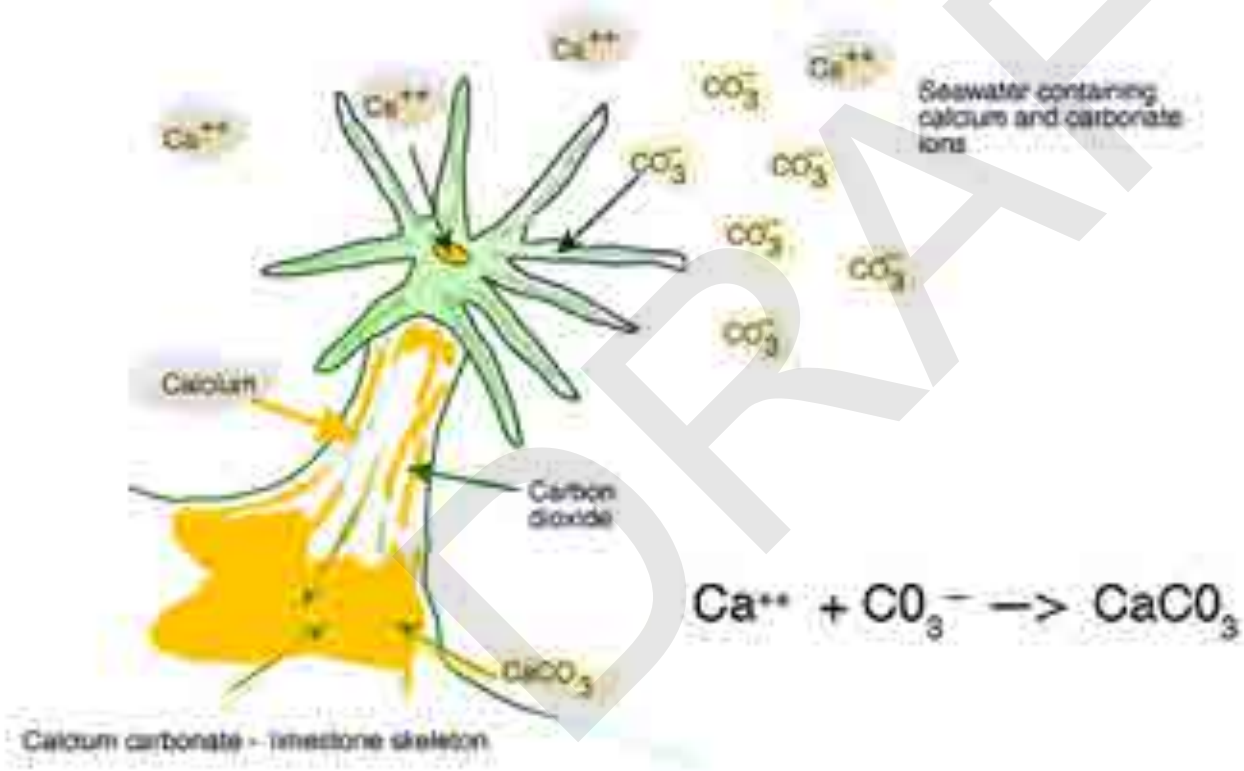
Carbon dioxide dissolves in rain and diffuses into seawater.

This dissolved carbon dioxide forms bicarbonate ions that can combine with calcium to form calcium carbonate. Many marine animals especially the ones with shells absorb carbon in this form.



$$Ca^{++} + C0_3^{-} \rightarrow CaC0_3$$

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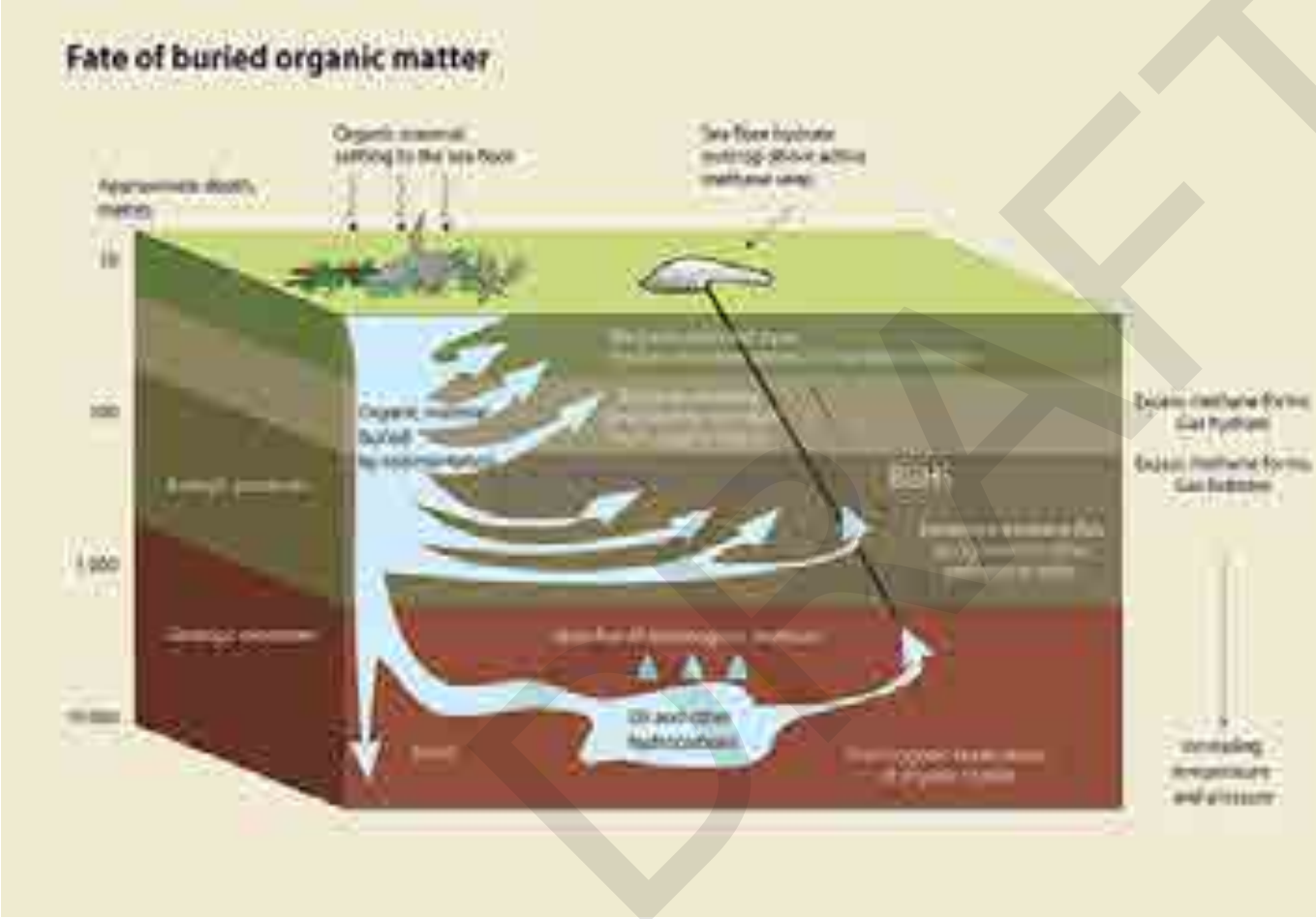
Large amounts of carbon containing compounds are also brought into the oceans as organic wastes that are washed down by the rivers.

River mouth Wide Bay region
Photo Bob Moffatt

Much of the dead and decaying organic matter of the sea is not decomposed and is buried in the sediments.



Ref:
https://en.wikipedia.org/wiki/Oceanic_carbon_cycle

Fate of organic buried matter
By GRID-Arendal - GRID-Arendal, Public Domain, https://en.wikipedia.org/w/index.php?curid=55925857

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Eventually these remains may form fossil fuels which humans can recover and burn.

This process releases carbon dioxide into the atmosphere.

Fuel pump
Photo Bob Moffatt

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The burning of fossil fuels by industry converts the carbon in the fossil fuel into carbon dioxide. Over 500 million tonnes of carbon dioxide are being added to the atmosphere each year.

Gladstone power house
Photo Bob Moffatt

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Vehicles also produce significant amounts of carbon pollution that's harmful to human health.

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Cars in a city

Union of concerned scientists https://www.google.com.au/imgres?imgurl=https://www.ucsusa.org

Forests that convert this carbon dioxide back into oxygen are also being removed at a disturbing rate.

Last batch of sawnwood from the peat forest in Indragiri Hulu, Sumatra, Indonesia.

By Aidenvironment, 2006 - flickr:Riau flickr user:Wakx, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=10605283

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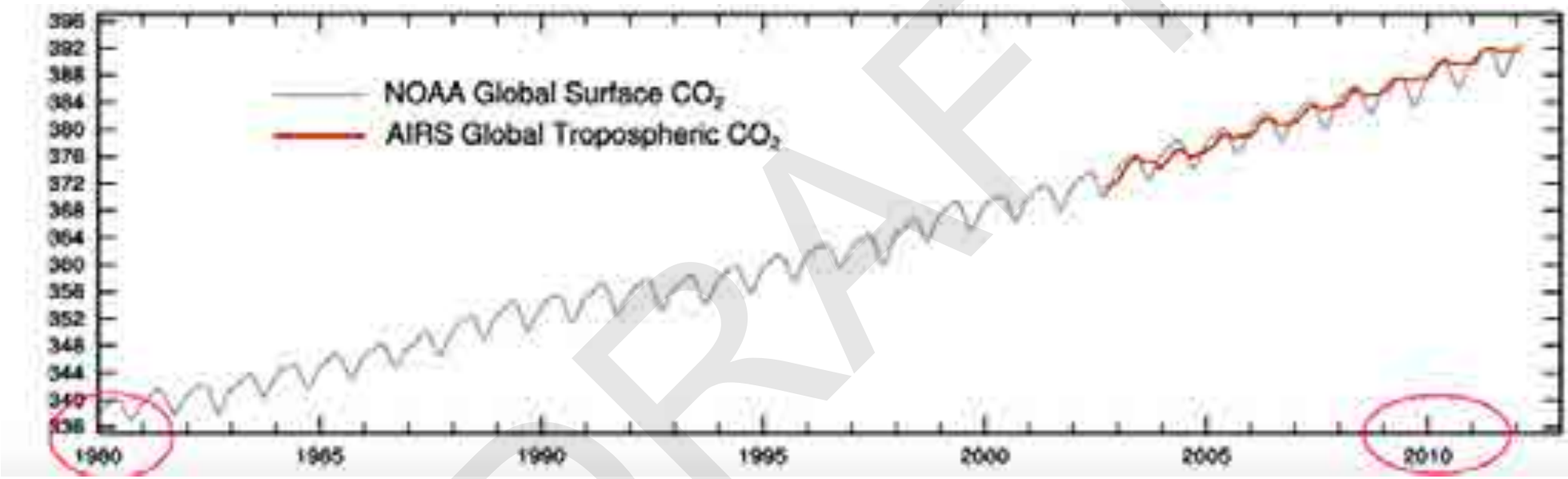
The end result is a build up of carbon dioxide in the atmosphere.



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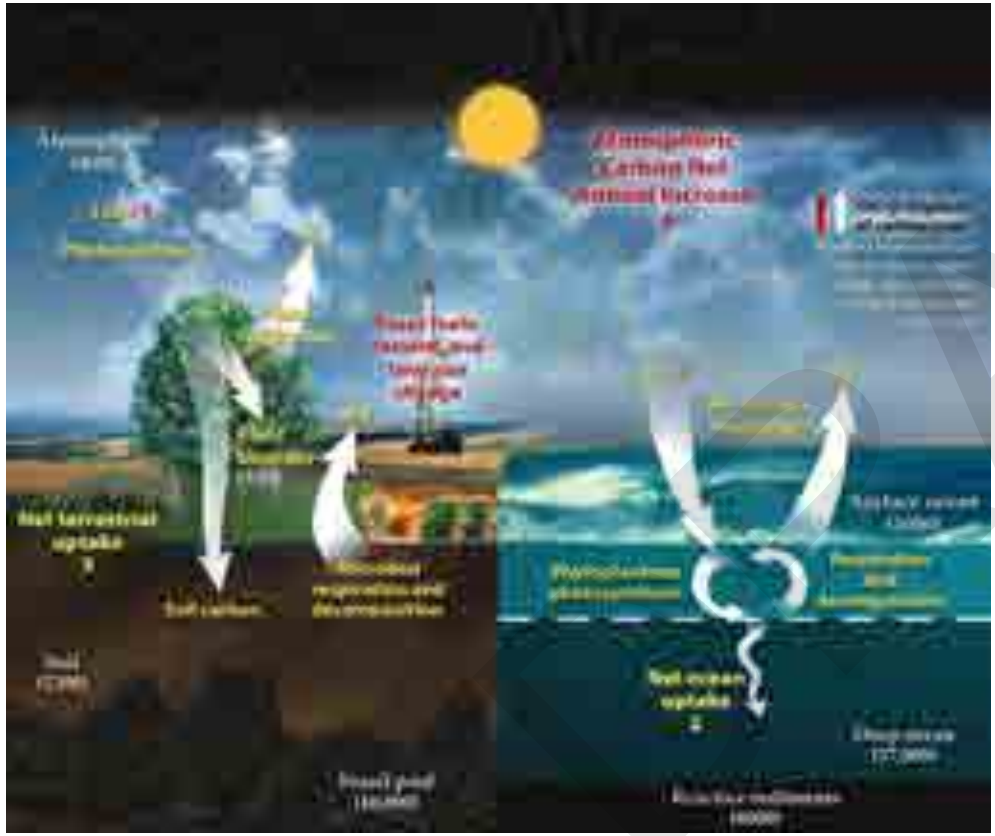
AIRS 2011 annual mean carbon dioxide concentration in the free troposphere

By Giorgiogp2 - w:File:AIRS Carbon Dioxide.png, GFDL, https://commons.wikimedia.org/w/index.php?curid=52468529

You can read more at wiki:

Search carbon cycle



By Diagram adapted from U.S. DOE, Biological and Environmental Research Information System. [Public domain], via Wikimedia Commons

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T004 Current driving forces

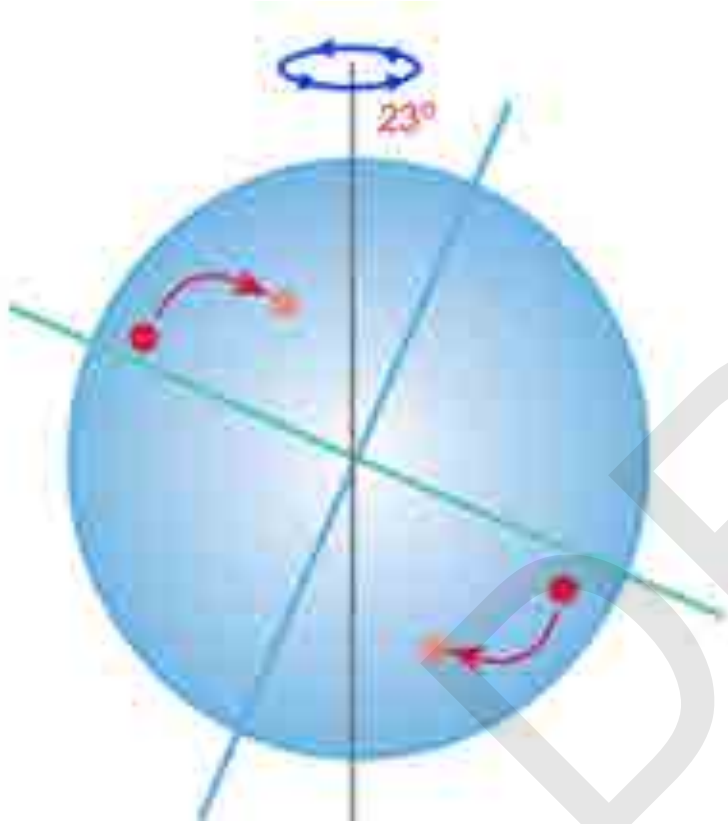

Illustration Bob Moffatt

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Wet Paper

Syllabus statement

The syllabus says ... you should be able to

describe how surface ocean currents are driven by wind, temperature and gravity.

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Describe - give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something.

Questions

1. Describe how the following drive ocean surface currents

A. Wind

B. Temperature

C. Gravity (tides)

2. List important Australian surface currents

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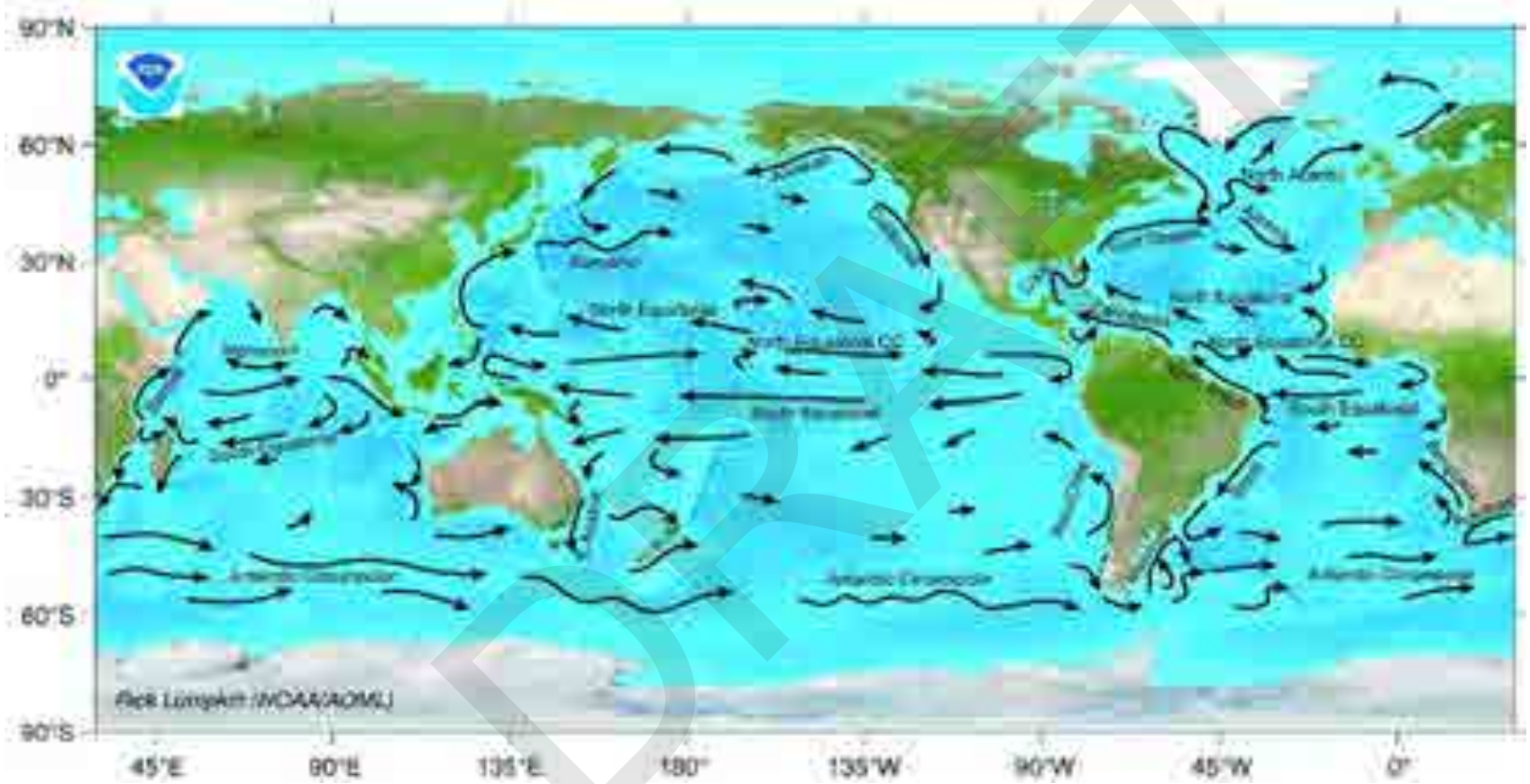
Definition

A surface ocean current is the movement of water on the surface of the ocean.



Ocean surface currents

By NOAA - here, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3918644

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Key ideas

- Ocean water circulates in currents.
- Surface currents are caused mainly by wind and affect the uppermost 10% of the ocean.
- Circulation of the other 90% of the ocean is driven by gravity, as dense water sinks and less dense water rises.
- Upwelling and downwelling describe the vertical movement of water masses.
- A force called the coriolis effect modifies the course of ocean currents.
- Ocean currents transfer heat from tropical to polar regions,
- Currents influence weather and climate and distribute nutrients and scatter organisms

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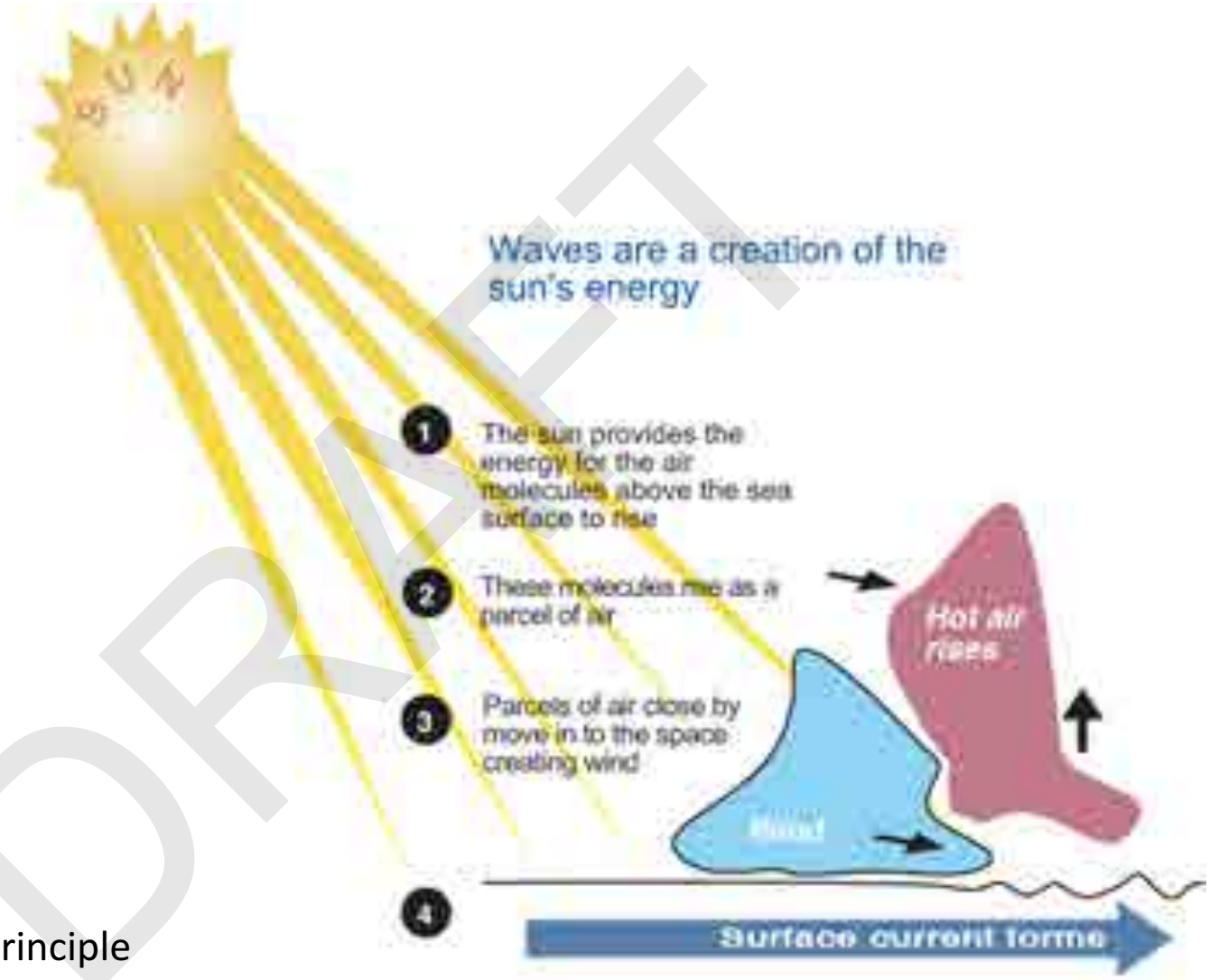
Wind

The sun heats the atmosphere, creating winds and moving the sea surface through friction.

This tends to drag the water surface along as the wind blows over it.



Wind and surface current principle

Illustration Bob Moffatt

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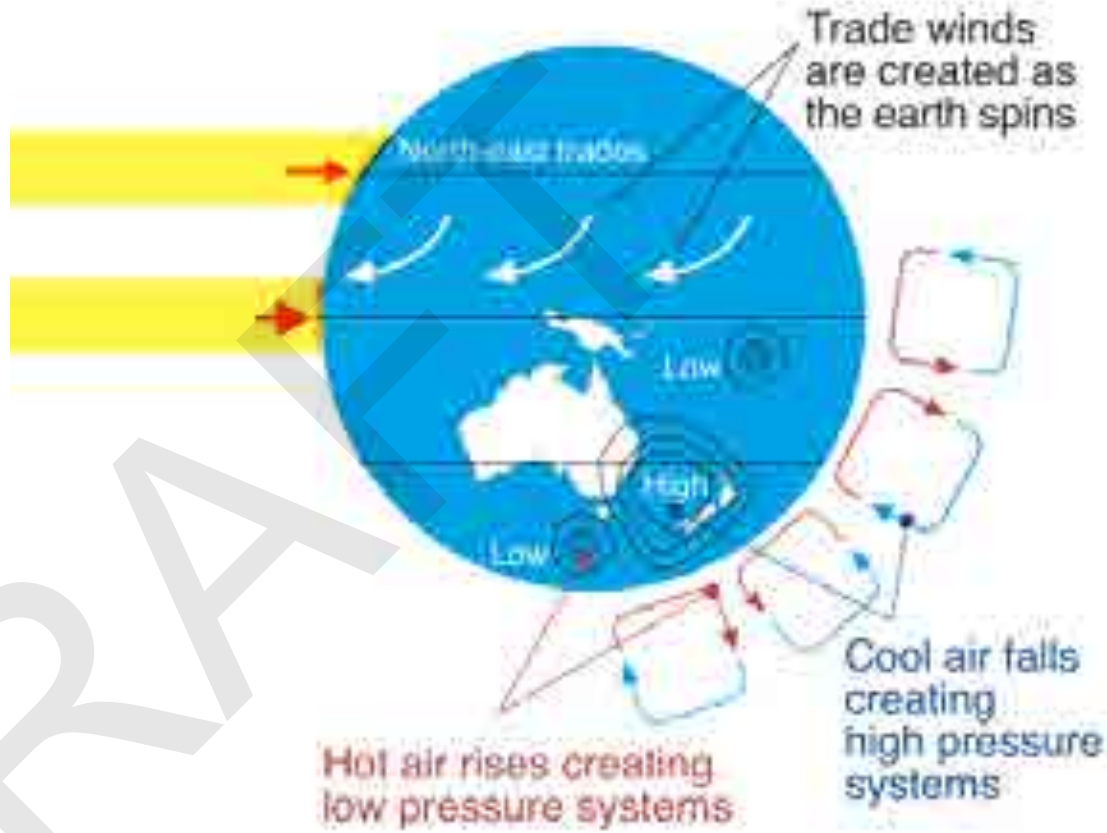
Wind patterns are caused by sun rays heating the earth unequally causing air to be heated to a higher temperature at the equator than at the poles.

This causes air at the equator to rise creating areas of low pressure.

When this rising hot air cools it falls, creating areas of high pressure.



Hadley cells and wind

Illustration Bob Moffatt

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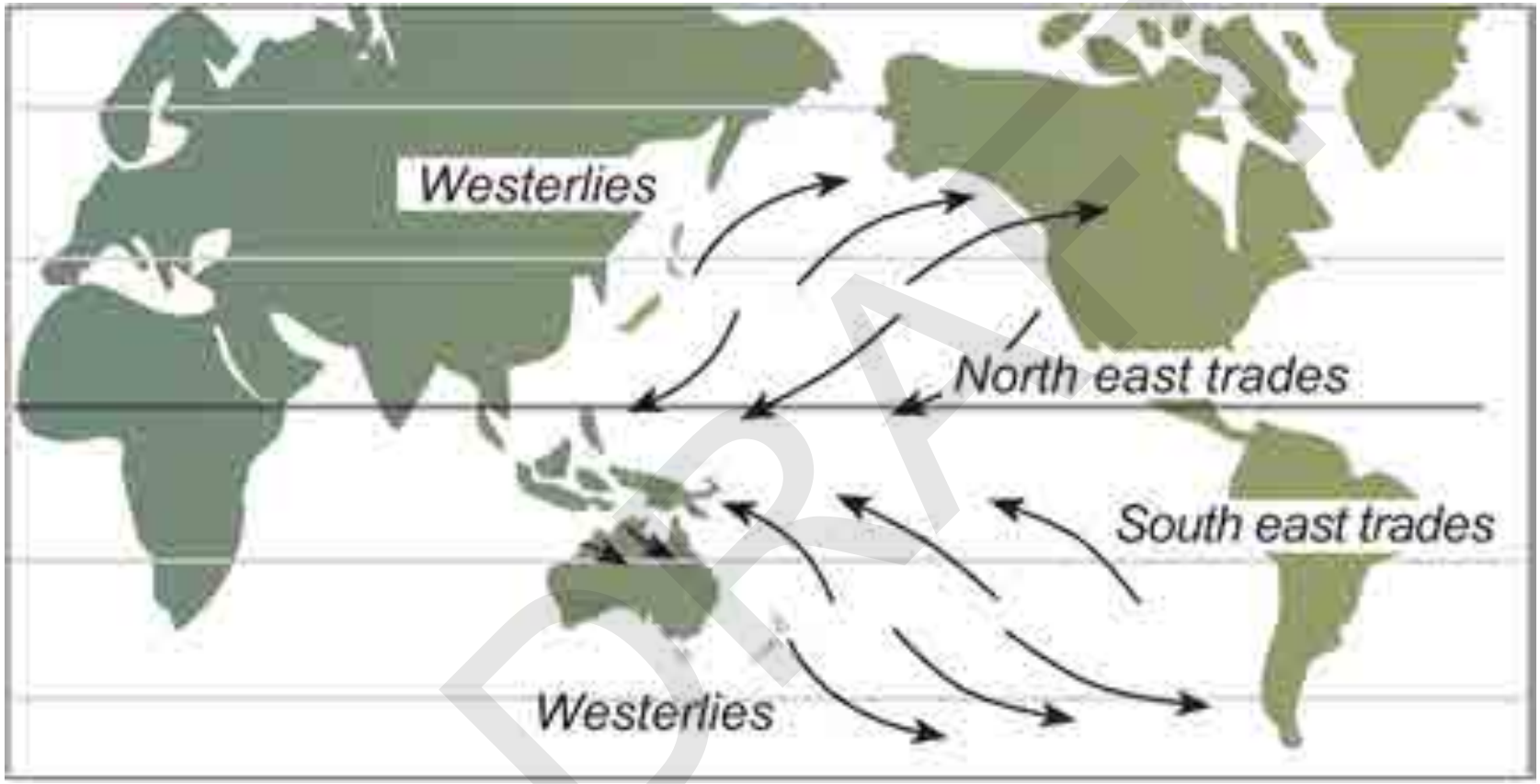
The spinning Earth causes these systems (called trade winds) to move in one prevailing direction, depending on their latitude.



Trade winds

Illustration Bob Moffatt

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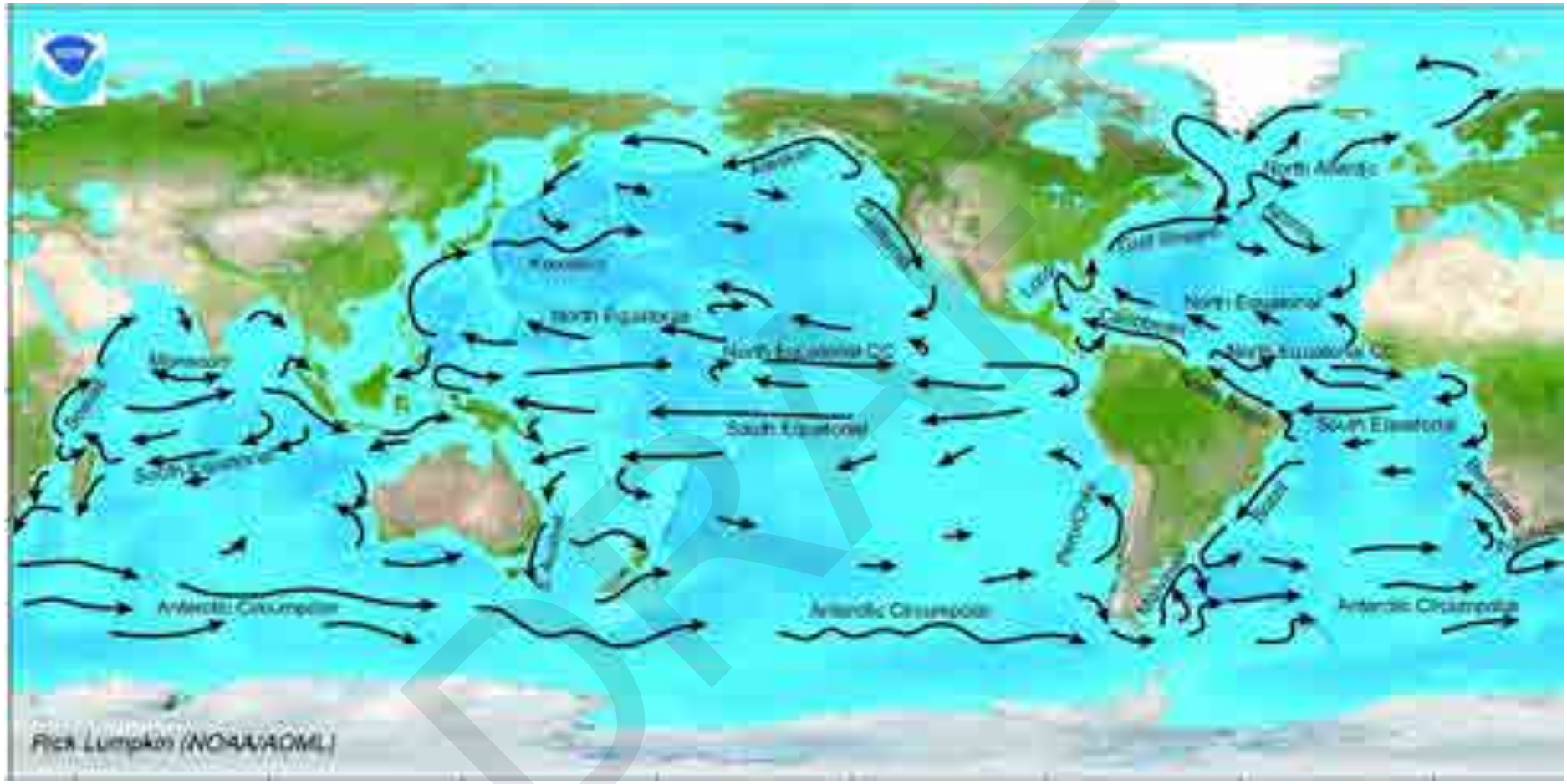
Trade winds generate the ocean surface currents.



Pacific Ocean currents

By NOAA (here) [Public domain], via Wikimedia Commons

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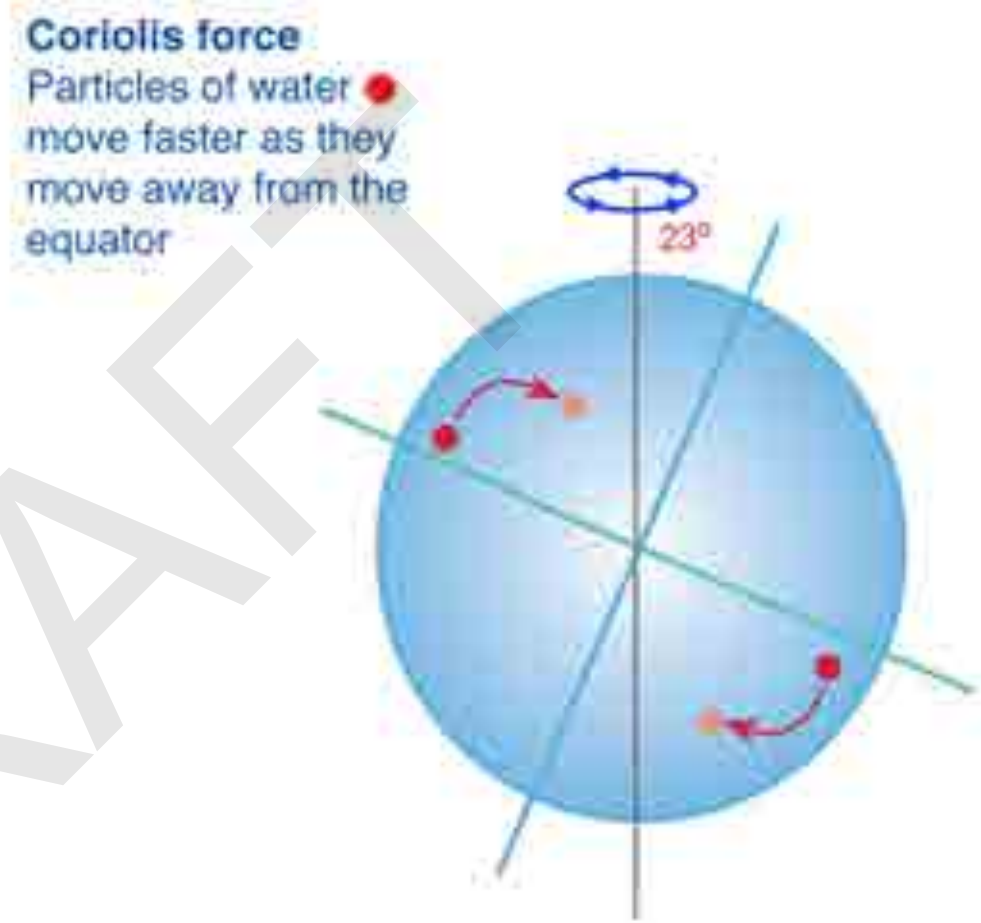
As the Earth spins, particles of water move faster as they moves away from the equator.

The force driving these particles faster is called the Coriolis force and is the apparent motion of freely moving objects as earth rotates beneath them.



Coriolis force
Illustration Bob Moffatt

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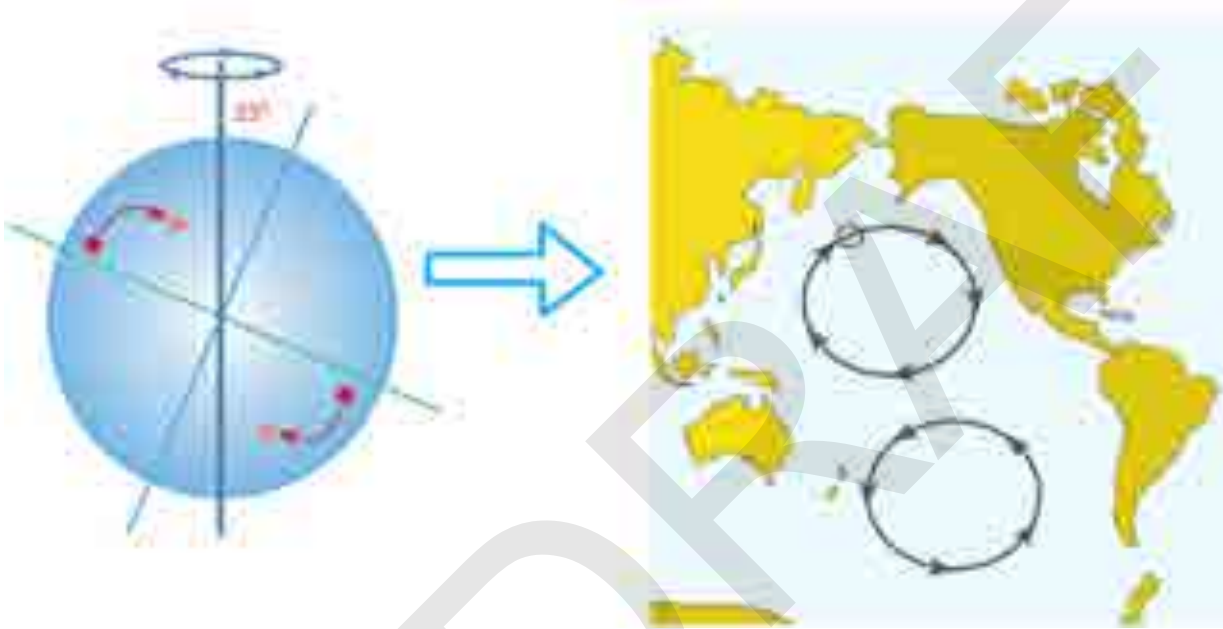
Coriolis forces cause ocean gyres. It is strongest near the poles, zero at the equator and makes storms swirl clockwise in the Southern hemisphere and counterclockwise in the Northern Hemisphere.



Coriolis force and effect

Illustration Bob Moffatt

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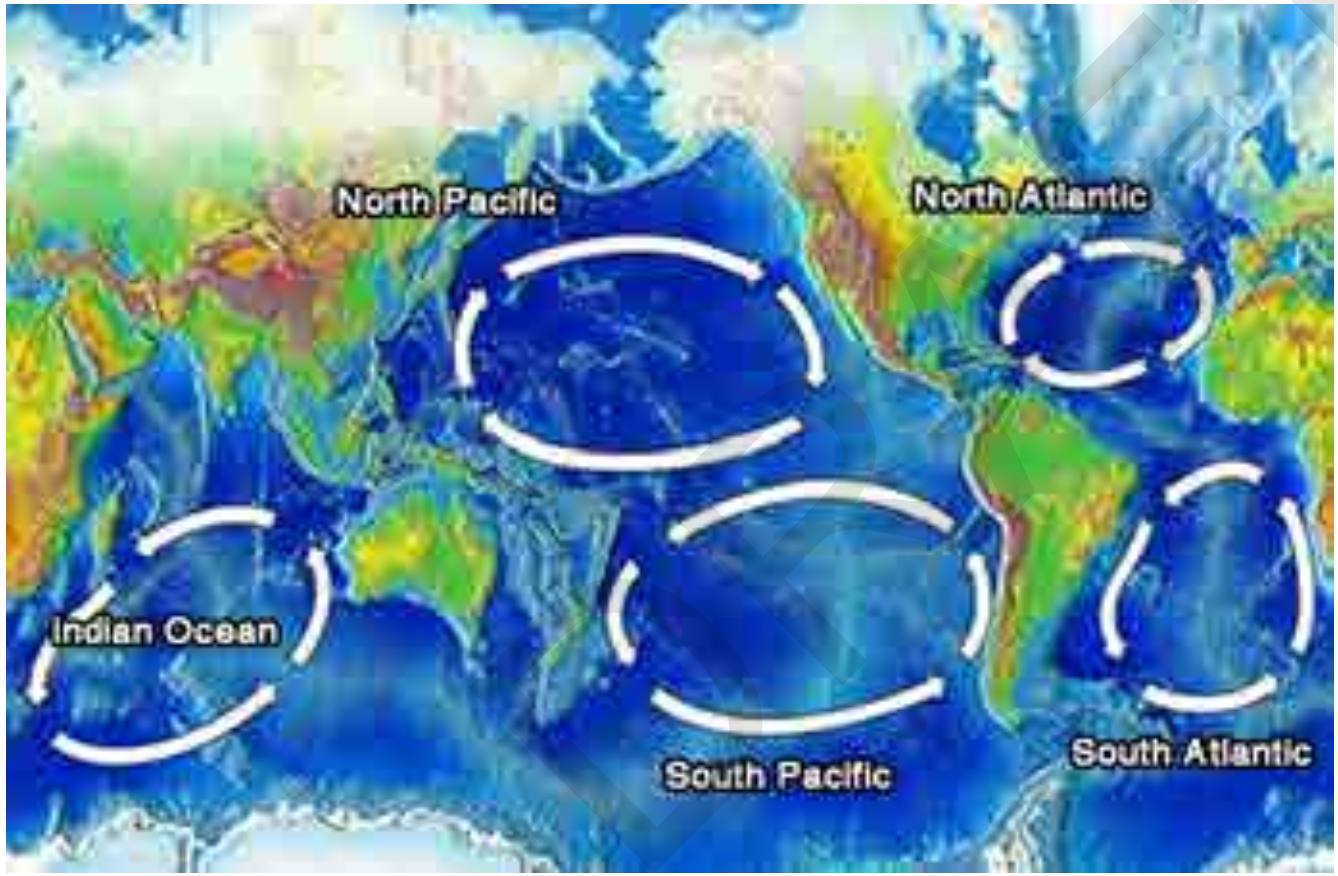
Major ocean-wide gyres the North Atlantic, South Atlantic, North Pacific, South Pacific, and Indian Ocean gyres. Each is flanked by a strong and narrow “western boundary current,” and a weak and broad “eastern boundary current”.

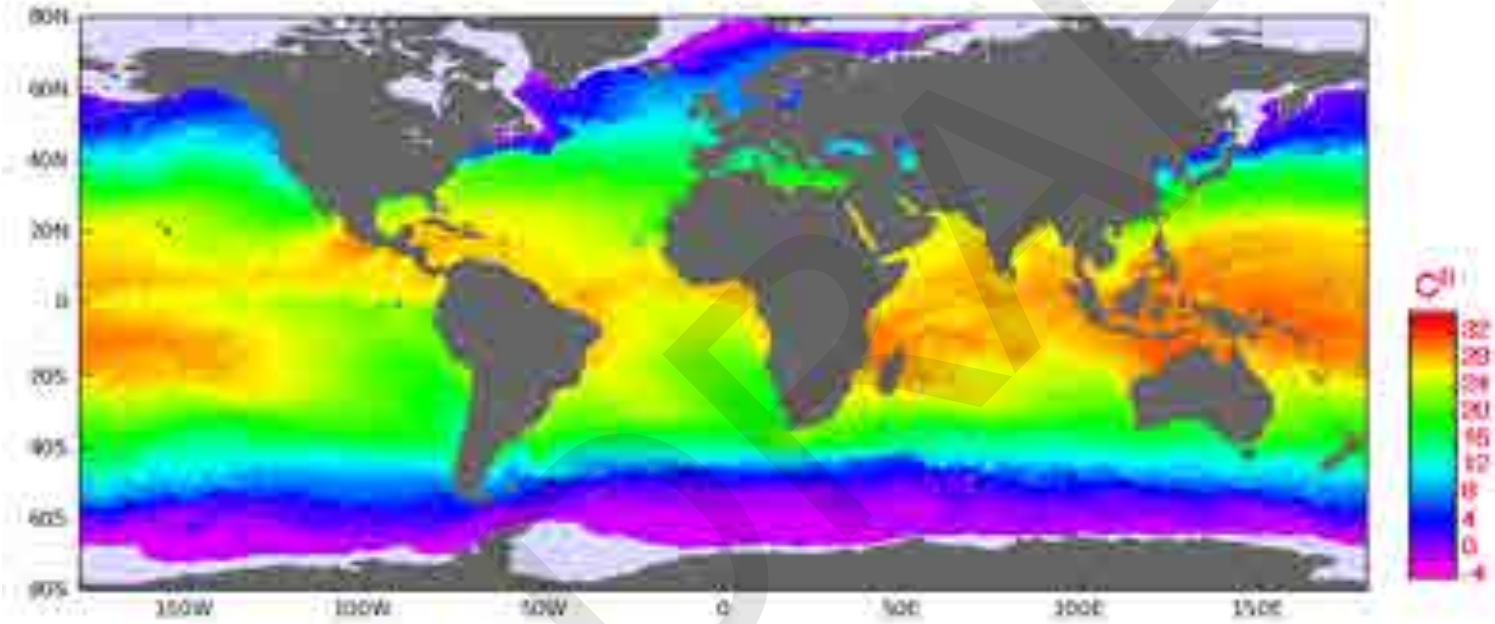


Five major ocean gyres

By NOAA (here, img) [Public domain], via Wikimedia Commons

Temperature and gravity

Heat from the sun on the ocean alters the density of the ocean surface water directly by changing its temperature and/or its salinity.



Sea surface temperatures NASA

By NASA Official website, [1]., Public Domain, https://commons.wikimedia.org/w/index.php?curid=49654946

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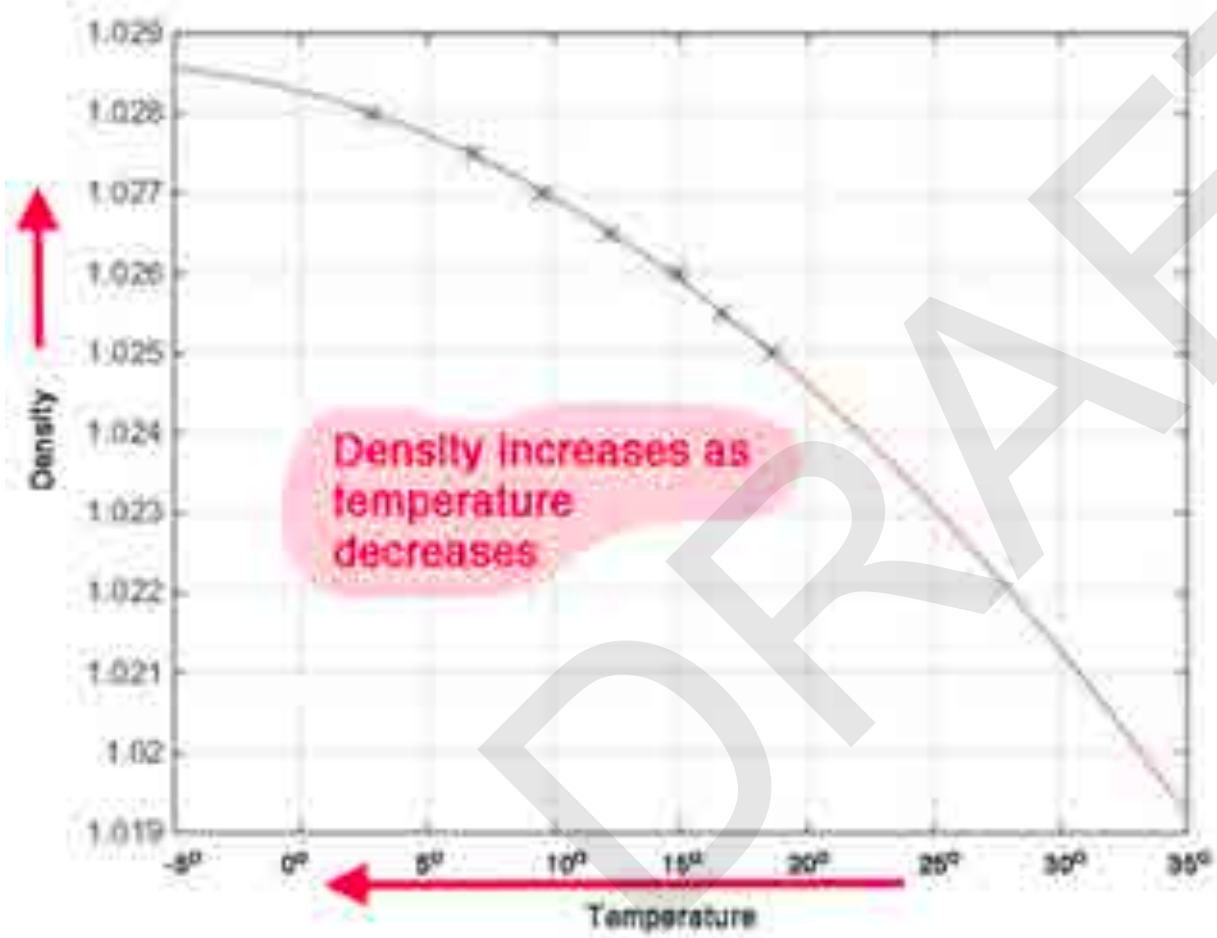
If water is cooled or becomes saltier through evaporation, it becomes denser.



Seawater density graph

Illustration Wet Paper

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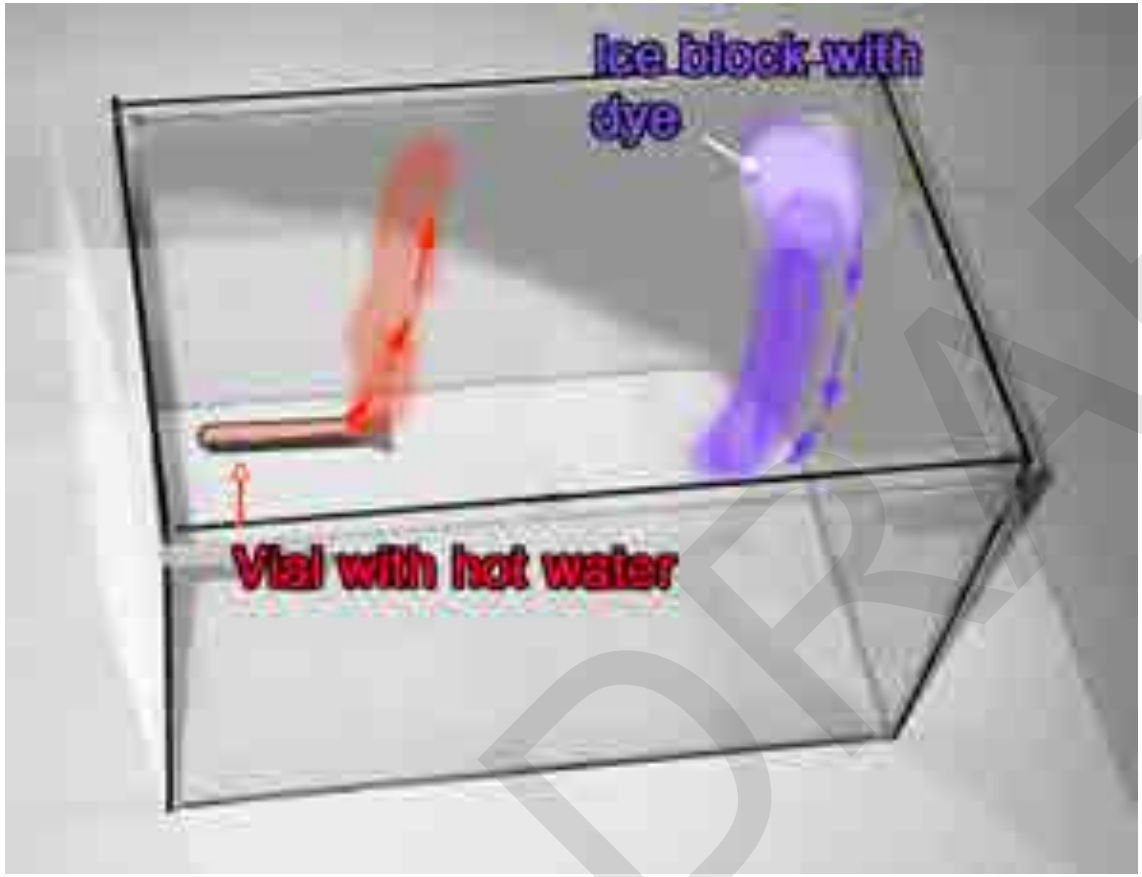
This can be shown in a simple demonstration using an aquarium filled with water, an ice block and a vial with warm water.



Convection experiment

Illustration Wet Paper

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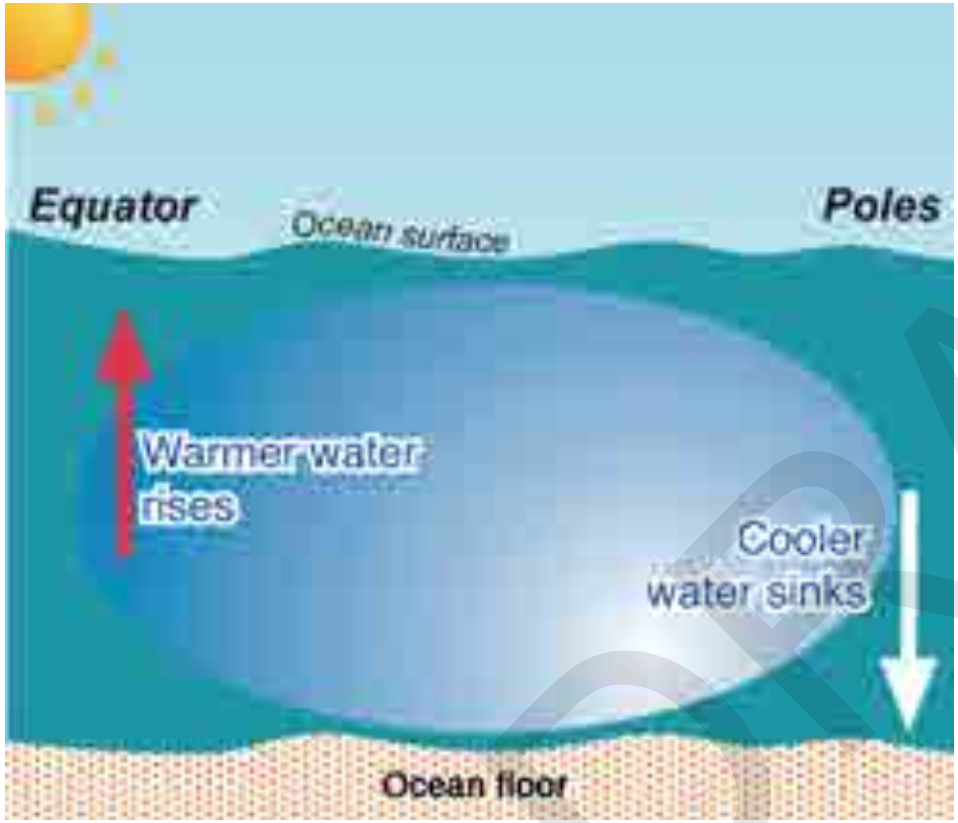
This can result in the water column becoming unstable, setting up density-dependent currents known as the thermohaline circulation.



Thermohaline circulation and gravity
Illustration Bob Moffatt

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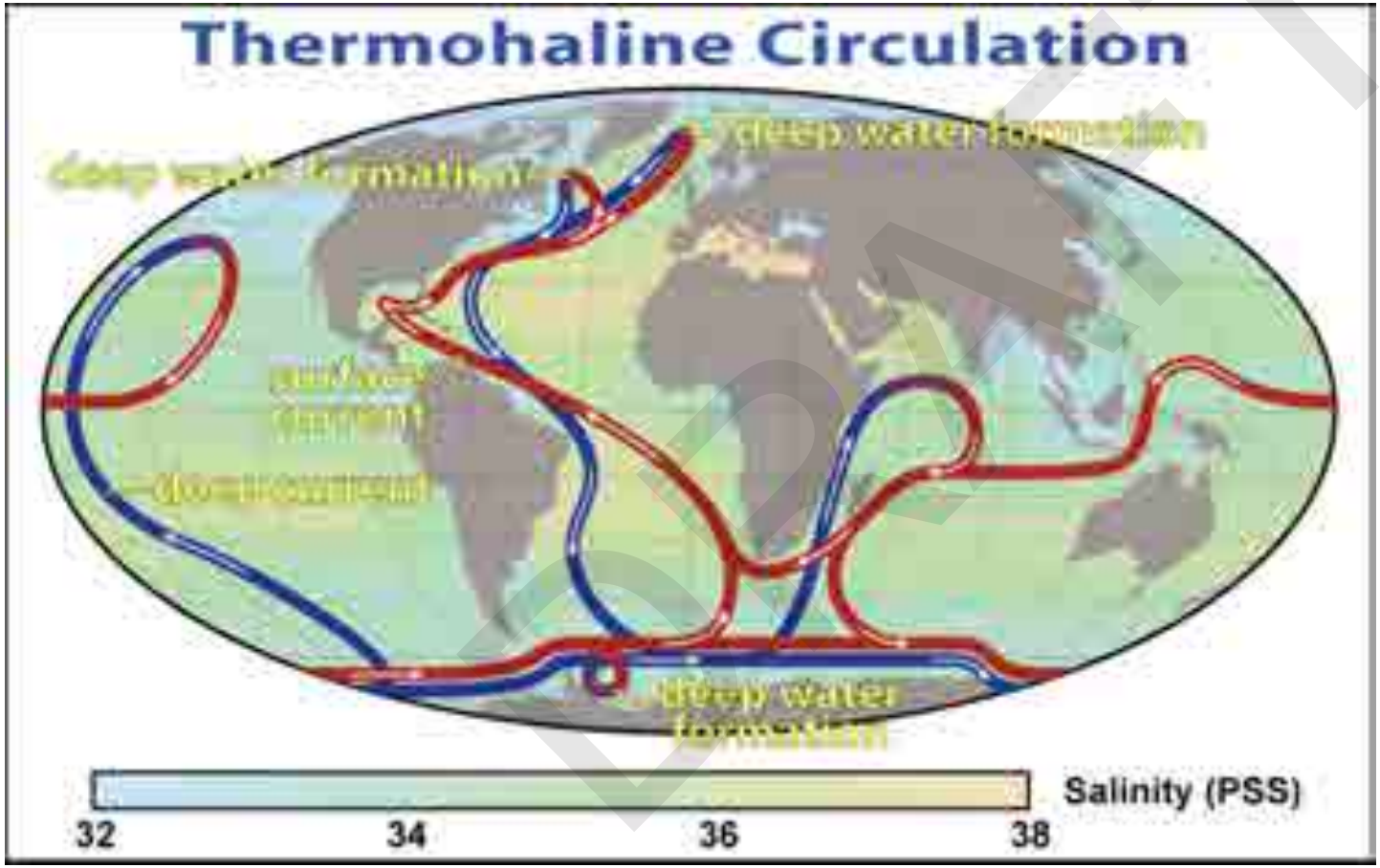
Thermohaline circulation, sometimes called the ocean conveyor belt, is a term that encompasses both horizontal and vertical movement of water masses.
It controls the vertical distribution of temperature and salinity in oceans.



Thermohaline circulation

By Robert Simmon, NASA. Minor modifications by Robert A. Rohde also released to the public domain (NASA Earth Observatory) [Public domain], via Wikimedia Commons

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Temperature, wind and gravity drive this conveyor belt in four ways.

a) The sun heats water north of the equator in the Atlantic Ocean and drives it from the Gulf Stream north heats the atmosphere in the cold northern latitudes. This loss of heat to the atmosphere makes the water cooler and denser.
b) Gravity then causes it to sink to the bottom of the ocean. As more warm water is transported north, more cooler water sinks and pushes this water along the ocean floor.

Ocean current conveyor belt a and b

Illustration Bob Moffatt

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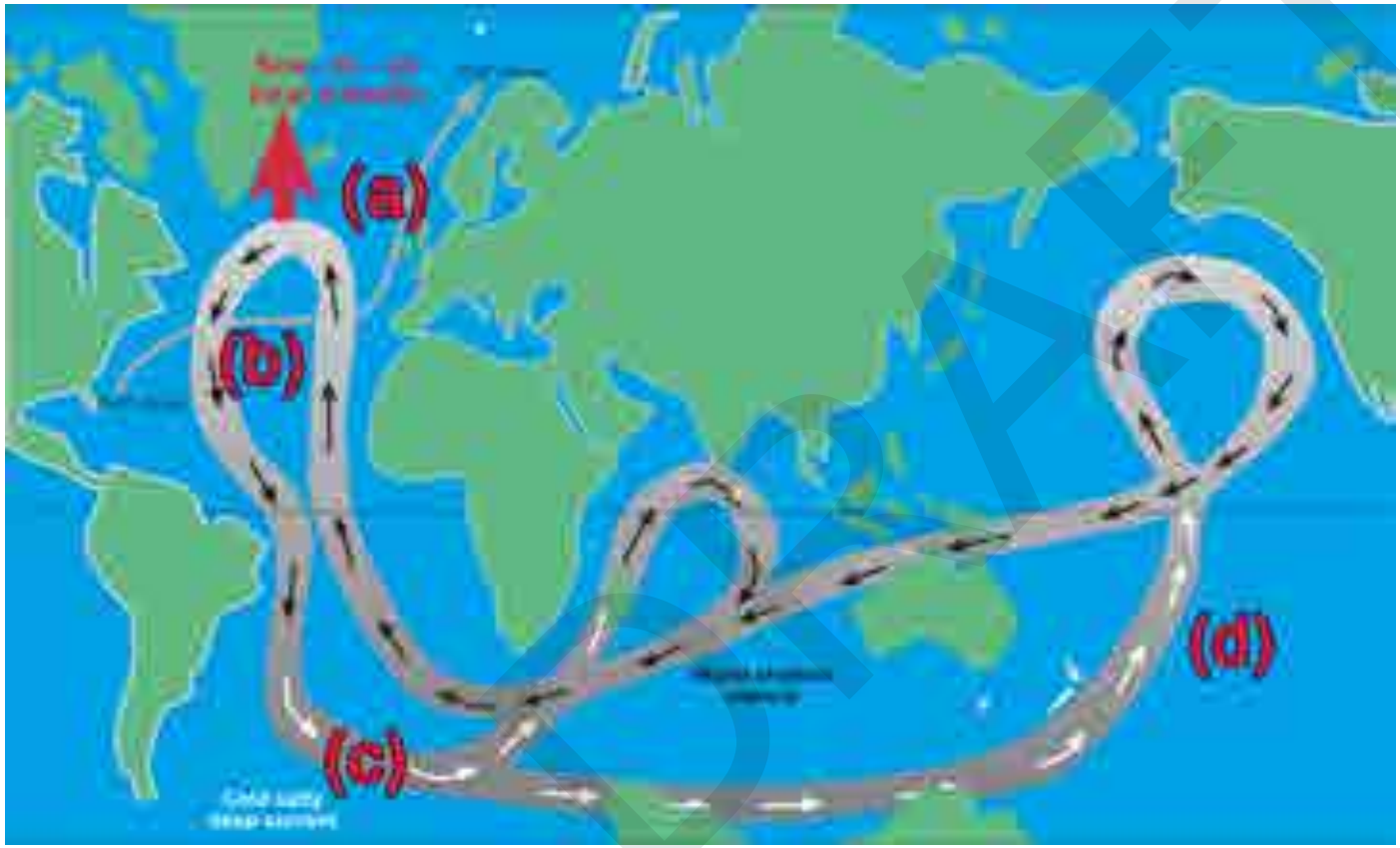
c) This cold bottom water flows south of the equator all the way down to Antarctica.
d) Eventually, the cold bottom waters returns to the surface through mixing and wind-driven upwelling, continuing the conveyor belt that encircles the globe.



Ocean current conveyor belt
Illustration Bob Moffatt

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Tidal currents

The current when the tide comes in is called a flood current and an ebb current when the tide goes out.

Tidal currents (NOAA)

https://oceanservice.noaa.gov/education/tutorial_currents/02tidal1.html

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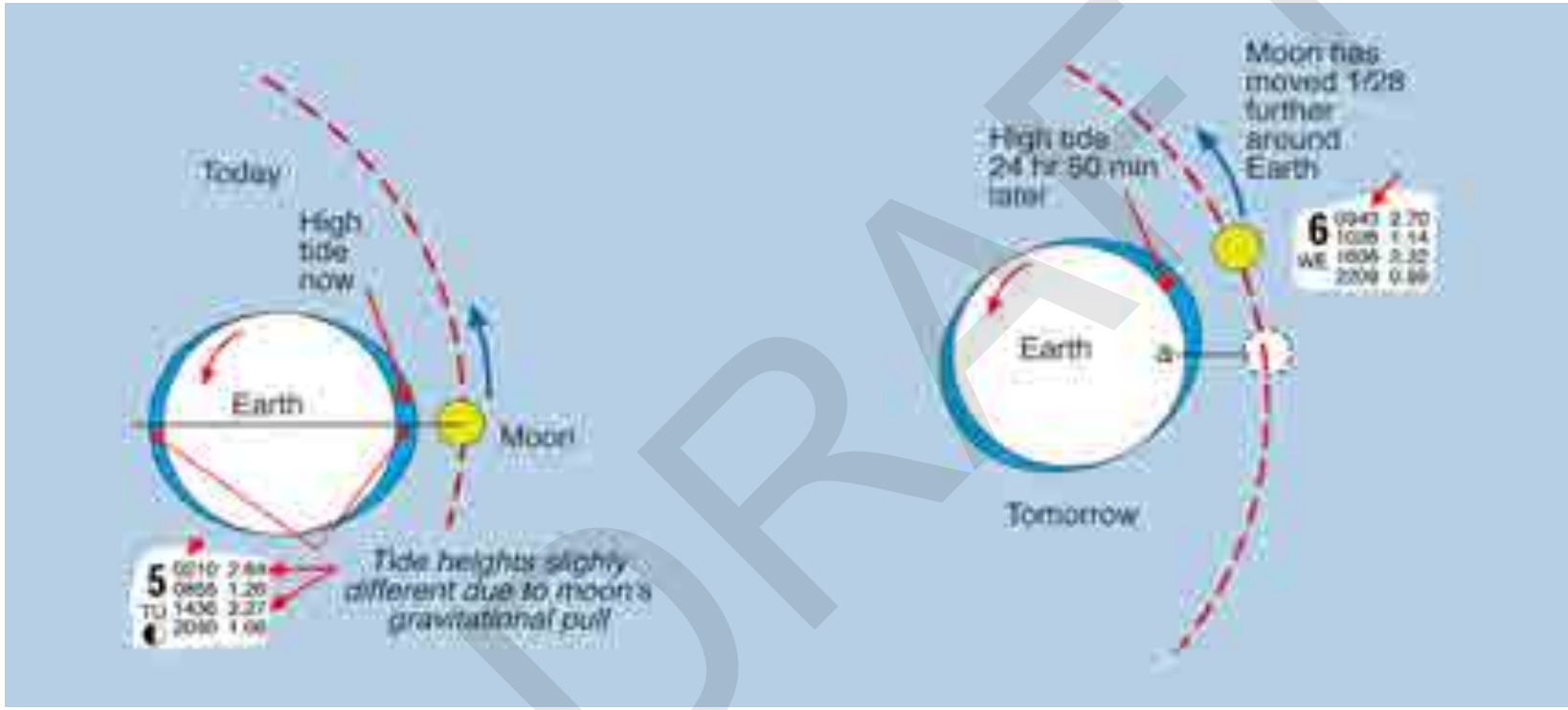
Daily tides

These are caused by the gravitational attraction of the moon to the Earth. One tide is higher than the other because of the difference in attraction.



Daily tides

Illustration Bob Moffatt

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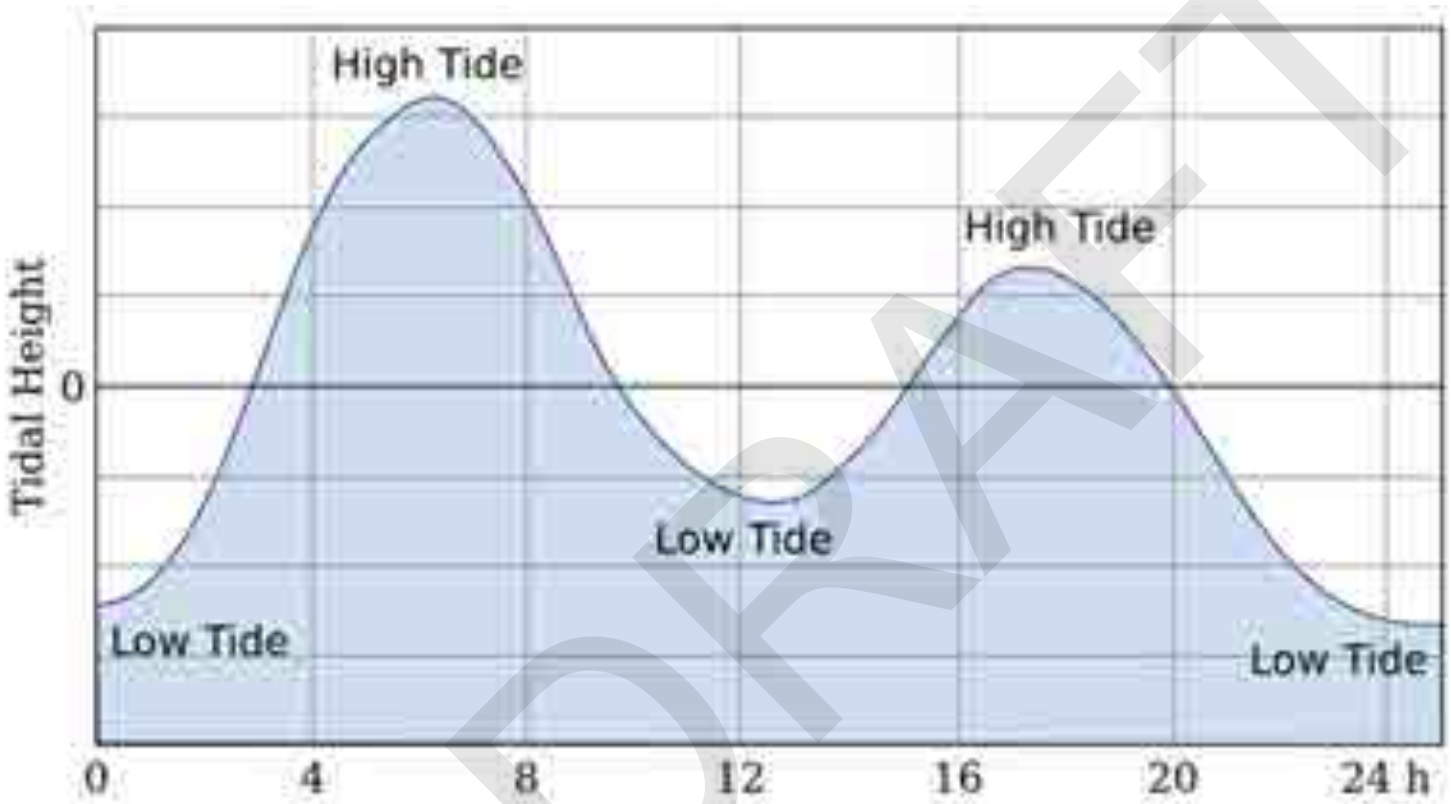
These can be shown in a graph.



Mixed semidiurnal tide

Graph by Diederik Willemsen

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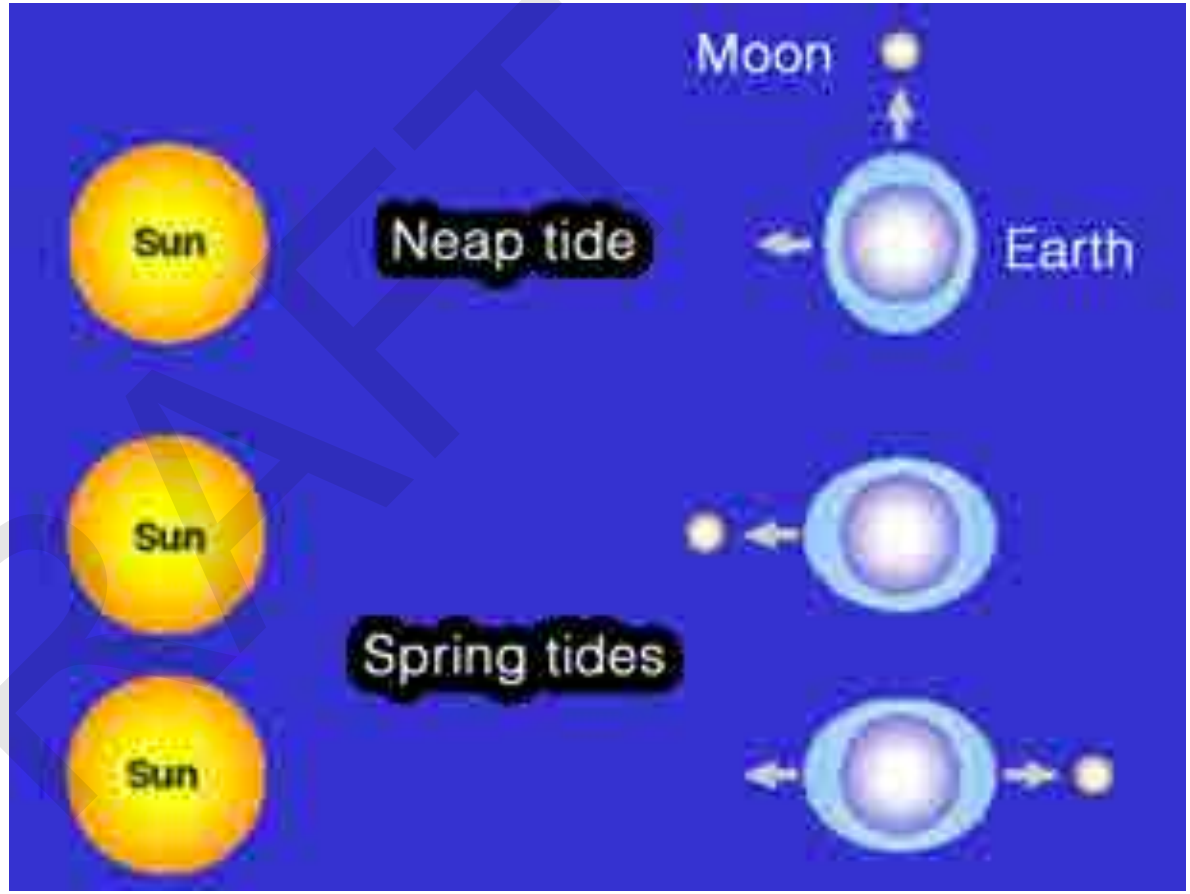
Spring tides occur where the gravitational pull of the Sun and the Moon are combined and the tides are at their highest.

Neap tides occur during a first-quarter Moon and again at the last quarter Moon phase, the Sun is at right angles to the Moon.



Spring and neap tides
Illustration Bob Moffatt

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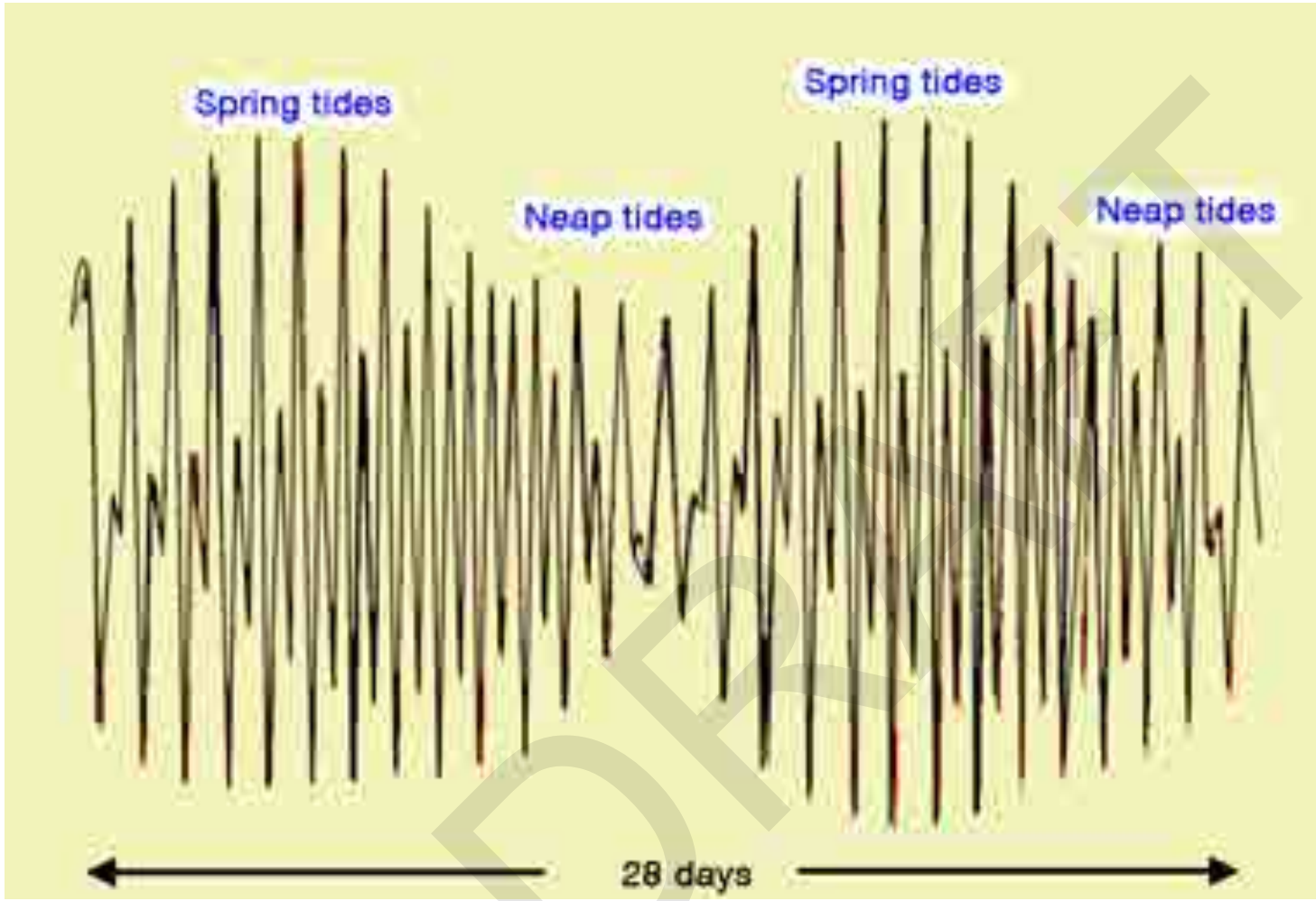

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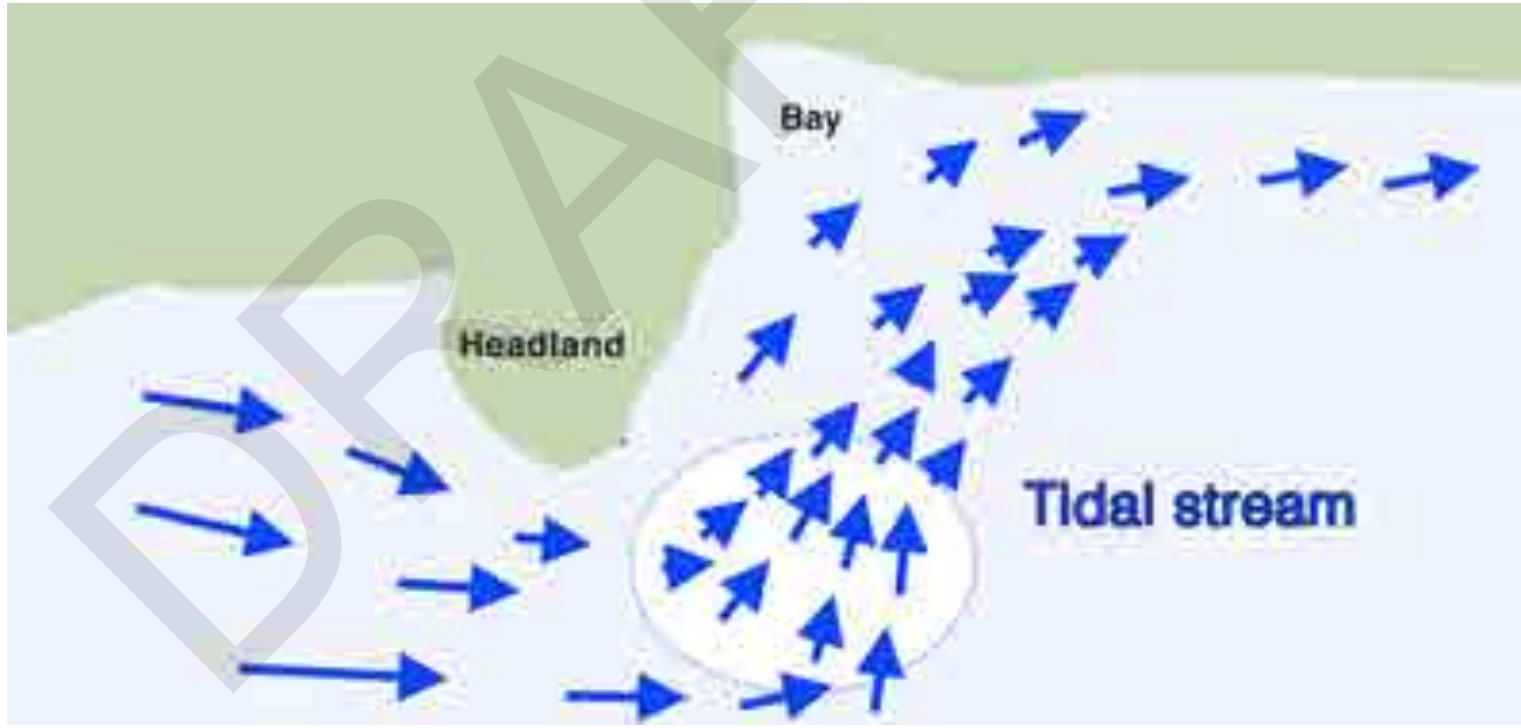
Spring and neap tides

Illustration Bob Moffatt

Strong tidal currents can form when large rises and falls occur in tide height in narrow channels or around headlands.

This current can be very strong when water flows through a narrow channel or headland.



Tidal stream
Illustration Bob Moffatt

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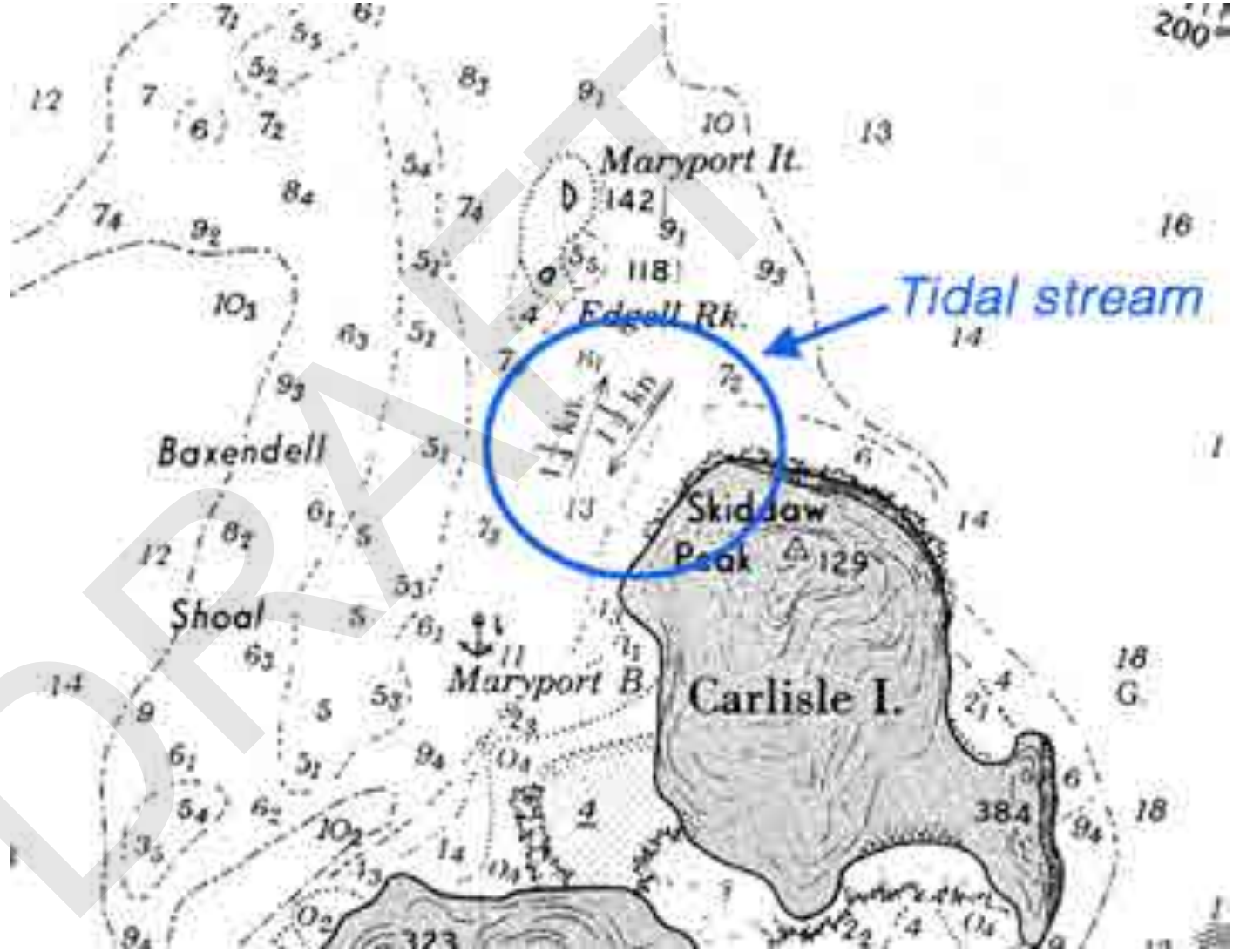
These are usually well marked on local charts, which also show the speed of the current.

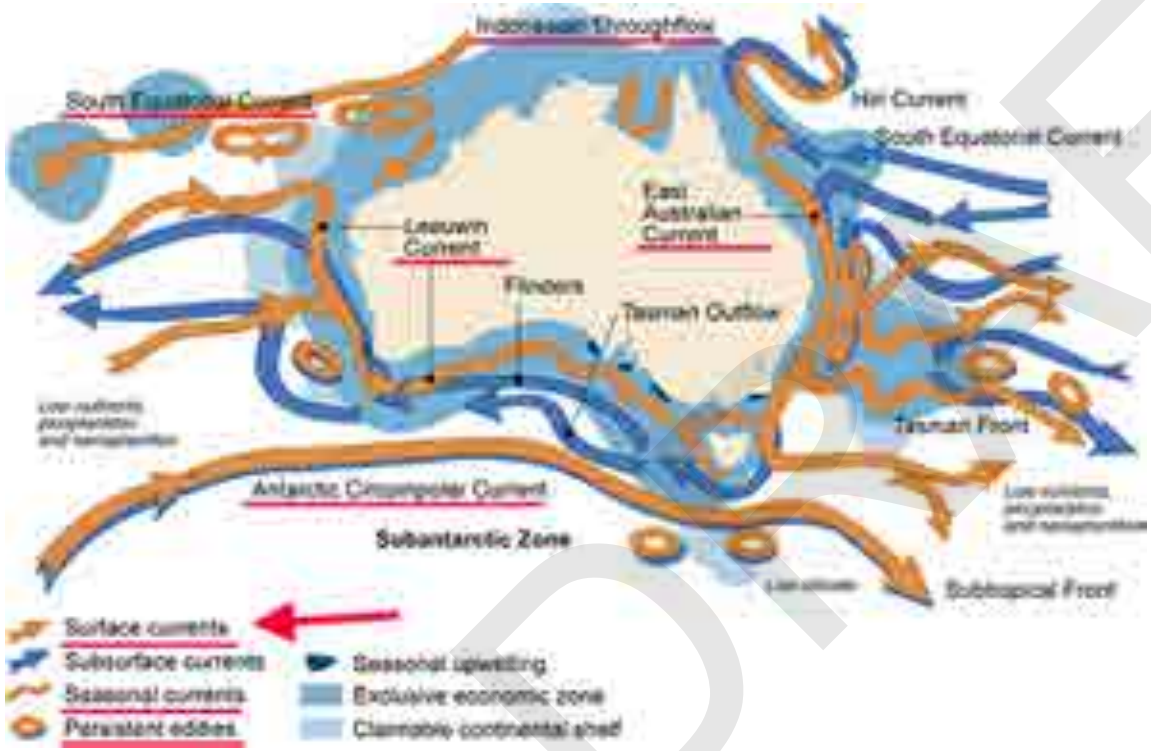


Tidal stream

Illustration Hydrographer for the Navy

Important surface currents around Australia

Important surface ocean currents around Australia are the Antarctic Circumpolar Current, Leeuwin, East Australian, The Indonesian throughflow



Australian ocean currents

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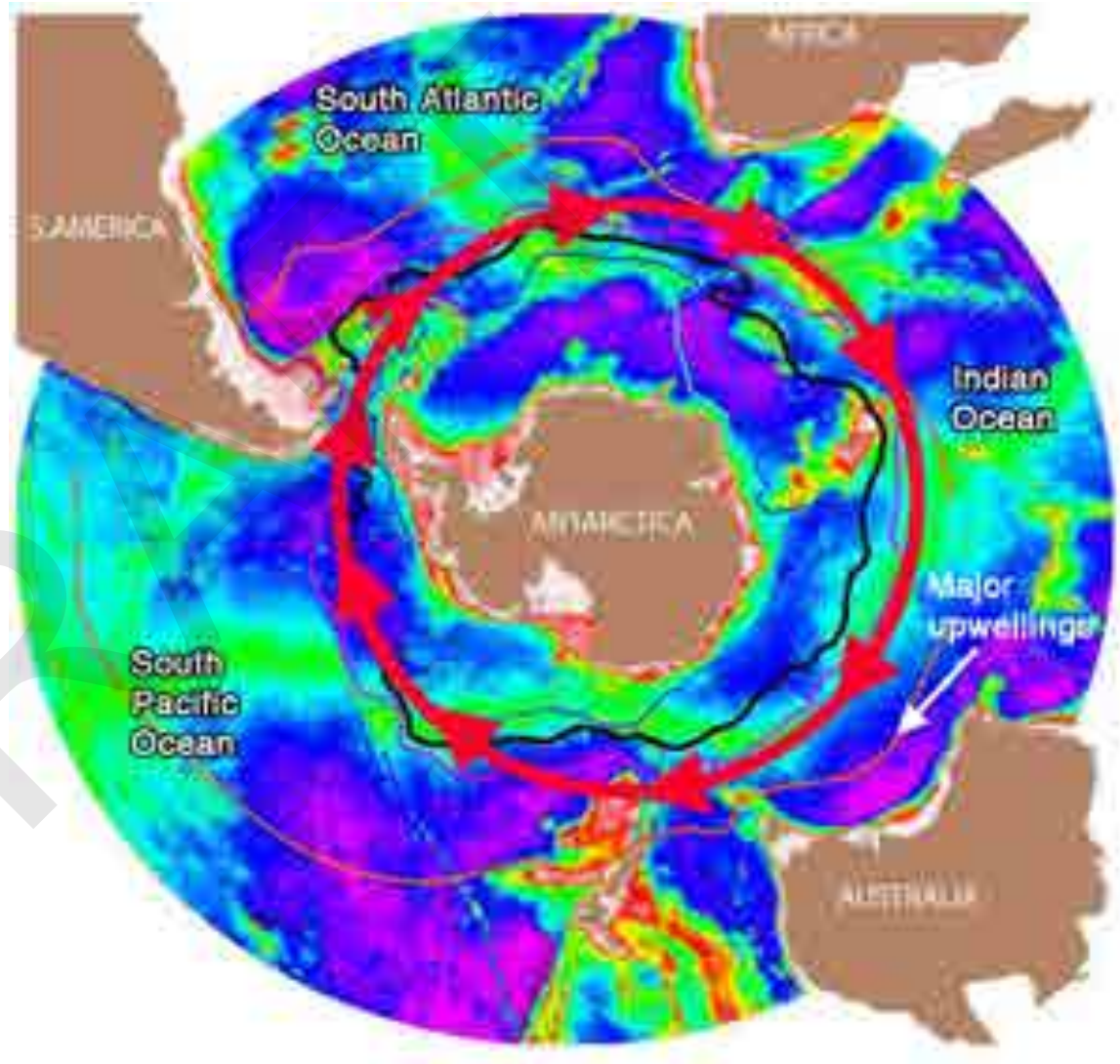
The Antarctic Circumpolar Current

This current is considered the powerhouse for global climate. It connects the Atlantic, Pacific and Indian Oceans in an eastward flow and features a region of high ocean nutrient production south of Australia.



Antarctic Circumpolar Current

By NASA (NASA) [Public domain], via Wikimedia Commons

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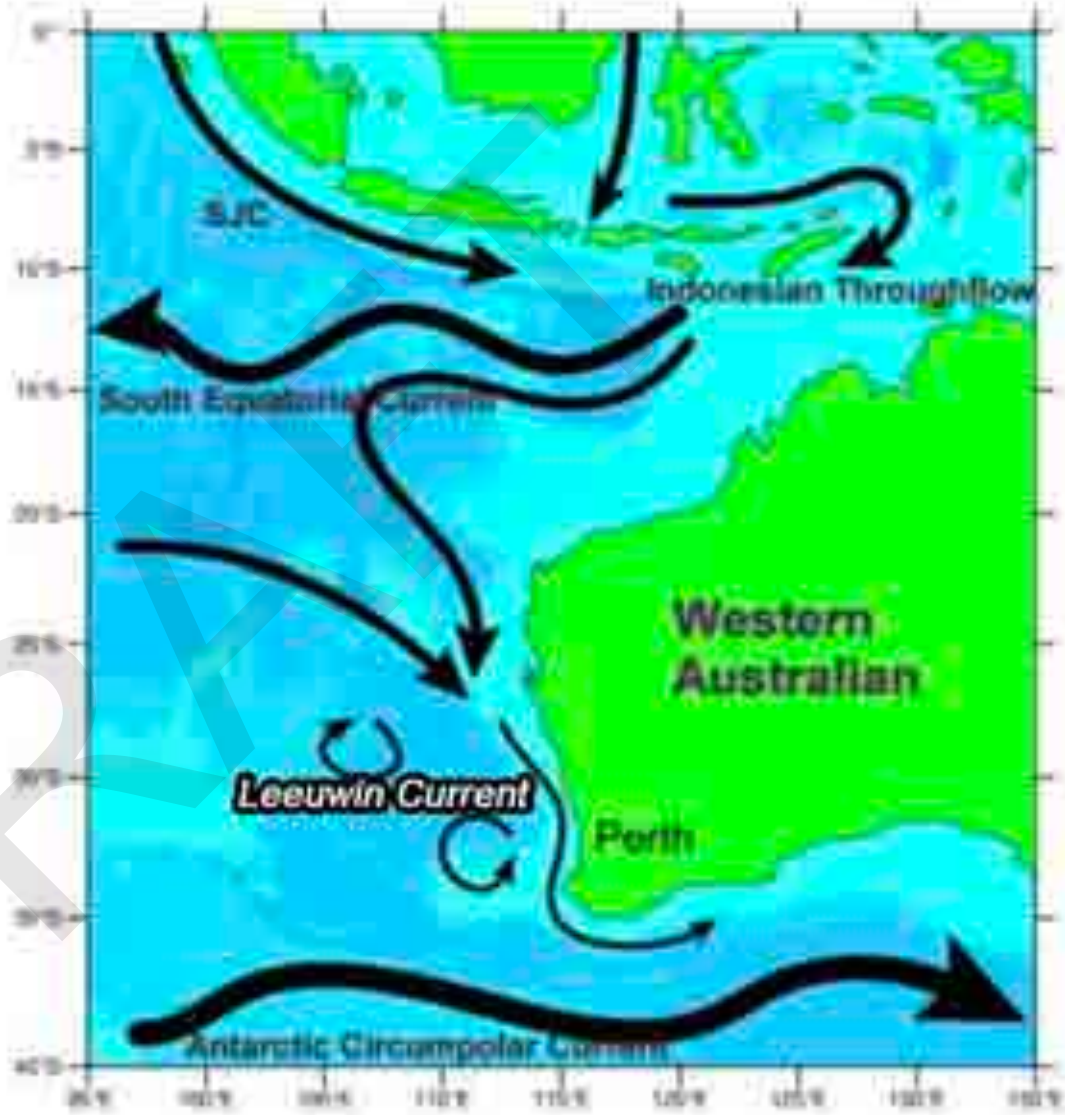
The Leeuwin Current

This current exerts a major influence on the distribution of marine life and Western Australia's weather.
It forms near the North West Shelf on Australia's west coast and travels south into a series of eddies finishing in the Tasman Sea.



Leeuwin Current

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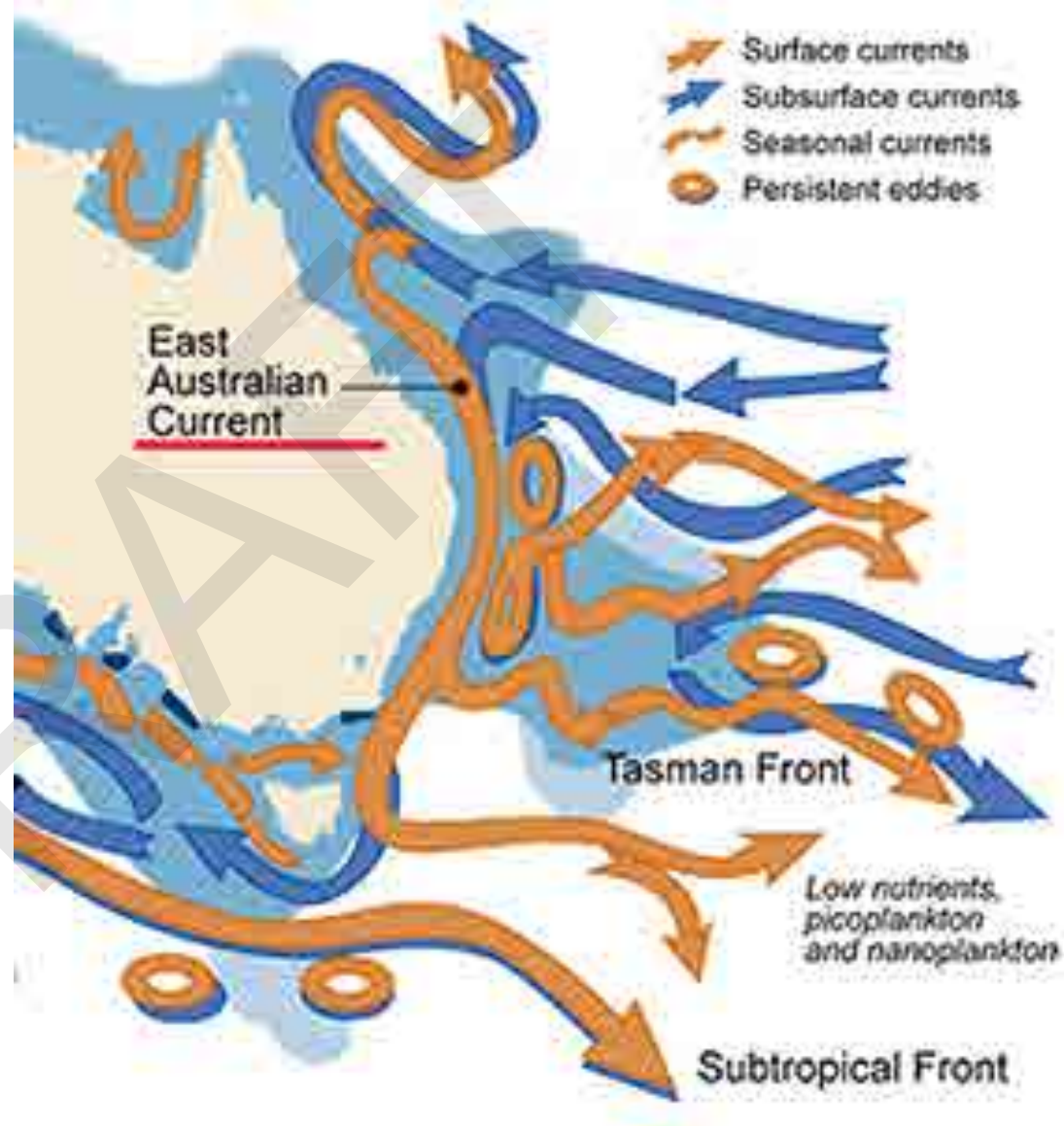
The East Australian Current

This current flows south along the east coast of Australia from near Queensland's Fraser Island to Tasmania.



East Australian Current

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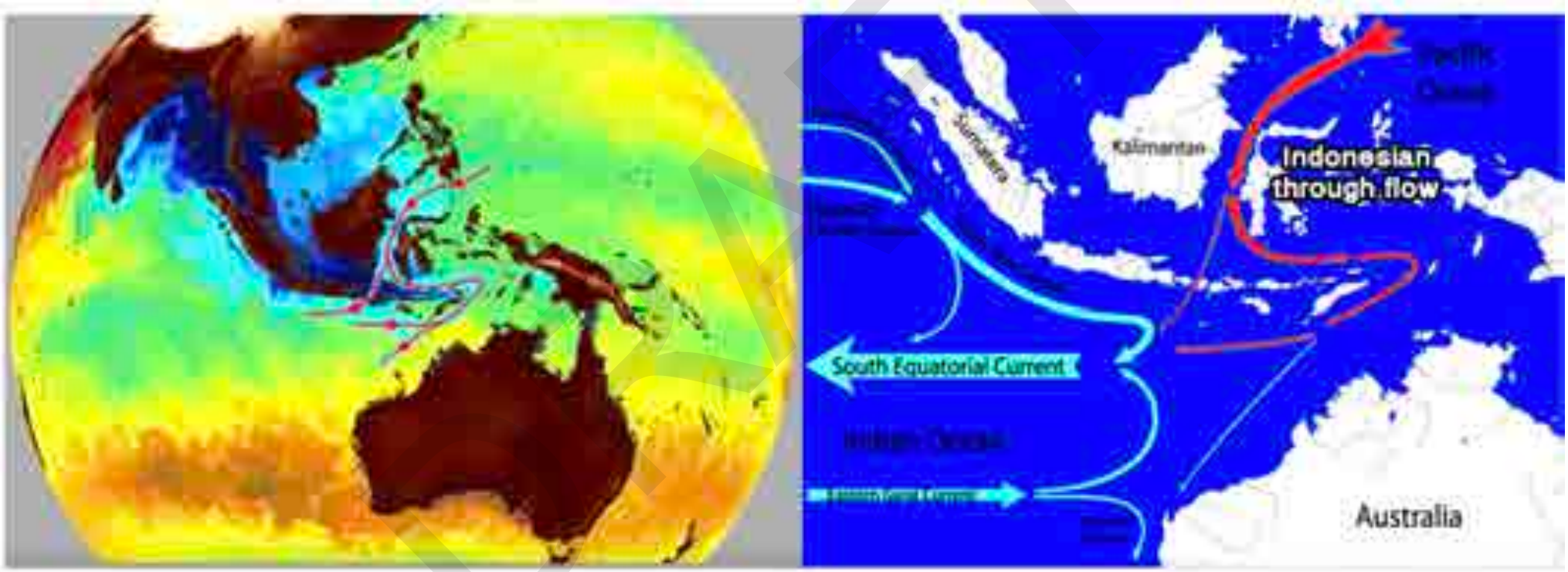
Indonesian throughflow

This is a system of currents that carries water westward from the Pacific to the Indian Ocean through the deep passages and straits of the Indonesian Archipelago. Warm tropical water influences the character of the Leeuwin Current.



Indonesian through flow

Left https://www.youtube.com/watch?v=ufw8w-pbtpg. By ehackert [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY-SA 4.0-3.0-2.5-2.0-1.0 (https://creativecommons.org/licenses/by-sa/4.0-3.0-2.5-2.0-1.0)], from Wikimedia Commons. Right Adapted from CSIRO Commonwealth of Australia

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T005 Ocean water, heat and nutrient distribution

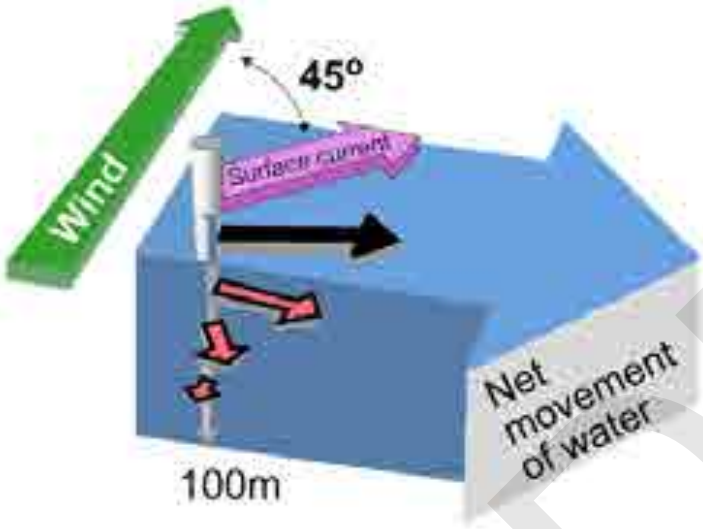

Illustration Bob Moffatt

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Syllabus statement

The syllabus says ... you should be able to describe

how water, heat and nutrients are distributed across coastal regions and global ocean basins (e.g. upwelling and downwelling, Ekman spiral, El Niño and La Nina events and Langmuir circulation.

Describe - give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something.

DRAFT

Question

Give an account of how water, heat and nutrients are distributed across coastal and ocean basins with specific reference to

a. Ekman spiral, upwellings and downwellings

b. El Niño and La Nina events

c. Langmuir circulation

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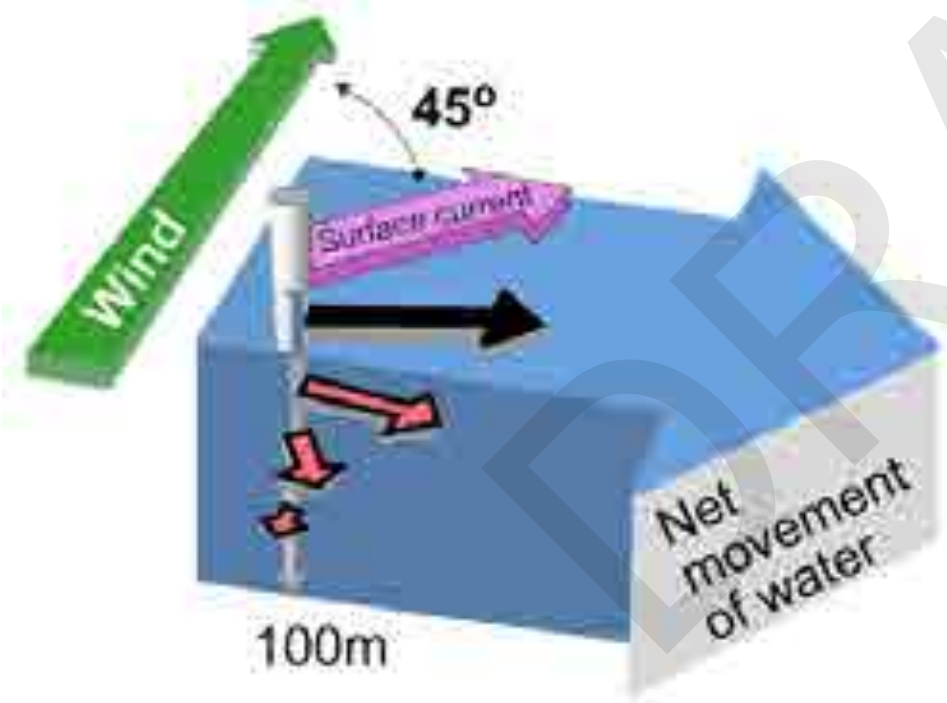
Ekman spiral, upwellings and downwellings

Currents decrease with depth in a spiral based on surface currents moving at a 45-degree angle to the wind direction caused by Coriolis forces and friction.

The deflection at the surface his called Ekman transport and with depth the Ekman Spiral.



Ekman Spiral
Illustration Bob Moffatt

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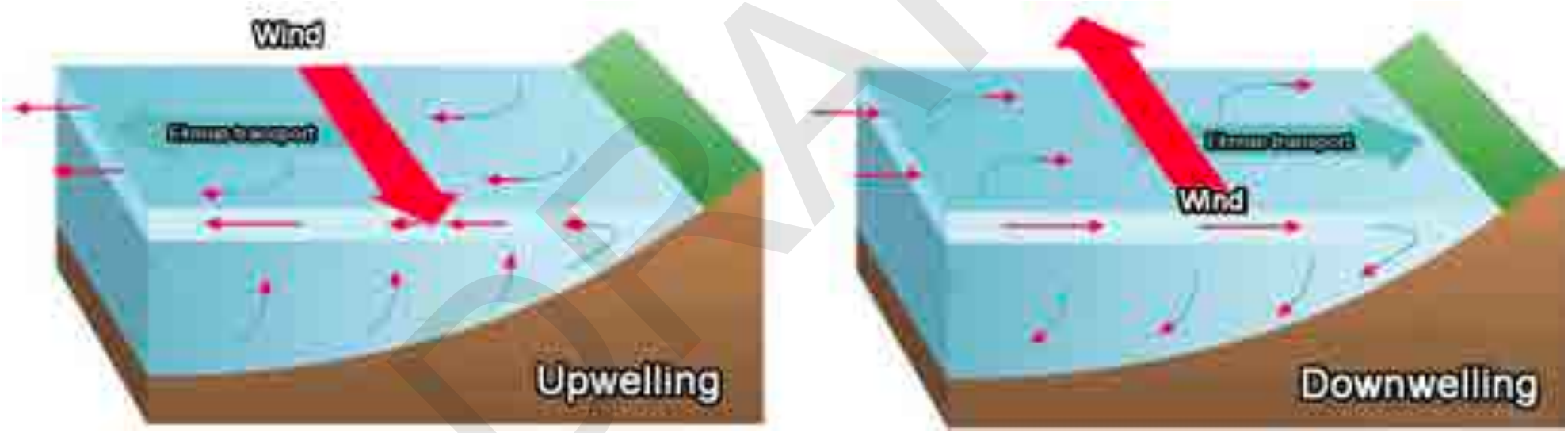
Upwelling

Where Ekman transport moves surface waters away from the coast, surface waters are replaced by water that wells up from below in the process known as upwelling.

Downwelling

Where Ekman transport moves surface waters toward the coast, the water piles up and sinks in the process known as downwelling.



Ekman transport, upwellings and downwellings

After NASA and American Geography Society

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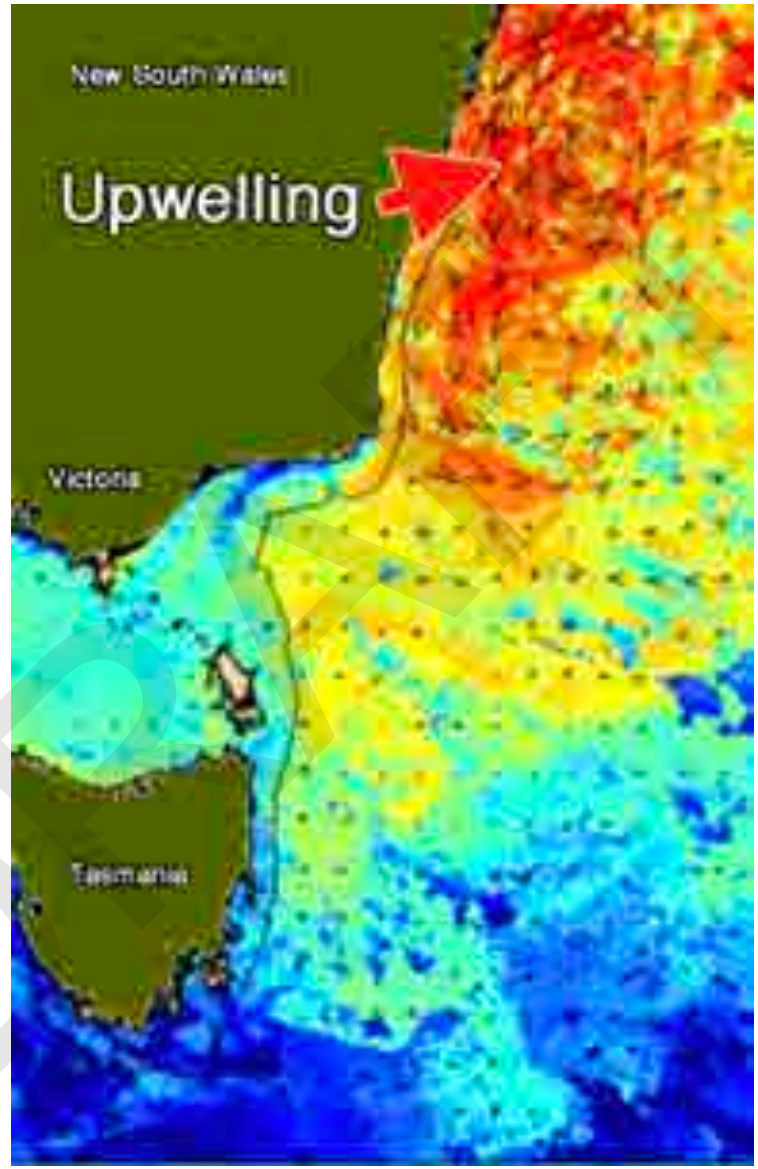
Coastal upwelling are affected by the continental shelf.

The Bonney upwelling region in NSW is known for its high productivity driven by the strong and predictable upwelling of nutrient rich waters.



Bonney upwelling

By CSIRO Marine division, modified Bob Moffatt

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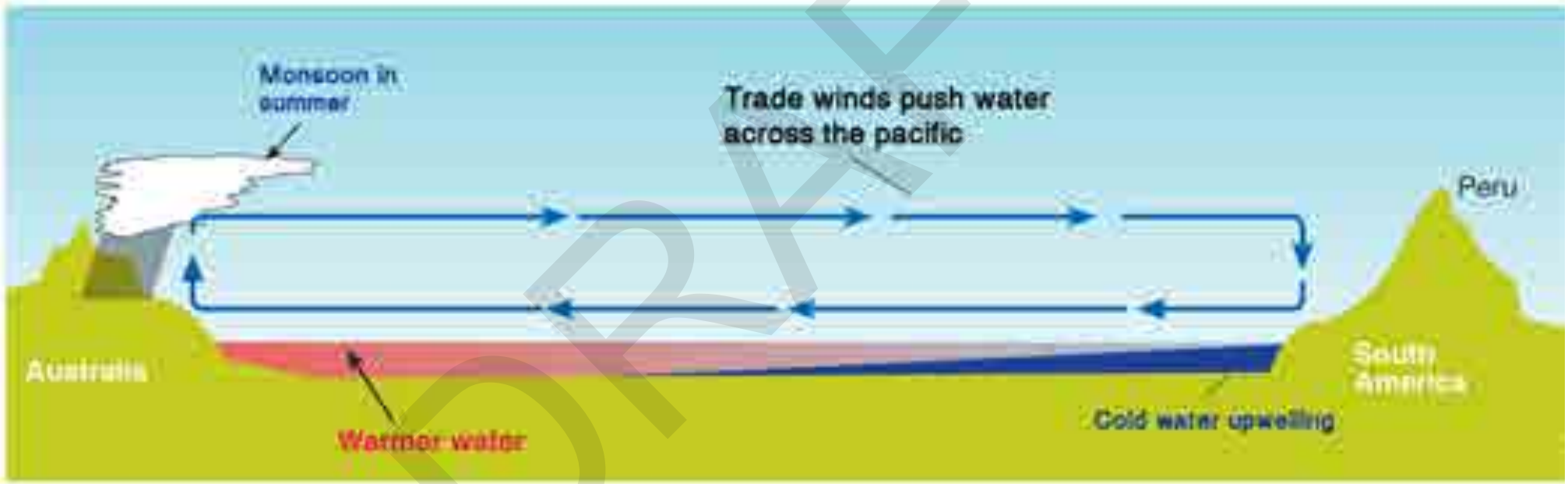
Easterly trade winds push large amounts of warm water across the Pacific causing upwellings in Peru and a monsoon in Australia.

This is called La Nina.



La Nina

Illustration Bob Moffatt

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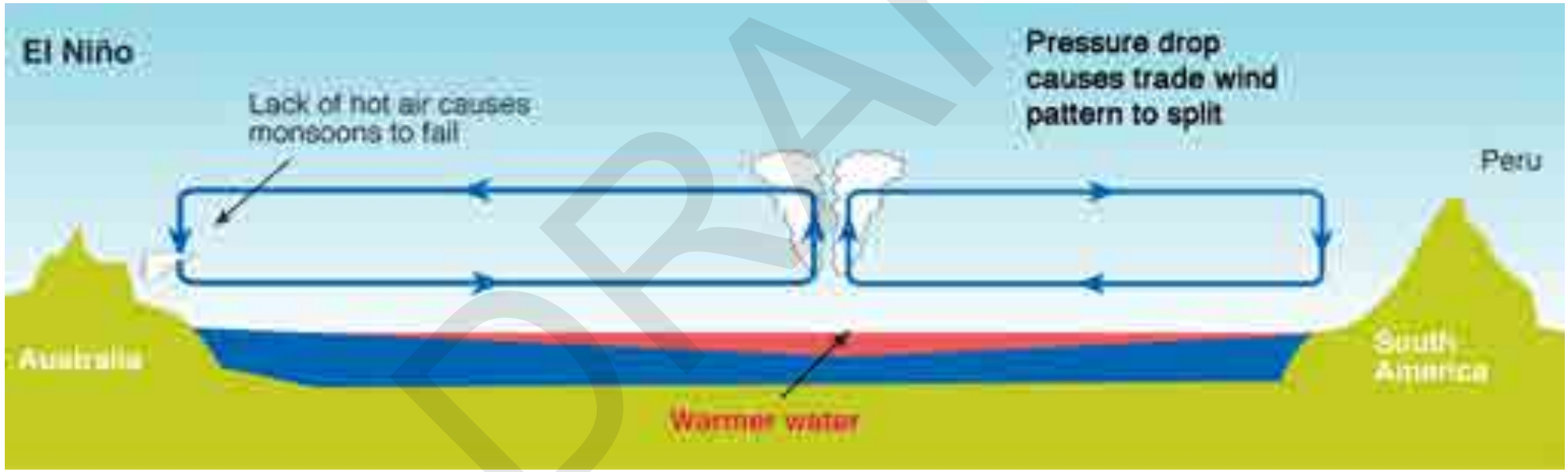
The push on the ocean surface from time to time falls, and warm water that was once driven westward, now runs back towards the central Pacific.

This disrupts the ocean-atmosphere system causing hot air to rise and split the trade wind circulation pattern.

This is called El Nino.



El Nino

Illustration Bob Moffatt

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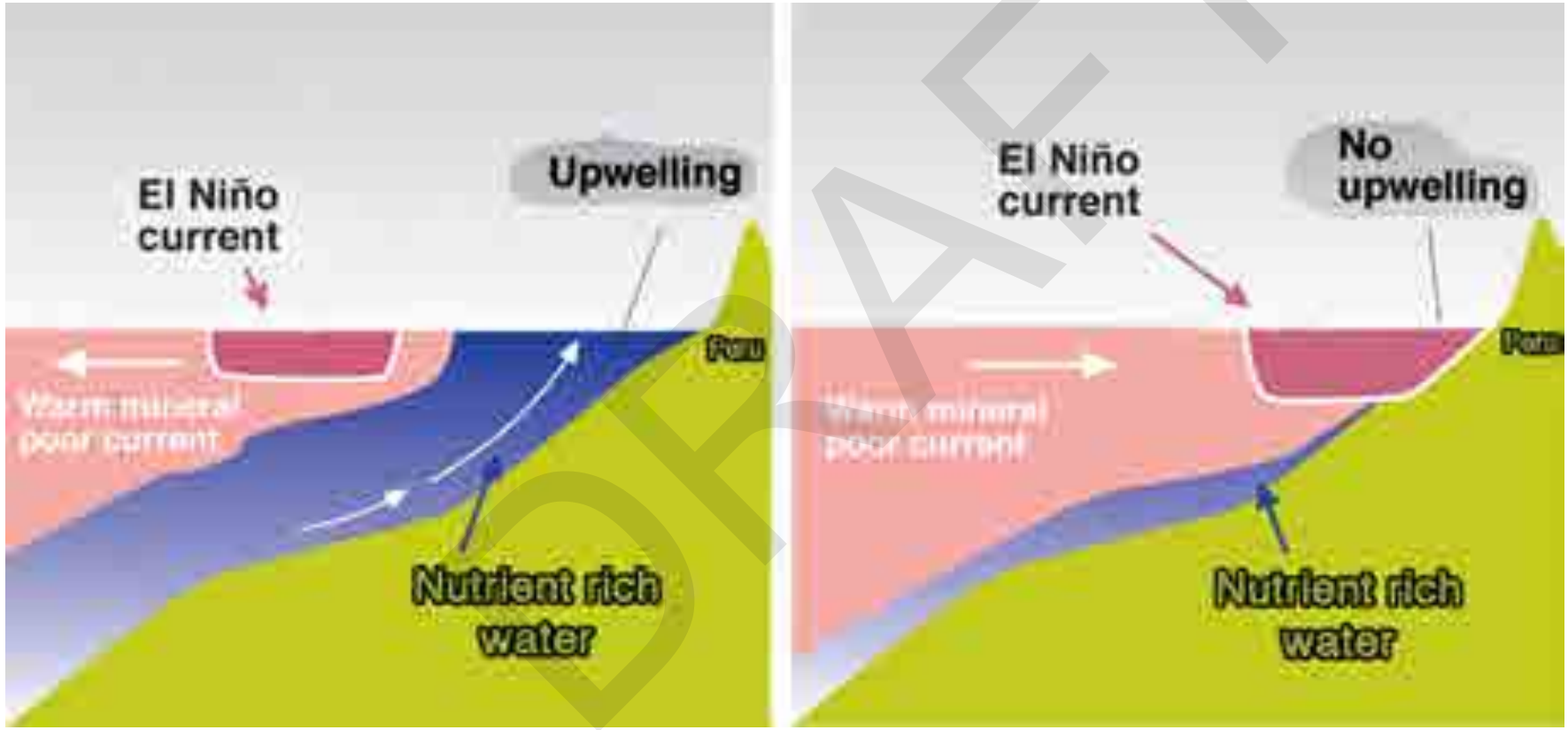
In the eastern Pacific, a branch of the Peru current breaks off, stopping cold water from entering upper layers of oceanic water.

It dramatically affects ocean nutrients in Peru.



El Nino currents and Peru

Illustration Bob Moffatt

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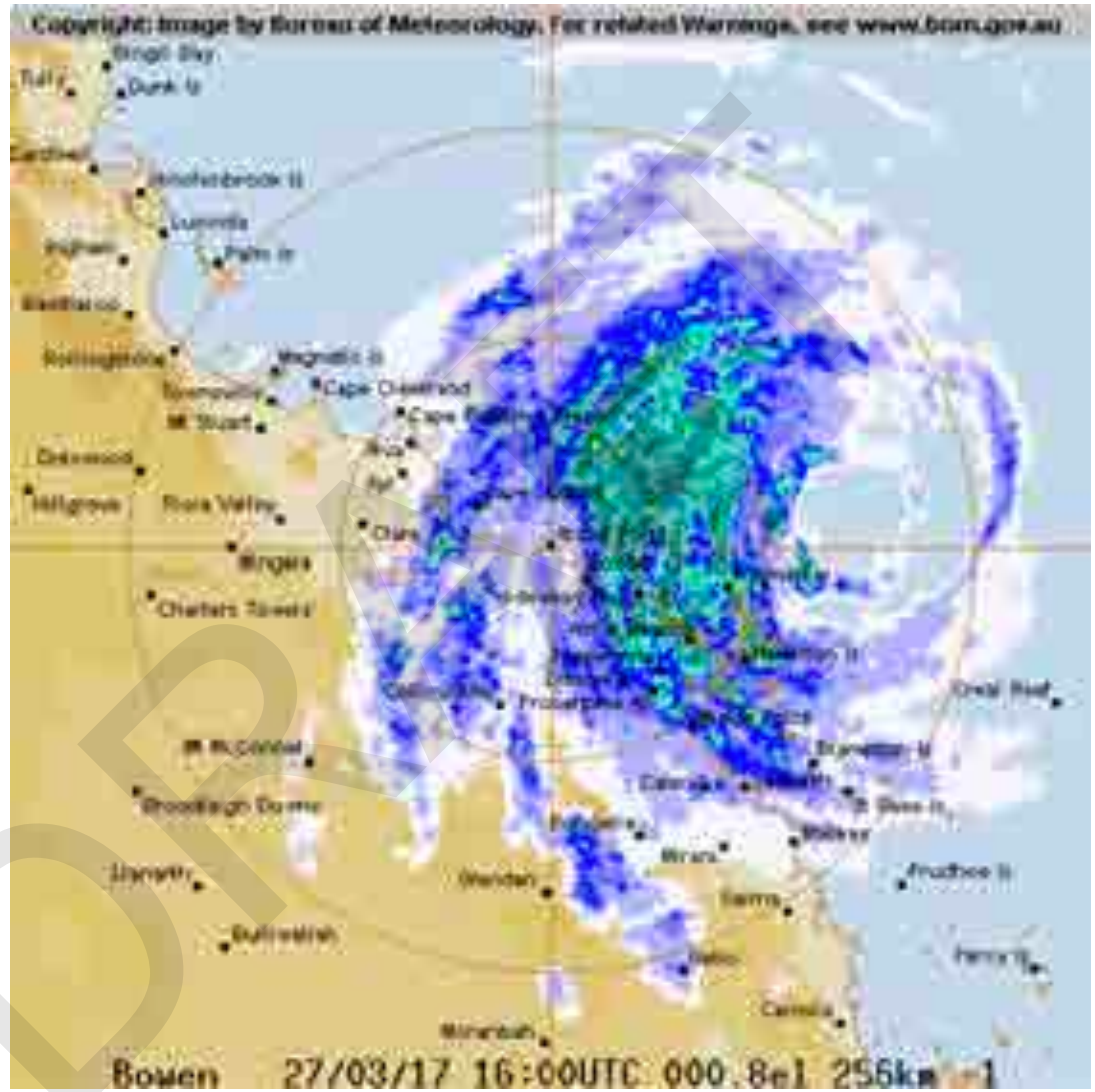
In Australia heat from
El Nino conditions
can cause bushfires

Bushfires
Photo Simone Baker

Cyclones from El nino conditions also bring large amounts of water to Queensland



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This seriously affects nutrient levels on inshore ecosystems.

Flood plume coastal river

Photo Bob Moffatt

DRAFT

T006 Seawater properties

Students and titration

Photo Dean Burnett

DRAFT

Wet Paper

Syllabus statement

The syllabus says ... you should be able to describe

the physical and chemical properties of water, including structure, hydrogen bonding, polarity, action as a solvent, heat capacity and density

Describe - give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something

DRAFT

Question

Give an account of the properties of water with reference to

I. Chemical properties involving molecular structure, hydrogen bonding, polarity, ionisation, solvent properties, pH and salinity

II. Physical properties involving states of matter, conductivity, heat capacity and density

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Key points

Chemical properties cannot be determined just by viewing or touching the substance; the substance's internal structure must be affected greatly for its chemical properties to be investigated.

A chemical property is any of a material's properties that becomes evident during, or after, a chemical reaction; that is, any quality that can be established only by changing a substance's chemical identity.

What are the Chemical Properties of Water?	
Molecular structure	H_2O - two hydrogen atoms and one oxygen atom
Solvation	Water dissolves more substances than any other liquid
pH	Pure water has a neutral pH of 7, which is neither acidic nor basic
Ionization	Water weakly ionizes
Reactivity	Metals such as gold, silver, copper, tin, etc. do not react with water

Chemical properties of water

By http://www.elementalmatter.info/water-properties.htm

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Physical properties can be observed or measured without changing the composition of matter and are used to observe and describe matter.

What are the Physical Properties of Water?	
Color	Nearly colorless with a hint of blue
Odor	None
Taste	Bland
Density	1.000 g/ml. The density of water is approximately one gram per cubic centimeter
Boiling Point	100 °C
Conductivity	Water is a good conductor of heat
Compressibility	The compressibility of water reduces the sea level
Specific Heat	Water has a high specific heat. Specific heat is the amount of energy required to change the temperature of a substance
Surface Tension	Water has a high surface tension - it is adhesive and elastic
Cohesion	Water is attracted to other water
Adhesion	Water can also be attracted to other materials

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Physical properties of water

By http://www.elementalmatter.info/water-properties.htm

I. Chemical properties

A. Molecular structure

B. Hydrogen bonding and polarity

C. Ionization

D. Solvent properties and pH

E. Salinity

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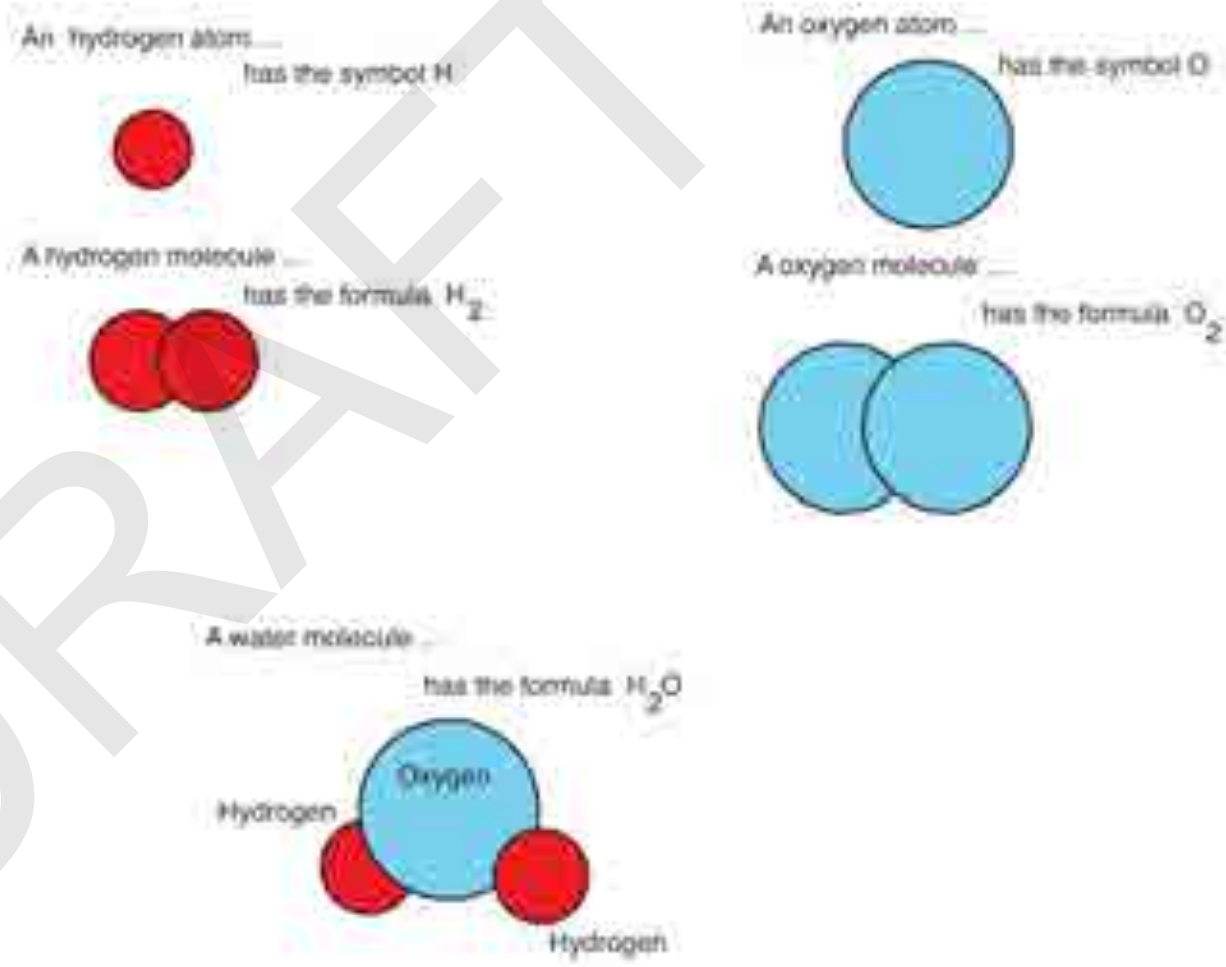
Molecular structure

Water is made of one molecule of oxygen and two molecules of hydrogen.



Water molecules

Illustration Bob Moffatt

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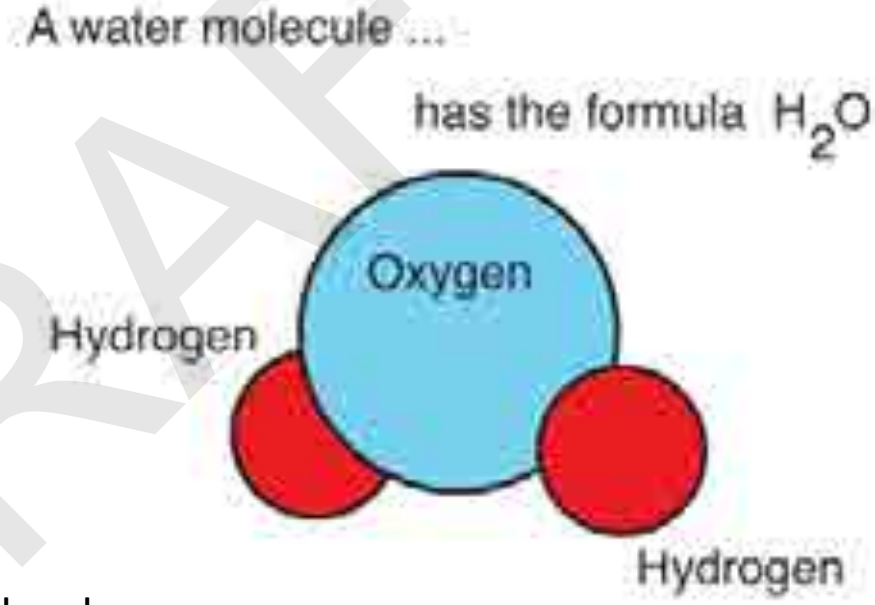
These atoms combine in a ratio, two hydrogen and one oxygen atoms to form the water molecule H_2O.

The atoms are held together by chemical bonds.

These bonds form because the electrons of the atoms are shared, each hydrogen atom shares an electron with an oxygen atom.



Water molecule

Illustration Bob Moffatt

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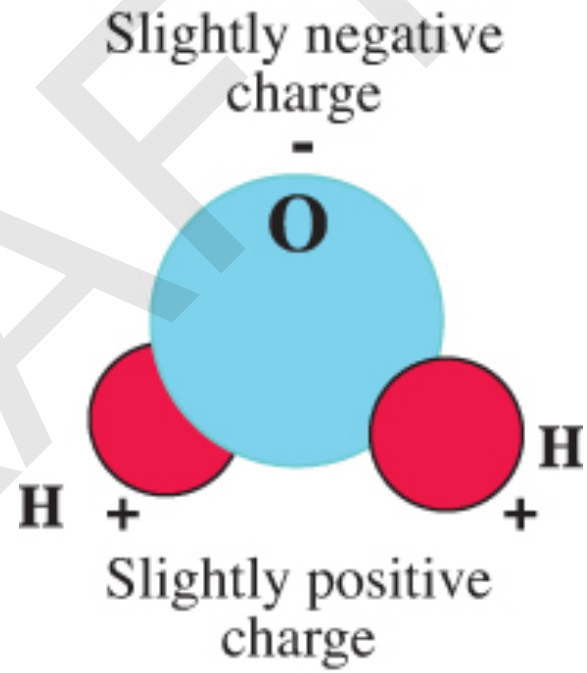
Hydrogen bonds and polarity

Water is a polar molecule and so is slightly positive on the hydrogen side and slight negative on the oxygen side.



Water molecule showing charges

Illustration Bob Moffatt

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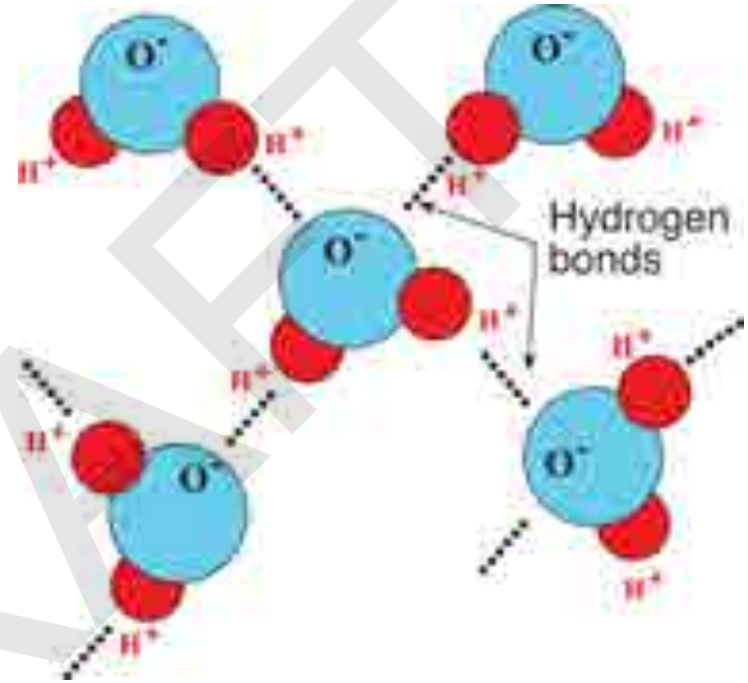
A hydrogen bond forms between the positive hydrogen side of this molecule and other negative ions.



Water molecules hydrogen bonding
Illustration Bob Moffatt

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Ionization

This is the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons to form ions, often in conjunction with other chemical changes.

$$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$$

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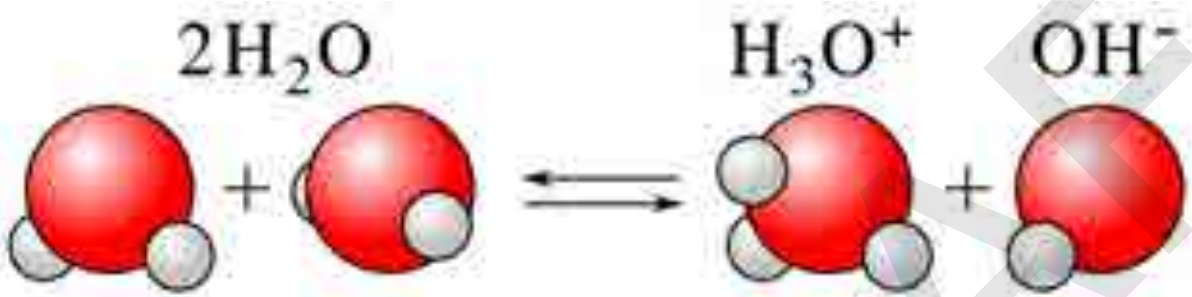
Water ionizes into the hydronium ion H_3O^+ and the hydroxide ion OH^-.



Water ionization

By Cdang - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=7942156

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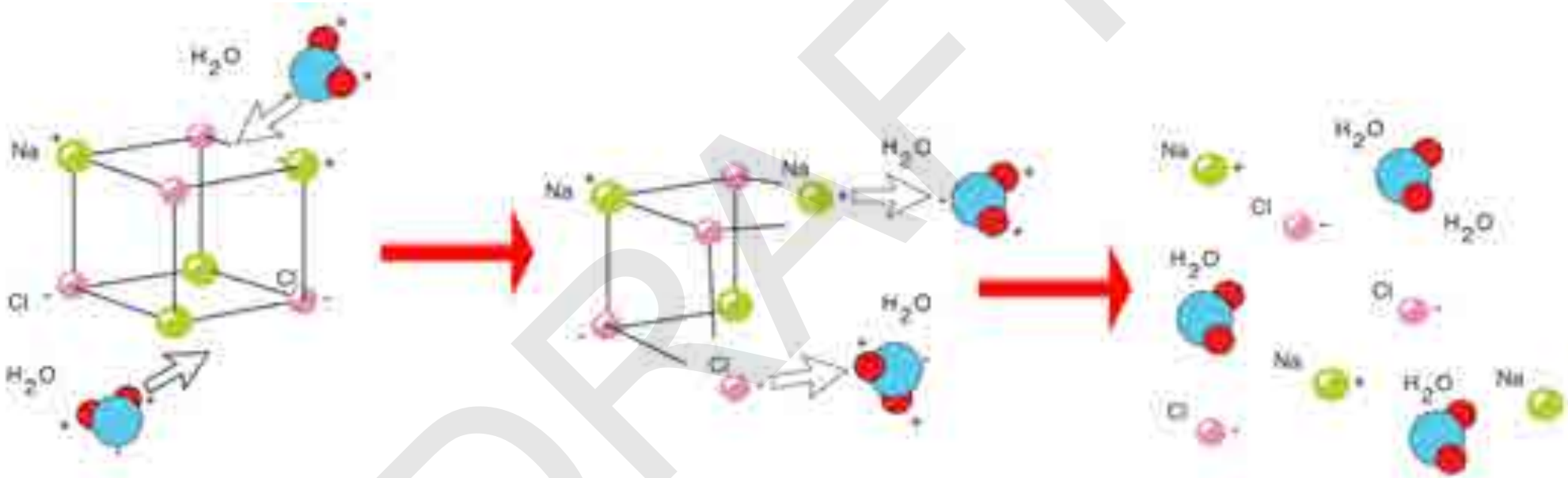
Water and salt ionises salt breaking its crystal form causing to to dissolve.

Molecules and ions with which water forms hydrogen bonds (such as sodium chloride) are hydrophylic.



Salt and water ions

Illustration Bob Moffatt

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These substances can attract water from the air, so a mangrove can attract water, if it has salt on its leaves.

Mangrove leaf with salt
Photo Bob Moffatt

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On the other hand, ions and molecules that do not form hydrogen bonds with water are hydrophobic, which is the opposite.

This effect is seen when you put a drop of oil on water.

Oil spill Persian Gulf

Copyright Kuwait Environment Public Authority

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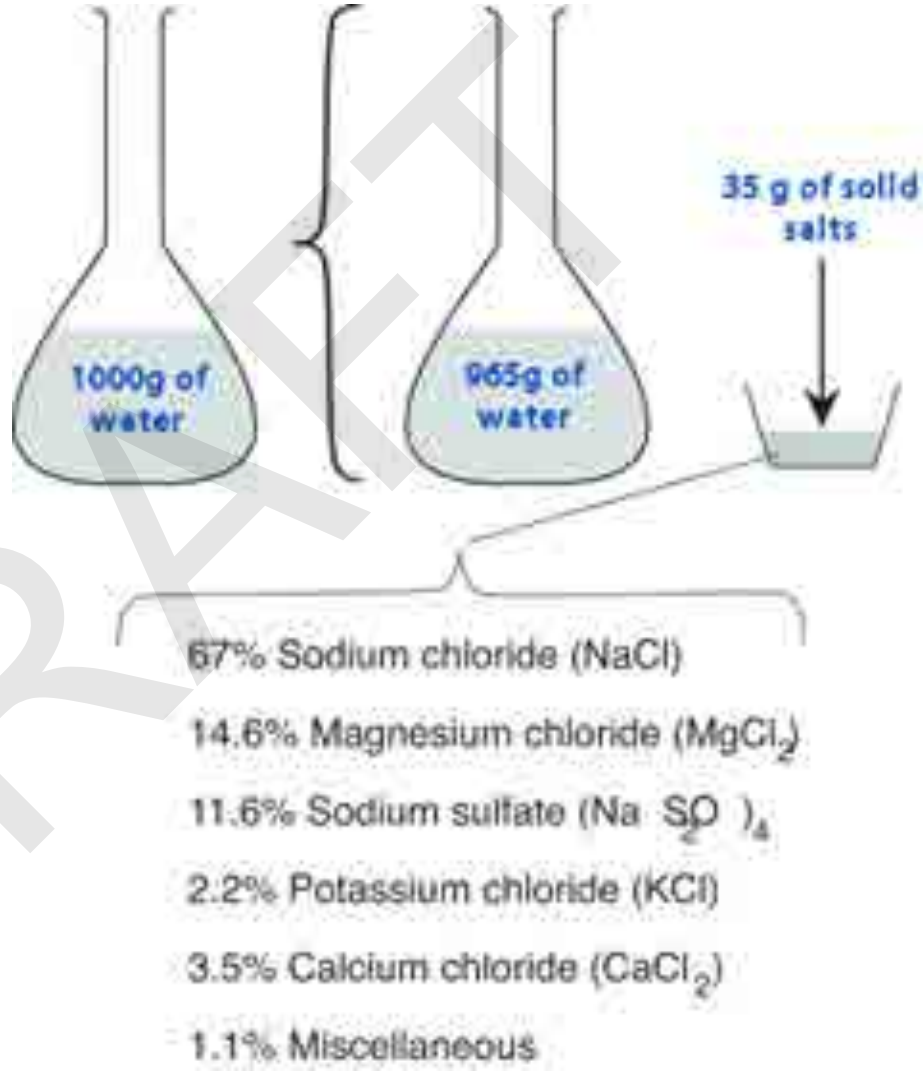
Ionization and salinity

Salinity is the concentration of dissolved salts in water, usually expressed in parts per thousand by weight.
Sea water has about 35 g of salt per litre of water. This usually expressed as 35 ppt.



Seawater composition
Illustration Bob Moffatt

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Solvent properties and pH

Water can also dissolve more substances than any other common liquid.

Water drop

By fir0002 | flagstaffotos.com.au [GFDL 1.2 (http://www.gnu.org/licenses/old-licenses/fdl-1.2.html)], via Wikimedia Commons

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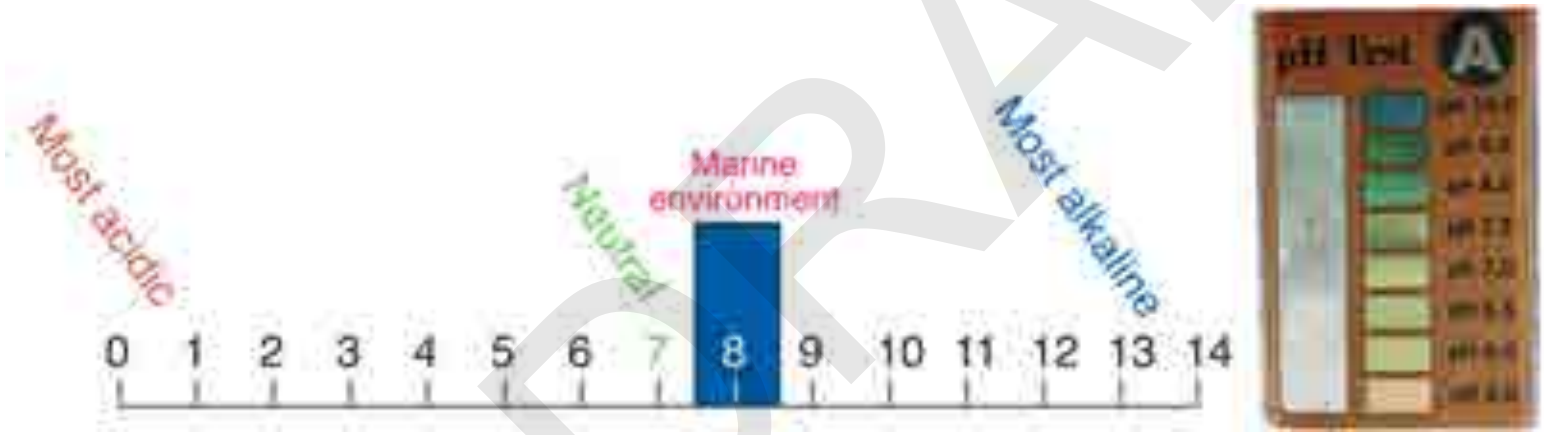
pH

pH stands for 'potential of Hydrogen' and is a measure of acidity or alkalinity of water soluble substances. A pH value is a number from 1 to 14, with 7 as the middle (neutral) point.
Values below 7 indicate acidity which increases as the number decreases, 1 being the most acidic. Seven is neutral.
Over the past 300 million years, ocean pH has been slightly basic, averaging about 8.2. Today, it is around 8.1.



pH line and kit

Illustration Bob Moffatt

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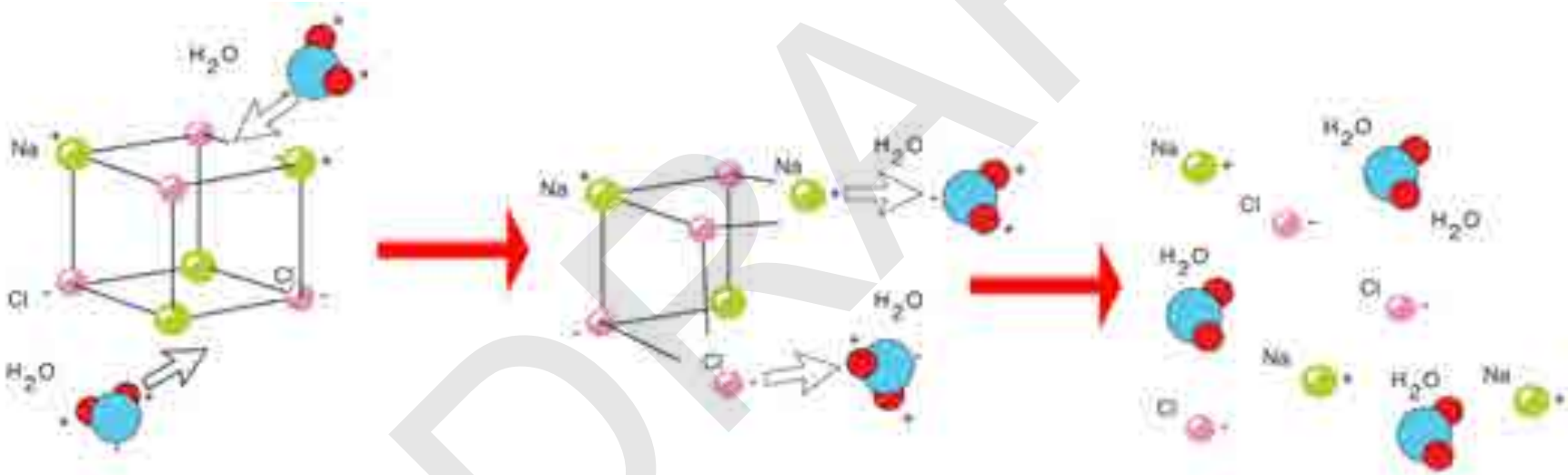
Water has an enormous ability to dissolve substances because of its polar nature.

When ionic compounds such as sodium chloride are added to water, hydrogen bonding will tend to pull those ionic compounds apart.

This makes water a natural solvent.



Salt and water ions dissolving
Illustration Bob Moffatt

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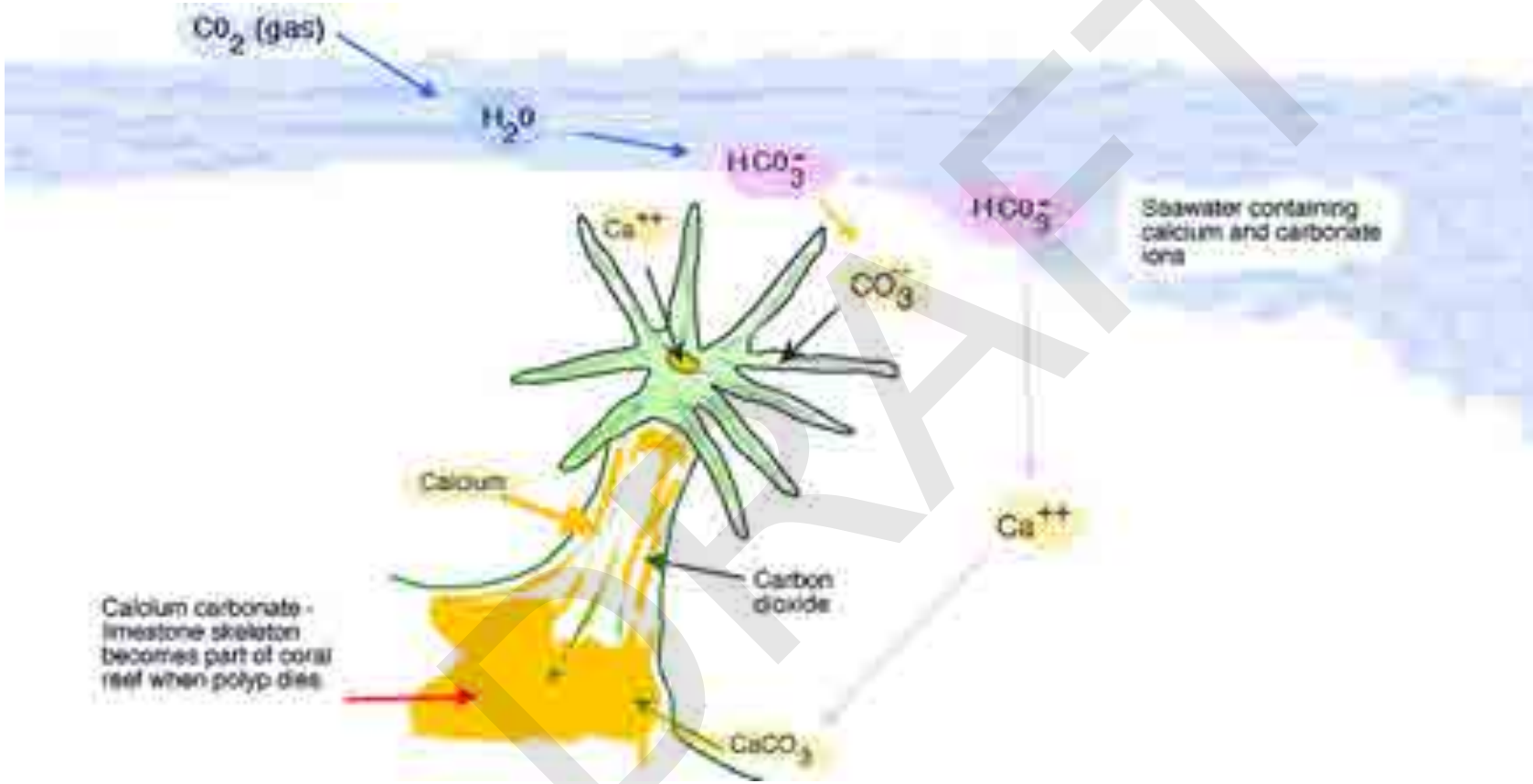
Water facilitates chemical reactions because once ionic compounds dissolve, their anions and cations circulate through the water allowing further reactions to occur.



For example water allows calcium to combine with carbon dioxide to form calcium carbonate.

Illustration Bob Moffatt

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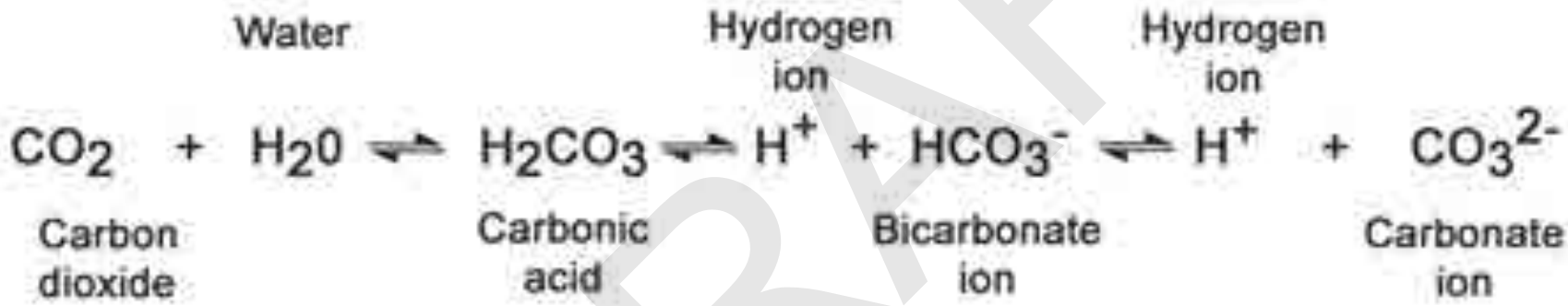
When carbon dioxide dissolves in water it exists in chemical equilibrium with carbonic acid which dissociates into hydrogen and carbonate ions.

The water gets the hydrogen ions making it acidic.



Carbonic acid formation and dissociation

Illustration Bob Moffatt

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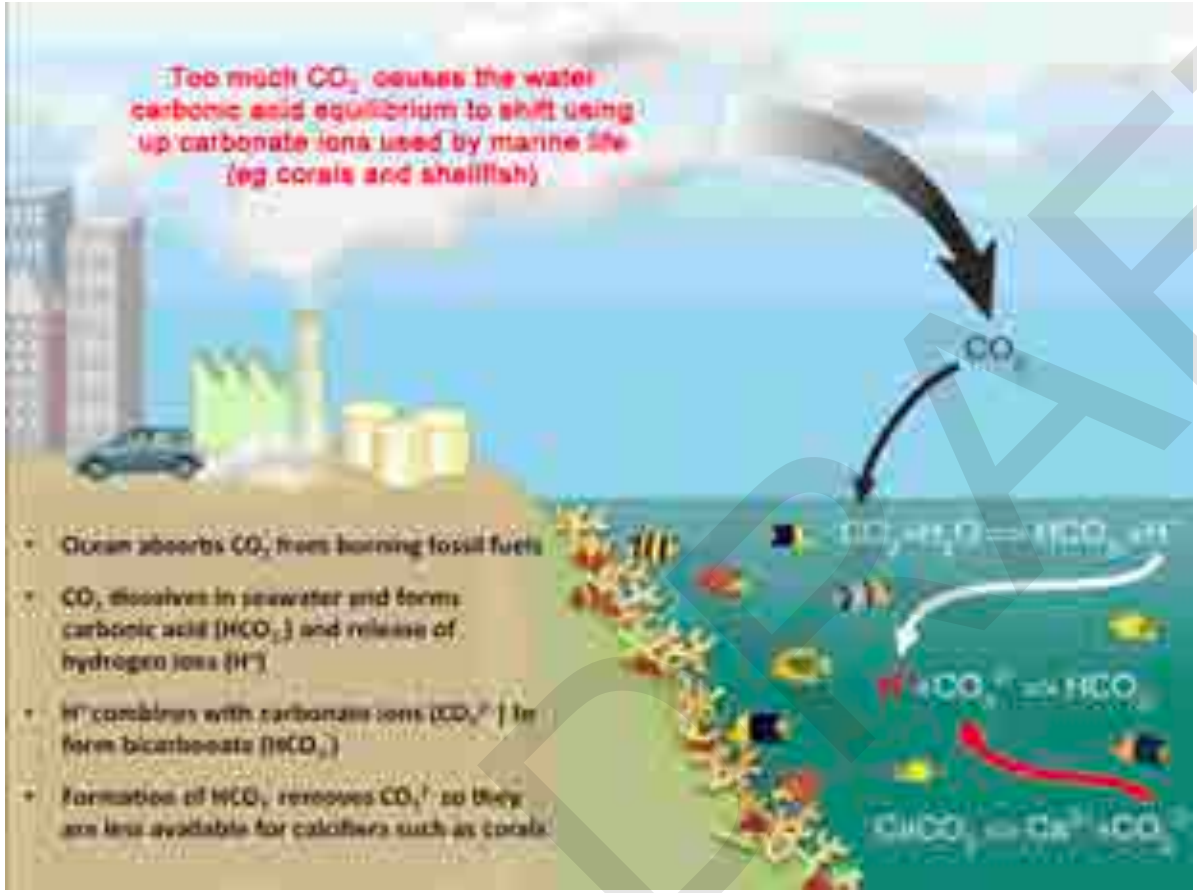
As atmospheric carbon dioxide increases, water increases the uptake of carbonate ions to maintain the equilibrium reducing calcium carbonate formation.



This reduces ocean pH making it more acidic.

Ocean acidification equation

Adapted from Hoegh-Guldberg, Ove, et al. “Coral reefs under rapid climate change and ocean acidification.” science 318.5857 (2007): 1737-1742.

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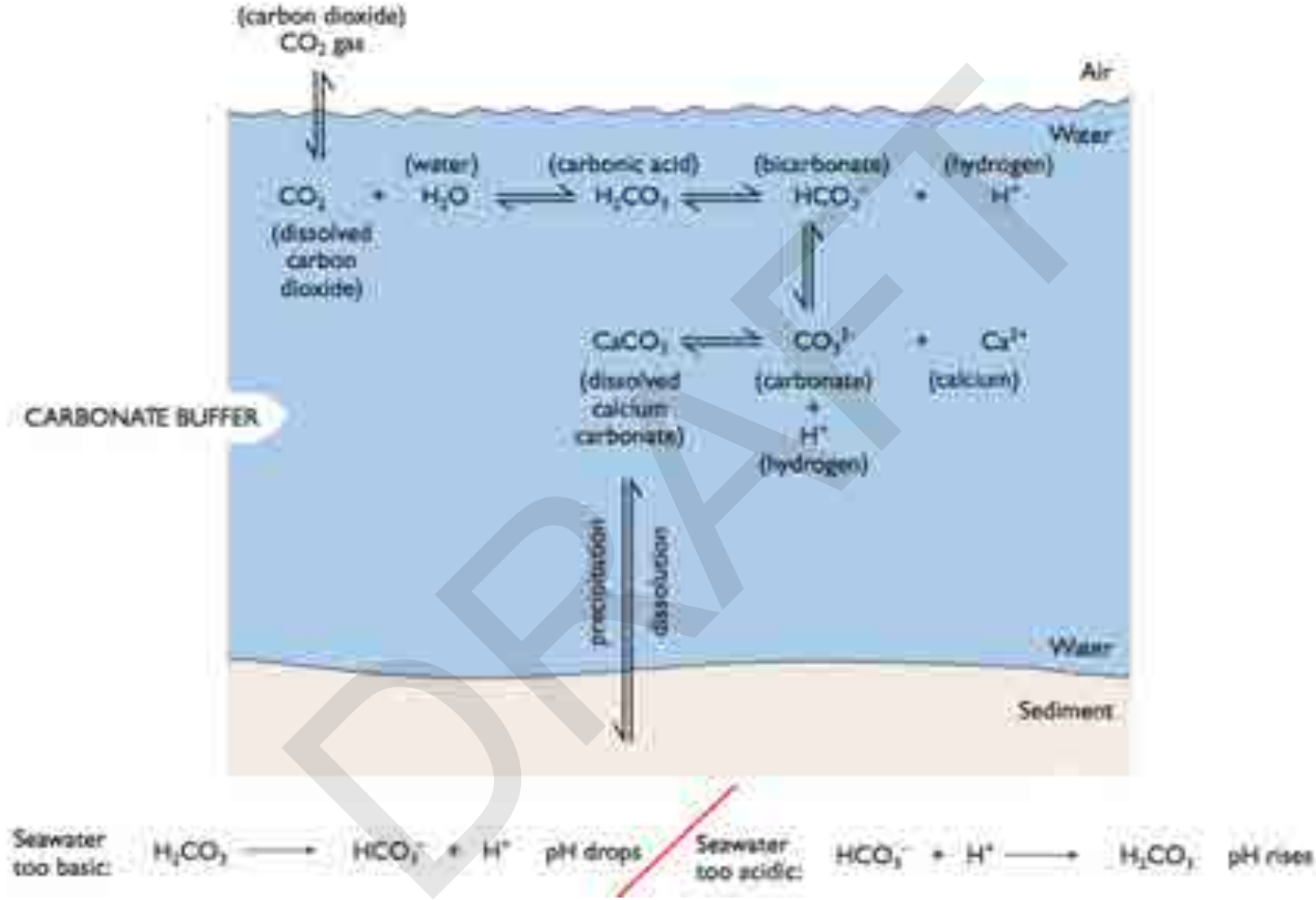

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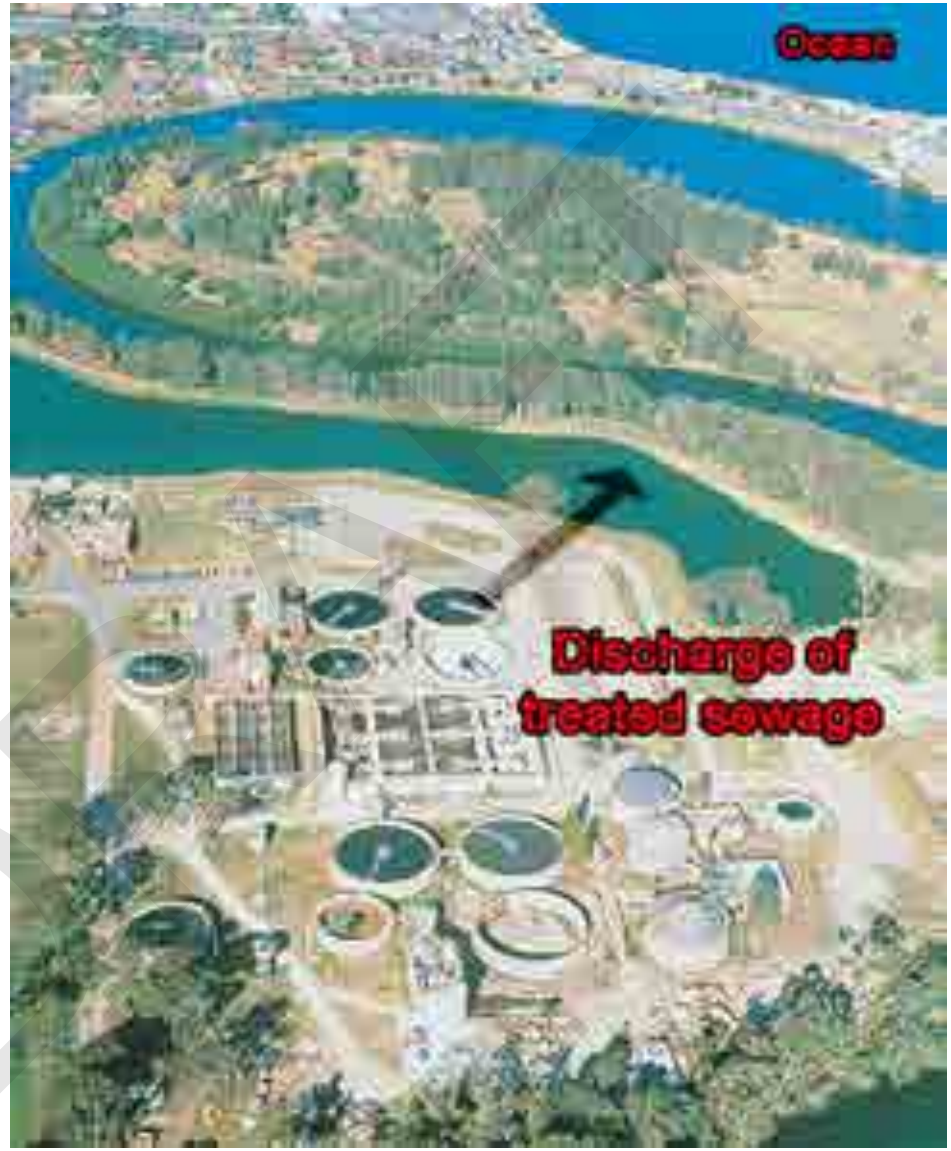
http://samples.jbpub.com/9781449686437/19992_CH04_Pinet.pdf

Another negative property is that water being such a good solvent is an excellent place for treated sewage and other pollution discharge.

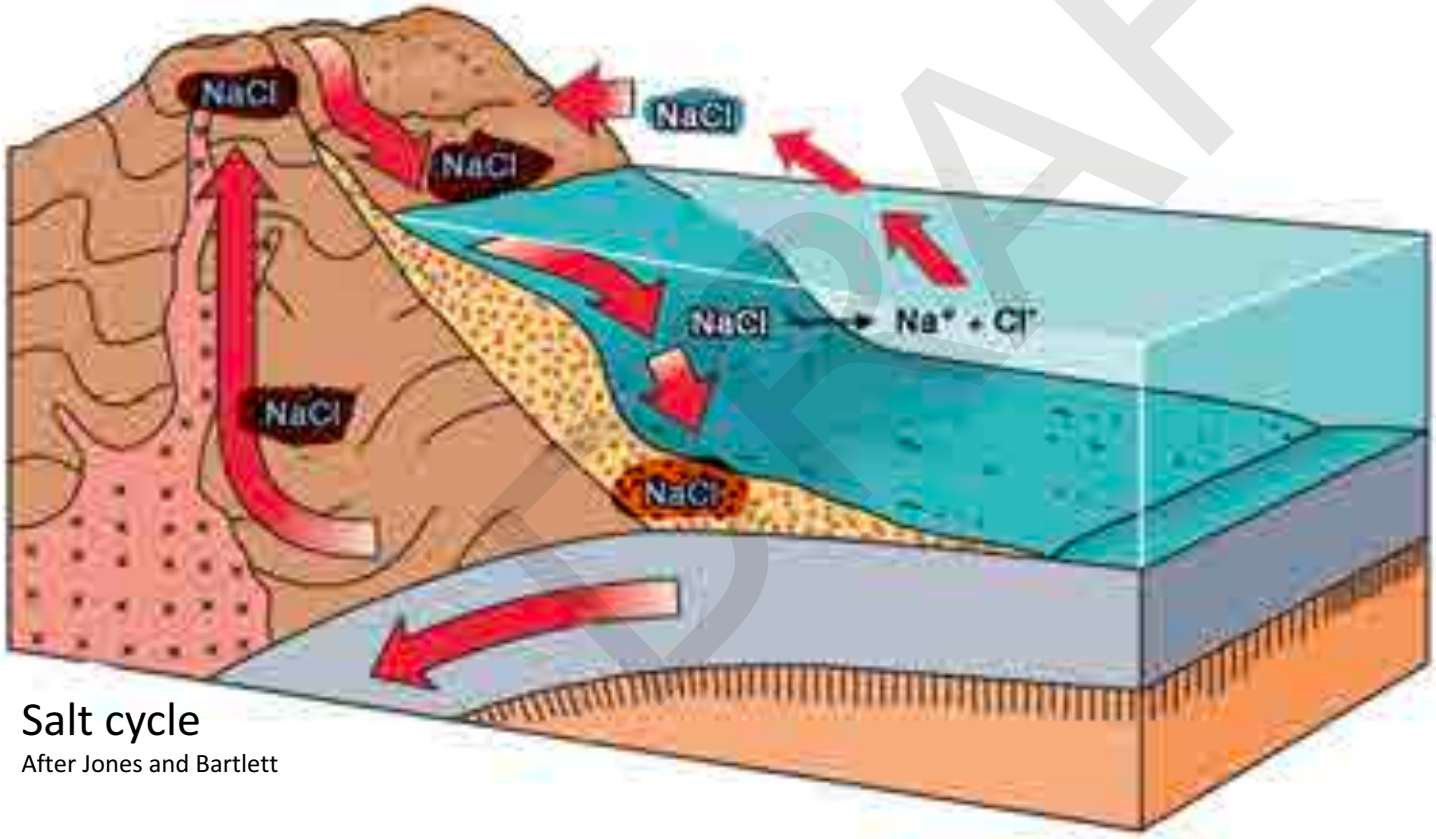


Sewage plant discharge
Photo GCCC

Salinity

Salt cycles starts in the sea from sediments which are uplifted over millions of years by subduction, then eroded forming part of the sediment load in rivers, then back to the sea as sediment.

Large amounts of salt are also blown from the sea to the land.



Salt cycle

After Jones and Bartlett

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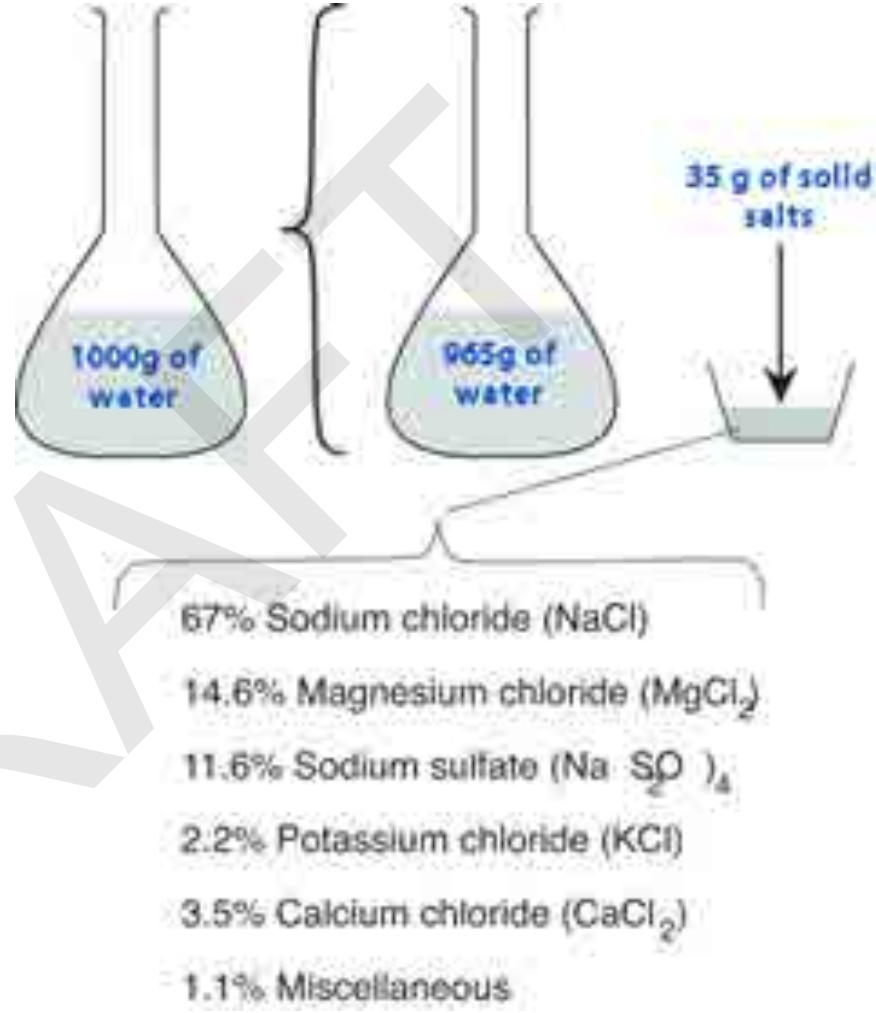
Salinity is the concentration of dissolved salts in water, usually expressed in parts per thousand by weight

Sea water has about 35 g of salt per litre of water. This usually expressed as 35 ppt.



Seawater composition

Illustration Bob Moffatt

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This chemical property allows molecules to dissociate into ions.

Salt has the formula NaCl and when it dissolves it splits into two ions Na^+ and Cl^-

Salt and water ions

Illustration Bob Moffatt

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Ionisation allows us to establish a chemical test for salinity.

Solutions of seawater, potassium dichromate and silver nitrate are used in a titration.

Seawater titration set up

From College of Science, University of Cantebury

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As the silver nitrate is run into the flask, the silver ions combine with the chloride ions to form a white precipitate of silver chloride.

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

Silver chloride formation

From College of Science, University of Cantebury

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When all the chloride ions are used up the silver ions combine with the chromate ions to form a red solution of silver chromate.

Salinity is determined by the amount of silver ions required to use up all of chloride ions.

$$2\,Ag^{+} + CrO_4^{2-} \longrightarrow Ag_2CrO_4$$

Silver chromate end point

From College of Science, University of Cantebury

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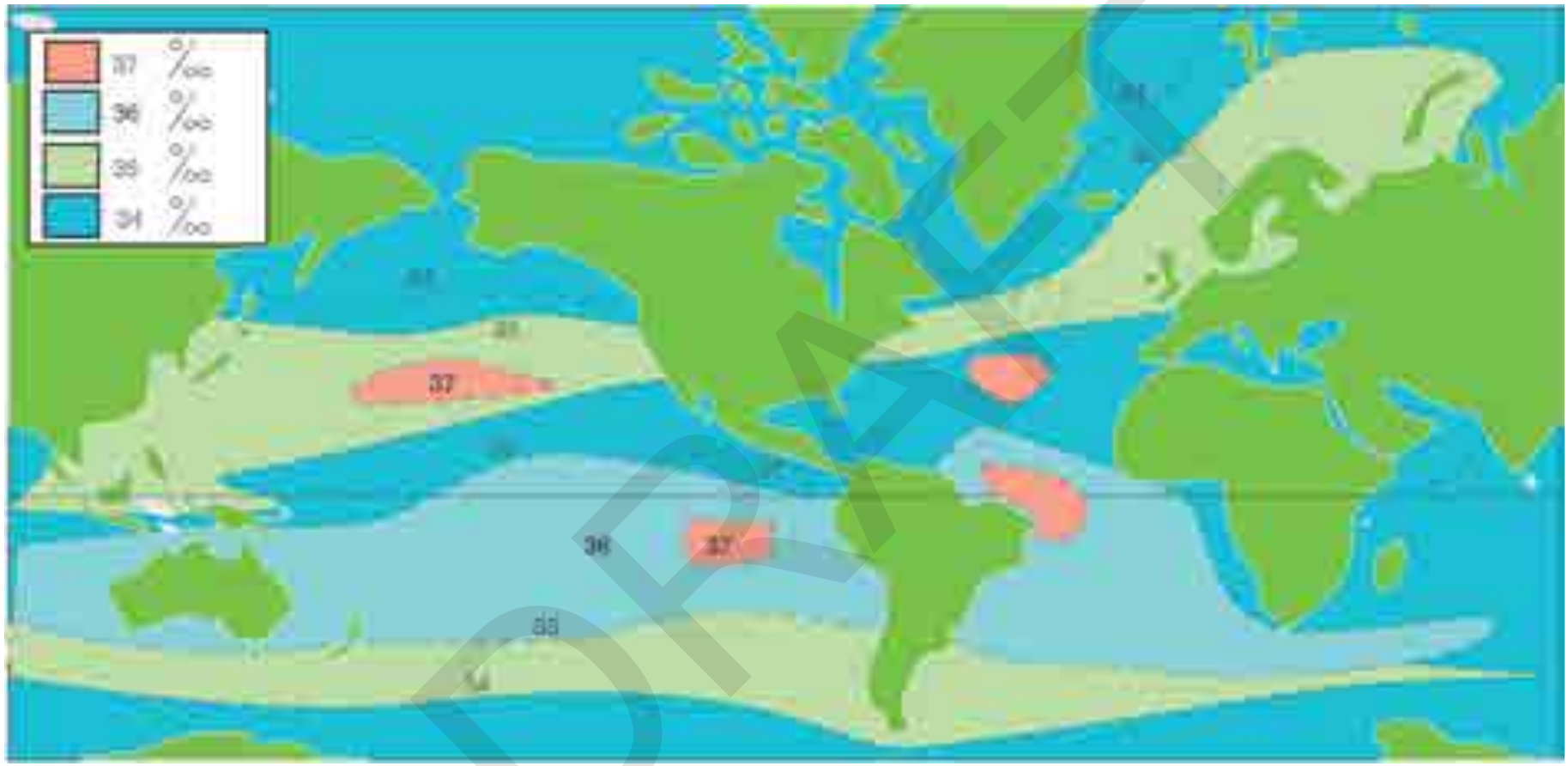
World salinities vary from 34 - 37 ppt



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World salinities

Illustration Bob Moffatt

There are exceptions, for example the Dead Sea where salinities are 10 times that of the ocean.

Dead Sea, man reading in 337 ppt

By Arian Zwegers (Flickr: Dead Sea, man reading) [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons

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Physical properties

A. States of matter

B. Heat capacity

C. Density

D. Viscosity

E. Surface tension

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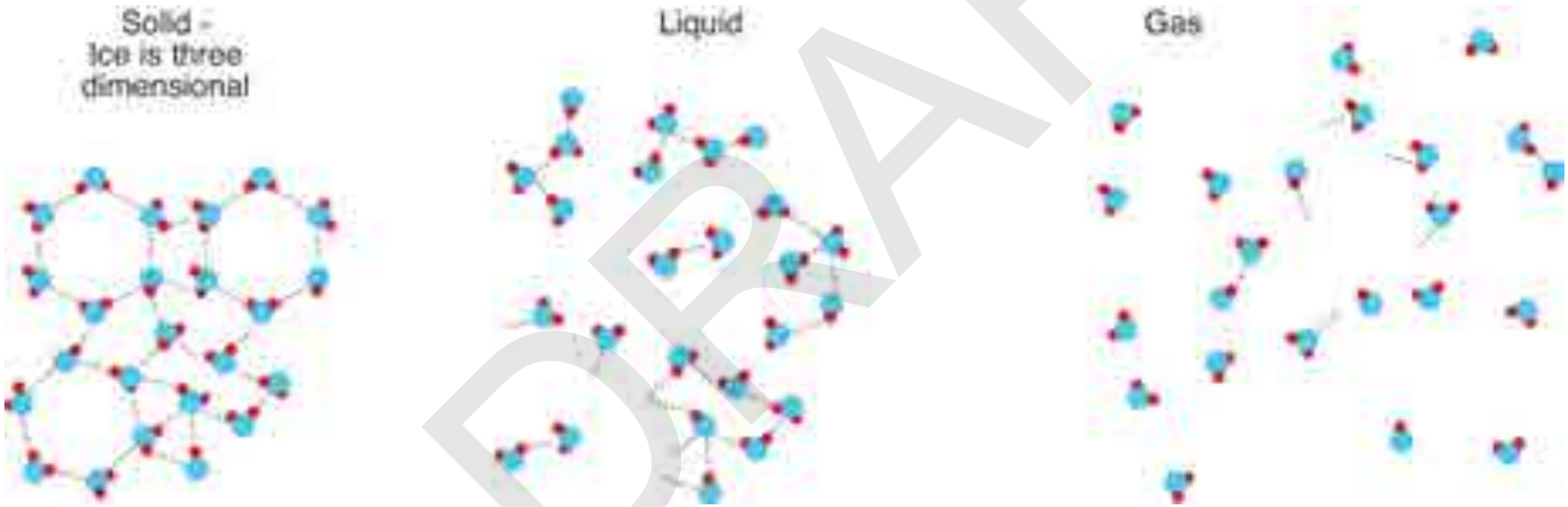
States of matter

Water can exist as a solid liquid or gas. Hydrogen bonding helps to keep it a liquid at room temperature and temperatures of 100°C are required to break the hydrogen bonds and convert liquid water into water vapour.



Water in its three states

Illustration Bob Moffatt

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These different charges attract other water molecules with their hydrogen bonds.

This results in sea water staying as a liquid right up to temperatures of 100oC.

This allows water in rock pools to remain even at high temperatures.

Liquid water also contributes to heat transfer through ocean currents.

Rock pool Kimberley region
Photo Bob Moffatt

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When water heats up above 100^{o}C, the hydrogen bonds let go and water vapour forms. Here the molecules are far apart and move freely.

The process is called evaporation and occurs on any large body of water.

As water vapour rises the molecules slow down and hydrogen bonds reform resulting in clouds.

As a gaseous (vapour) component of the atmosphere, water helps transfer heat from warm low latitudes to cold high latitudes.

Cloud formed by moist winds

Lord Howe Island tourism

DRAFT

Solid - at the poles, water temperatures plummet towards zero.

As icebergs are made of freshwater, they will be less dense than salt water a float.

Iceberg
Photo Bob Moffatt

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The freezing of water into a solid (ice) during the winter season at the higher latitudes increases surface salinity and makes possible the sinking of dense surface water.

This water is the only source of oxygen for the deep ocean.

Seal on iceberg
Photo Bob Moffatt

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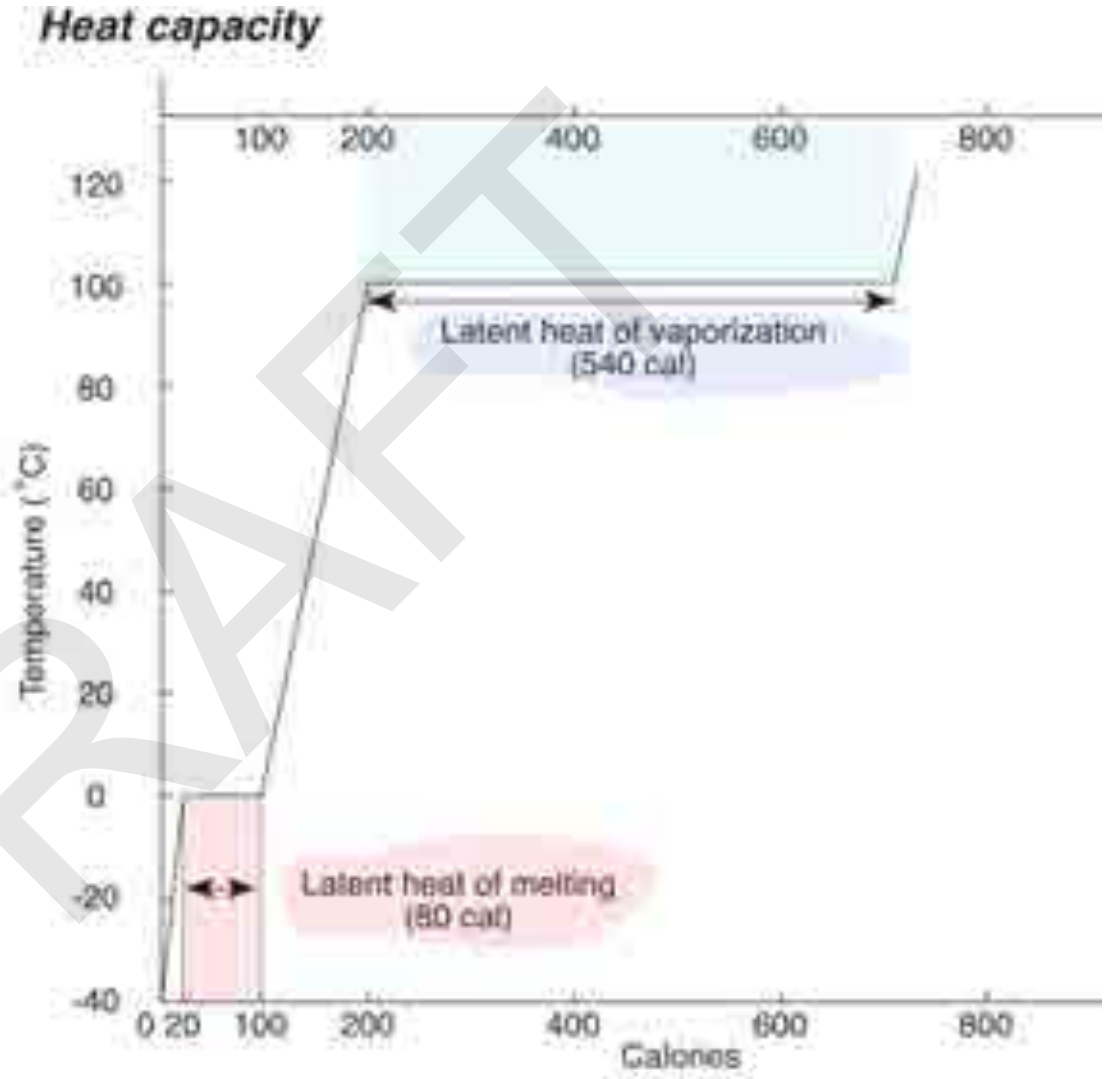
Heat capacity

Heat capacity is the heat required to raise the temperature of a substance one degree and is expressed in calories.
Less heat is required to melt ice than vaporise water to steam.



Heat capacity of water

Illustration Bob Moffatt

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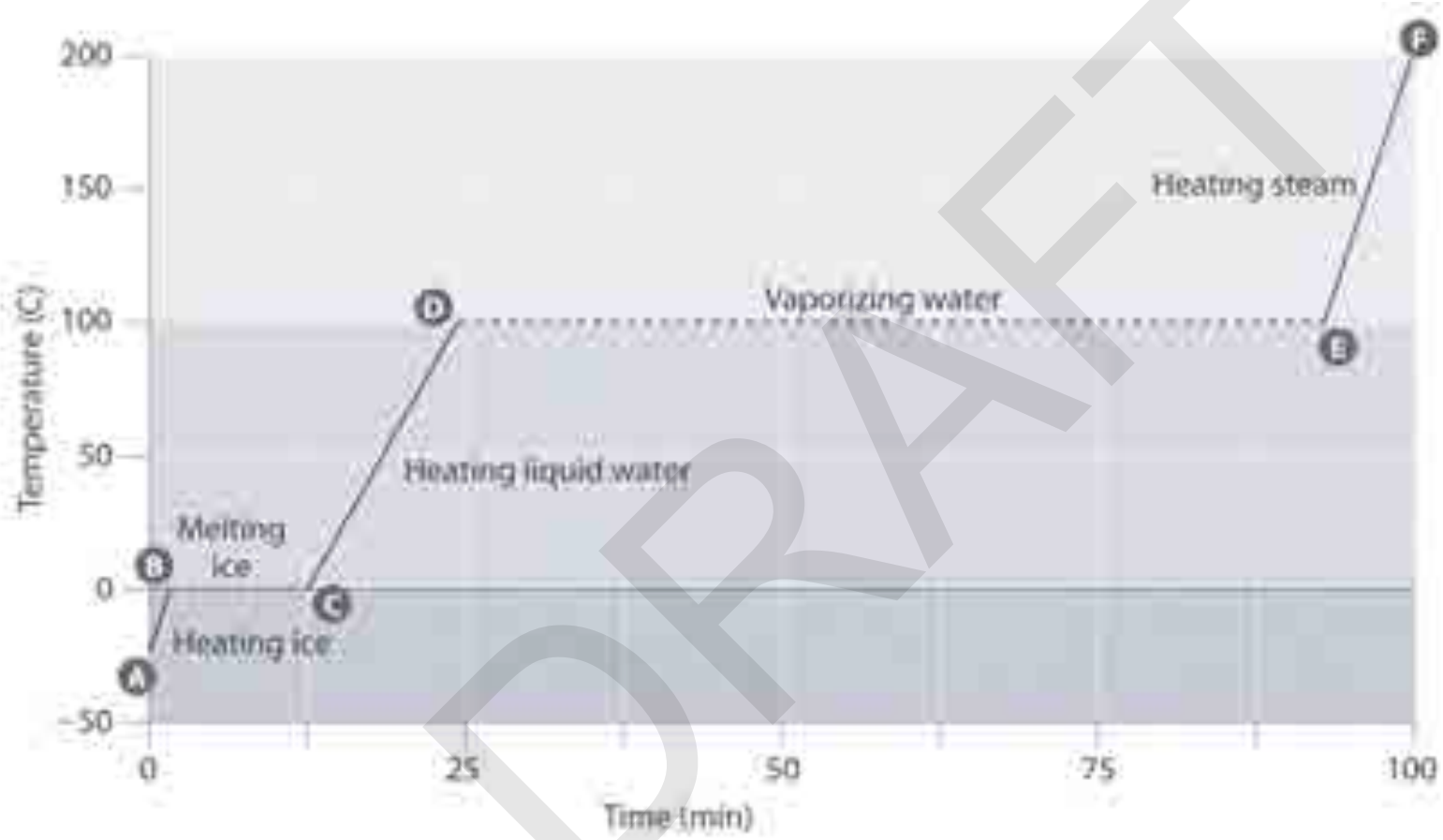
The rate at which heat is added does not affect the temperature of the ice/water or water/steam mixture.



Heating curve for water

https://chem.libretexts.org/LibreTexts/Valley_City_State_University/Chem_122/Chapter_2%3A_Phase_Equilibria/2.3%3A_Heating_Curves

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Water can absorb or loose an enormous amount of heat without undergoing a large temperature change and is the most important moderator of climate.

Whale Shark
Below H2O

DRAFT

Density

The density of a substance is the mass per unit volume measured in grams and volume in cm3.

As water cools more hydrogen bonds form in water and the movement of the molecules slows.

The molecules are drawn closer together and the mass per unit volume increases to 4°C where its mass is equal to its volume.

The density is therefore 1.

As ice freezes, the volume increases so icebergs float.

Densities of some common substances

Substance	Density at 25 °C (g/cm^3)
Gold	19.3
Mercury	13.5
Lead	11.4
Iron	7.87
Aluminium	2.70
Bone	1.7 - 2.0
Water	0.997
Water	1.00 (4 °C)
Ice	0.917 (0 °C)
Wood	0.11 - 1.33
Air (dry)	0.00119 (1 atm)

Densities of common substances

Illustration Bob Moffatt

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Plankton that stay near the surface through bouyancy and frictional resistance to sinking are greatly influenced by the effect of temperature on density.

In low-density warm water, plankton must be smaller or more ornate, thereby increasing the ratio of surface area to unit of body mass, in order to reduce their rate of sinking.

Crab Zoe

Illustration Bob Moffatt

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Density changes with temperature.

At a salinity of 30ppt, the colder the water the higher the density.

Seawater density for various temperatures and salinities

	Temperature (°C)						
S (‰)	0	5	10	15	20	25	30
0	0.99987	1.00000	0.99973	0.99913	0.99813	0.99707	0.99567
5	1.00397	1.00401	1.00357	1.00301	1.00207	1.00087	0.99943
10	1.00801	1.00796	1.00756	1.00684	1.00585	1.00461	1.00314
15	1.01204	1.01191	1.01144	1.01067	1.00964	1.00836	1.00686
20	1.01606	1.01585	1.01531	1.01449	1.01341	1.01210	1.01057
25	1.02008	1.01980	1.01920	1.01832	1.01720	1.01585	1.01429
30	1.02410	1.02374	1.02308	1.02215	1.02099	1.01960	1.01801
35	1.02813	1.02770	1.02697	1.02600	1.02478	1.02337	1.02176
40	1.03216	1.03166	1.03088	1.02985	1.02860	1.02715	1.02551

Densities

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Salinity temp density comparison

Illustration Bob Moffatt

So in colder high density water, plankton can be much bigger

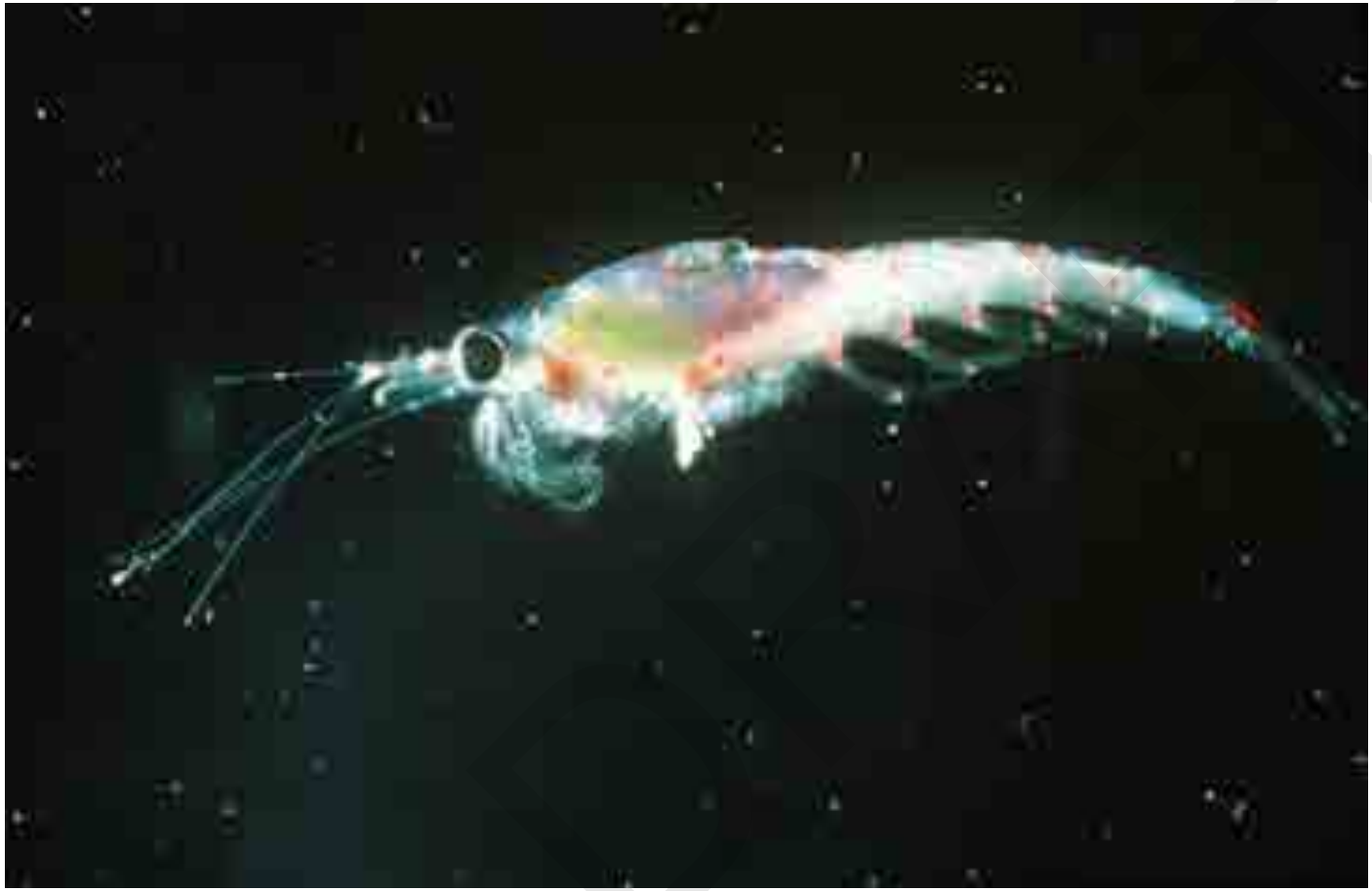

Figure Antarctic Krill
Photo ANARE

Some animals can be larger but still be plant eaters (eg Manta Ray).

Manta ray

Photo Below H20

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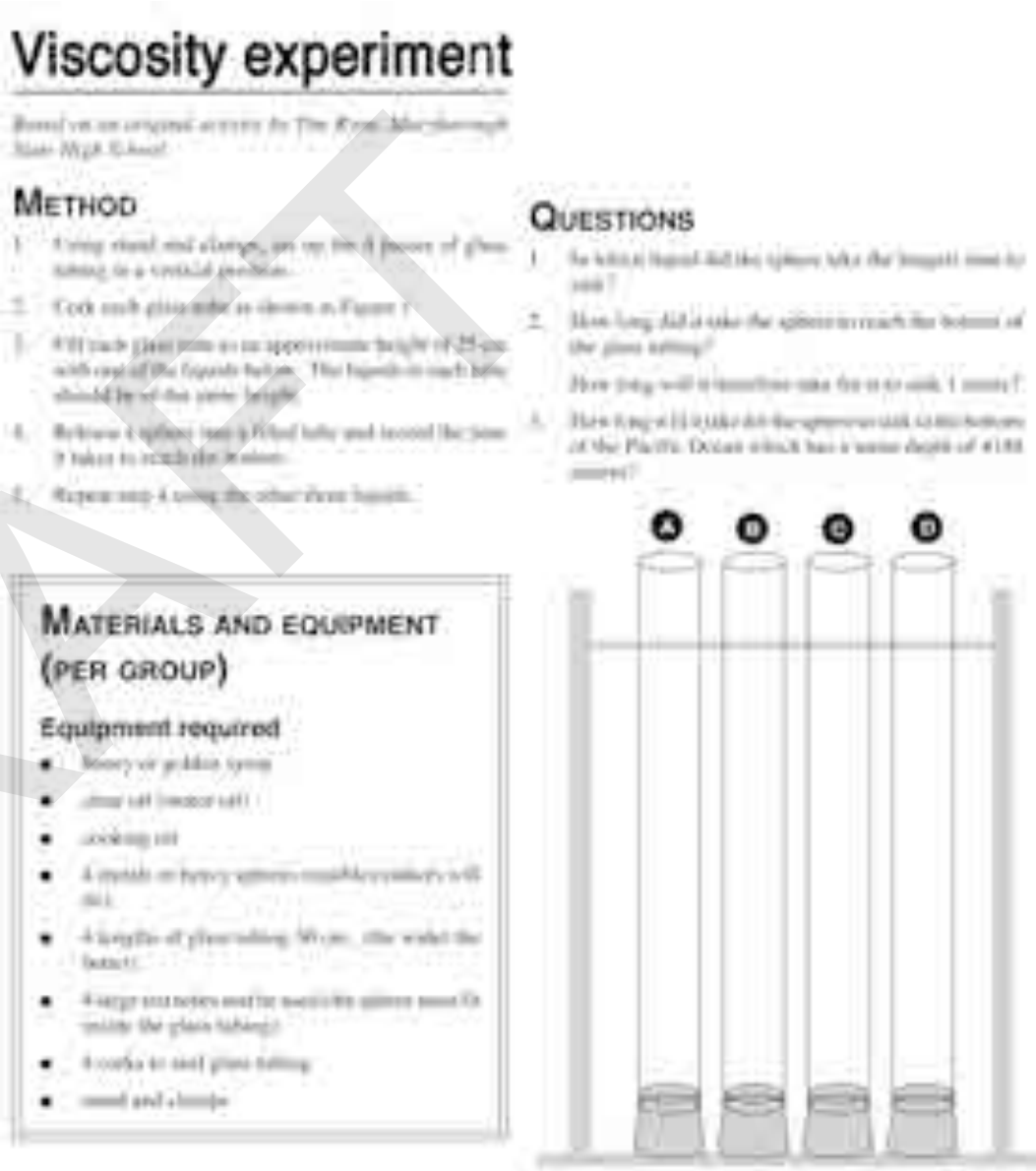
Viscosity

Viscosity is the resistance of a liquid flowing through or passing an object.

As an experiment you could drop a number of shaped objects through a number of liquids to see which was more viscous.



Viscosity experiment

Method

Questions

Materials and equipment (per group)

Equipment required

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Viscosity experiment
Illustration Bob Moffatt

Water is nearly 800 times denser than air and so it strongly resists movement.

Fish that need to move rapidly through sea water need to be more streamlined or fusiform.

Tuna

Illustration Kerry Kitzelman

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Surface tension

Where the air meets the upper layers of liquid water, the hydrogen bonds are strong making a type of skin on the water called surface tension.

This allows light animals to literally 'walk on water'.

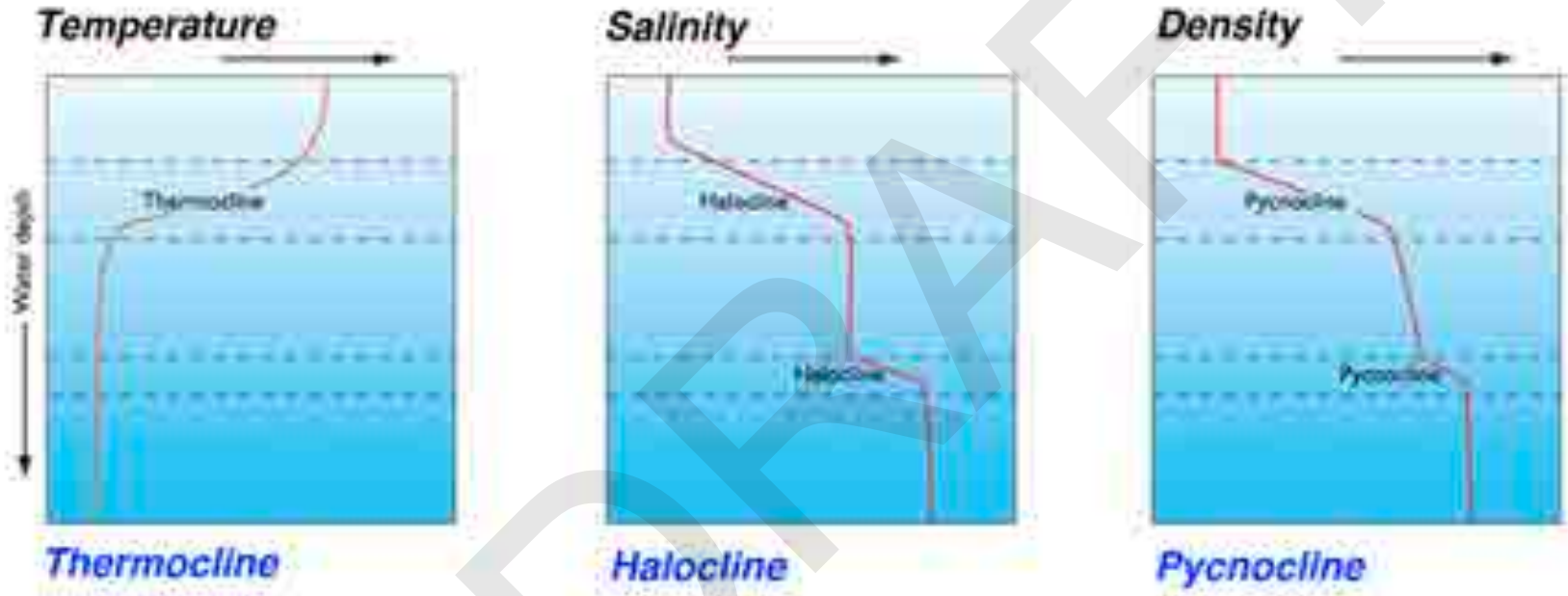
Only a few marine creatures take advantage of this including water striders in mangroves and some planktonic life forms.

Water strider

By Bruce J. Marlin [CC BY-SA 2.5 (https://creativecommons.org/licenses/by-sa/2.5)], via Wikimedia Commons

DRAFT

T007 Effects of temperature, density and salinity



Effects of temperature, density and salinity

Illustration Bob Moffatt

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Wet Paper

Syllabus statement

The syllabus says ... you should be able to define

thermocline, halocline and pycnoclin

Define - give the meaning of a word, phrase, concept or physical quantity; state meaning and identify or describe qualities

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Key points

The density of seawater depends largely on temperature and salinity.
Water temperature is regulated by the sun and varies with latitude.
Salinity depends on the effects of evaporation and rainfall and varies also with latitude.
Sharp vertical gradients of

temperature are called thermoclines;

salinity - haloclines and

density - pycnoclines

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Question

State the meaning of these terms and illustrate your answer with a graph

A. Thermocline

B. Halocline

C. Pycnoclin

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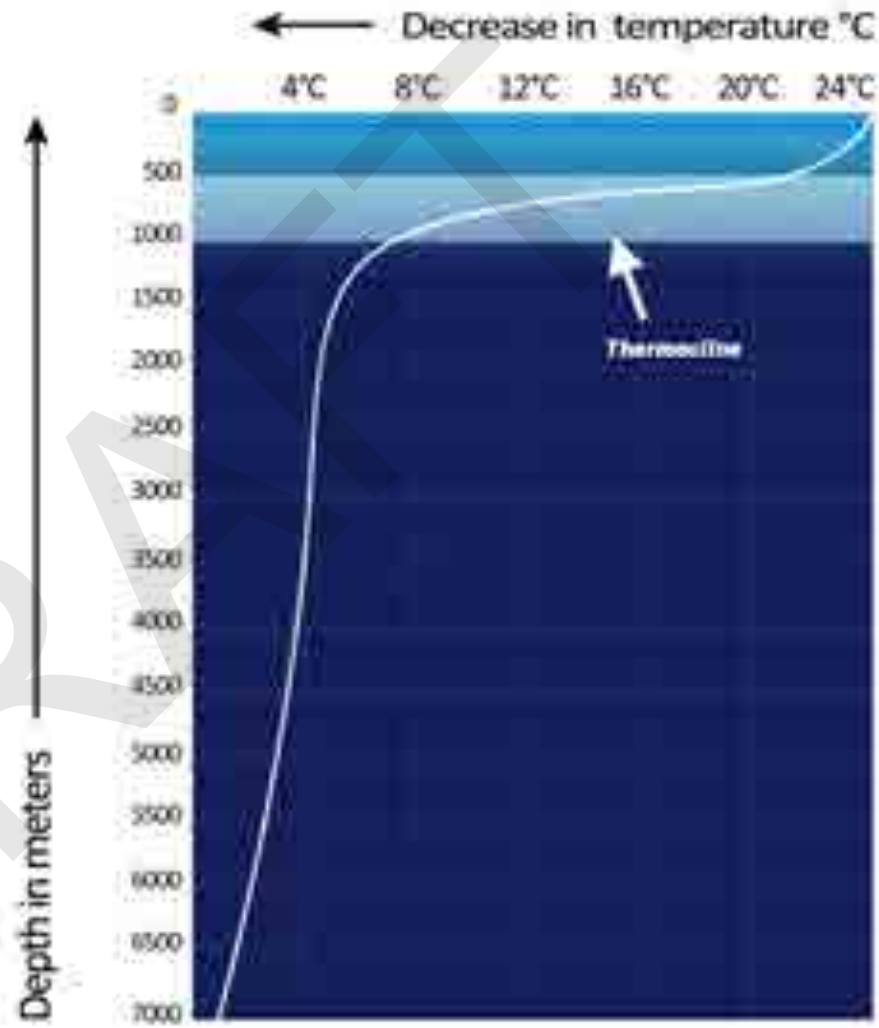
Thermocline

A thermocline is a thin but distinct layer in a large body of fluid in which temperature changes more rapidly with depth than it does in the layers above or below.



Thermocline

By Praveenron - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=31055923

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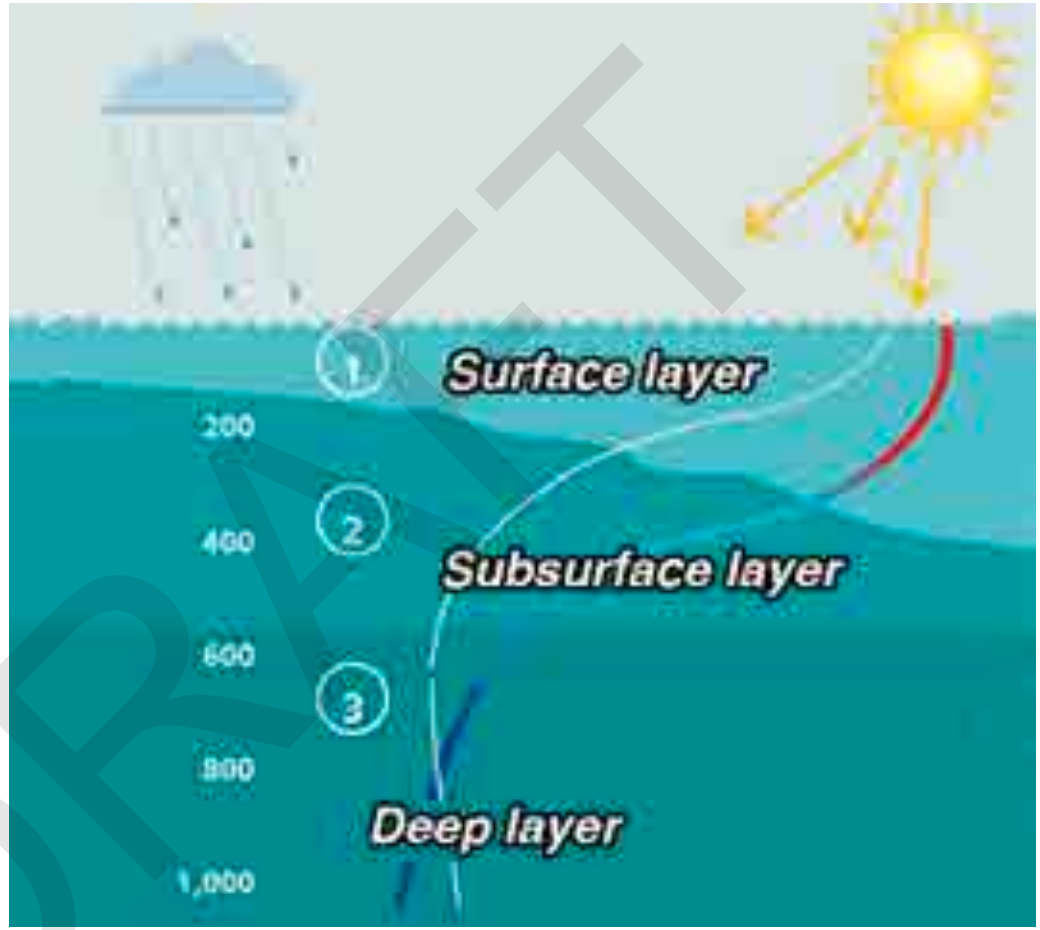
In the ocean, the thermocline divides the upper mixed layer from the calm deep water below.

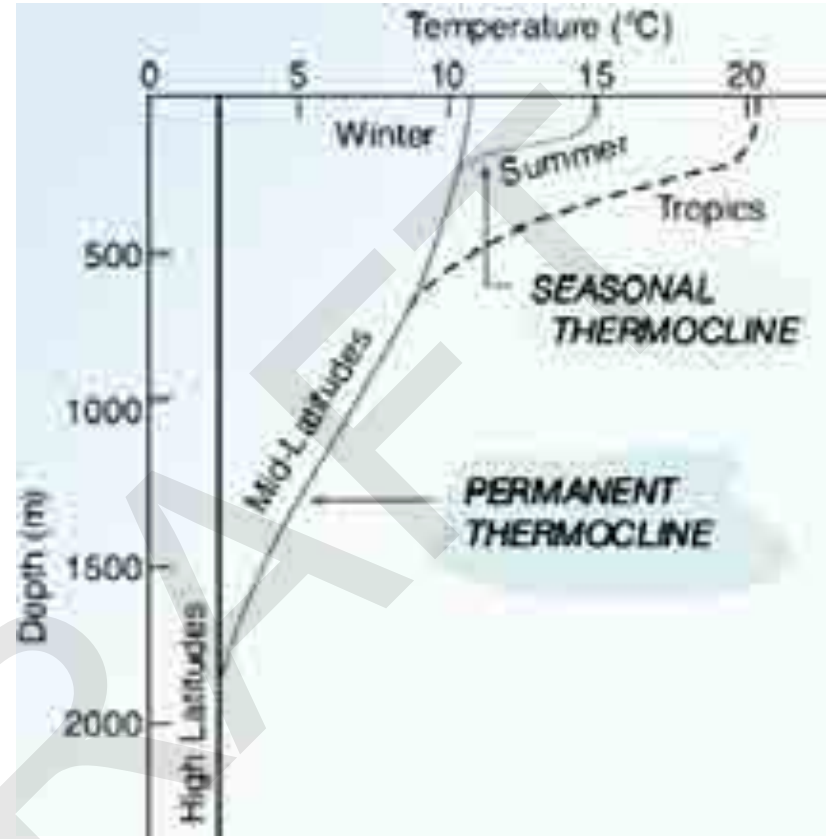


Layers in the sea

After https://www.amnh.org/exhibitions/permanent-exhibitions/rose-center-for-earth-and-space/david-s.-and-ruth-l.-gottesman-hall-of-planet-earth/what-causes-climate-and-climate-change/the-world-ocean/layers-of-the-ocean

DRAFT

Depending largely on season, latitude and turbulent mixing by wind, thermoclines may be a semi-permanent feature of the body of water.



Thermocline seasonal depth

By Welcome1To1The1Jungle at English Wikipedia, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=4849808

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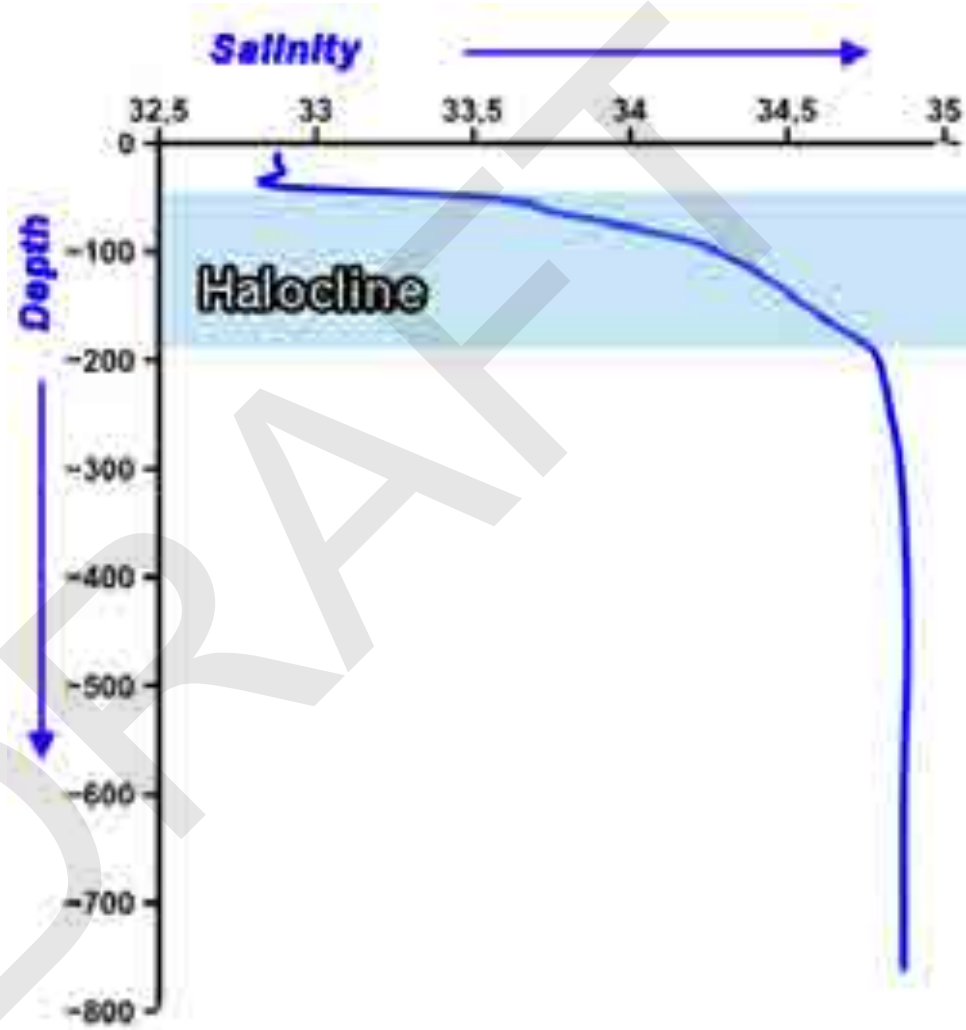
Halocline

This is an intermediate layer of oceanic water in which salinity increases more rapidly with depth than in the layers above and below it.



Halocline

Illustration Bob Moffatt

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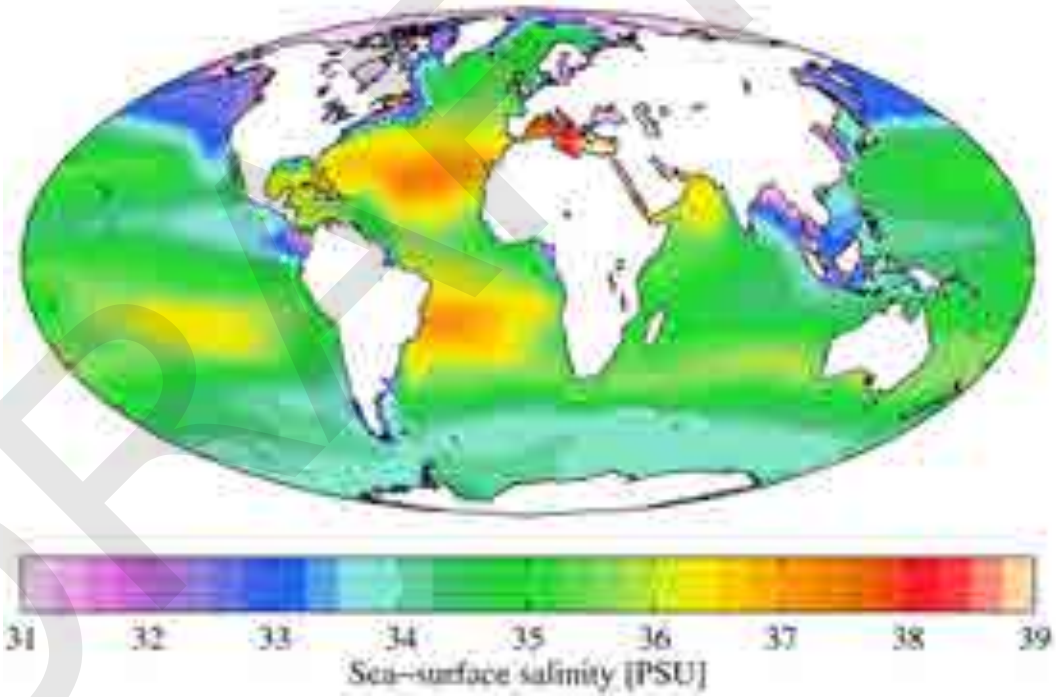
In the midlatitudes, an excess of evaporation over precipitation leads to surface waters being saltier than deep waters. Here the halo cline can cause salt water to mix.

In high latitudes regions surface waters are actually colder than the deep waters.

The halocline is responsible for maintaining water column stability allowing for the formation of sea ice, and limiting the escape of carbon dioxide to the atmosphere.



Sea surface salinities

By Plumbago - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=23016243

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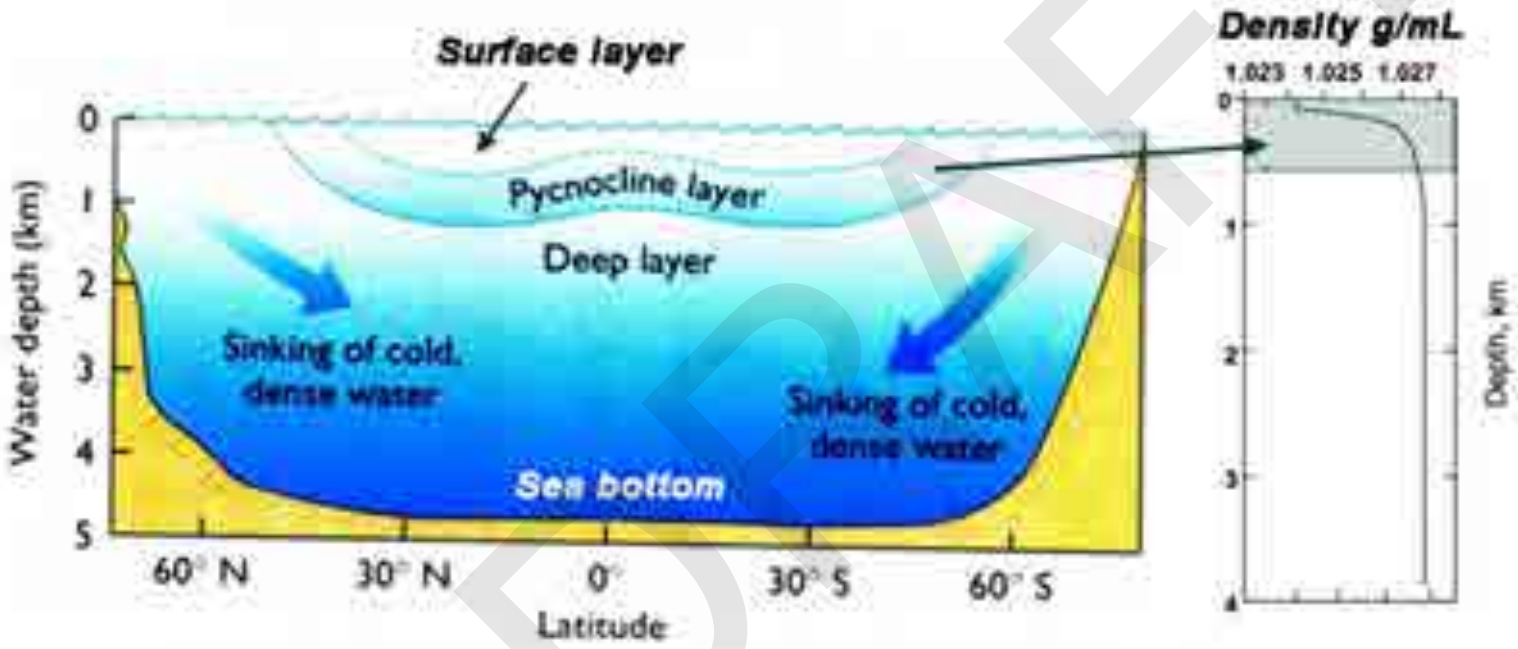
Pycnoclines

A pycnocline is the cline or layer where the density gradient is greatest within a body of water.



Pycnocline layer

After http://ocean.stanford.edu/courses/bomc/chem/lecture_03.pdf

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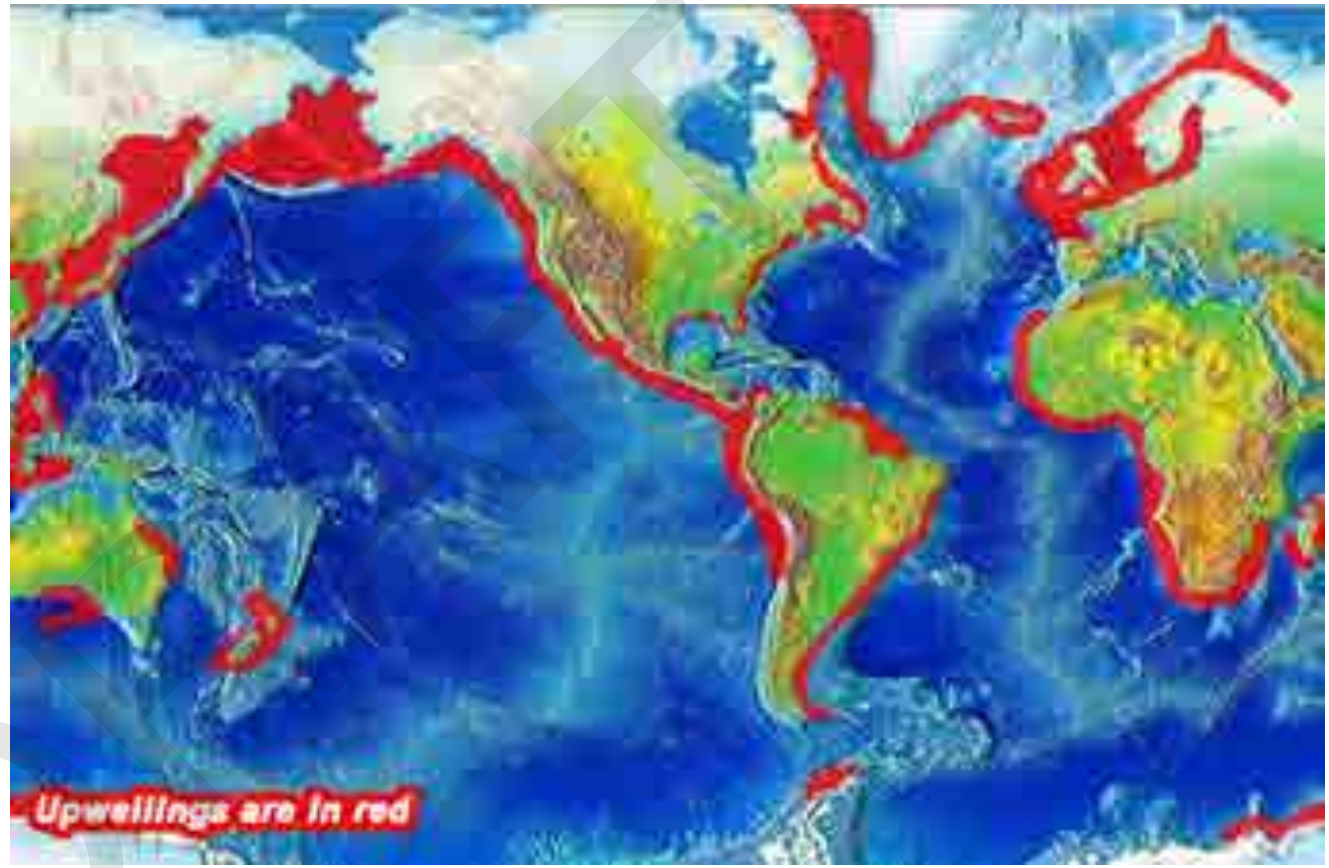
The physical properties in a pycnocline driven by density gradients also affect the flows and vertical profiles in the ocean.

These changes can be connected to the transport of heat, salt, and nutrients through the ocean, and the pycnocline diffusion controls upwelling.

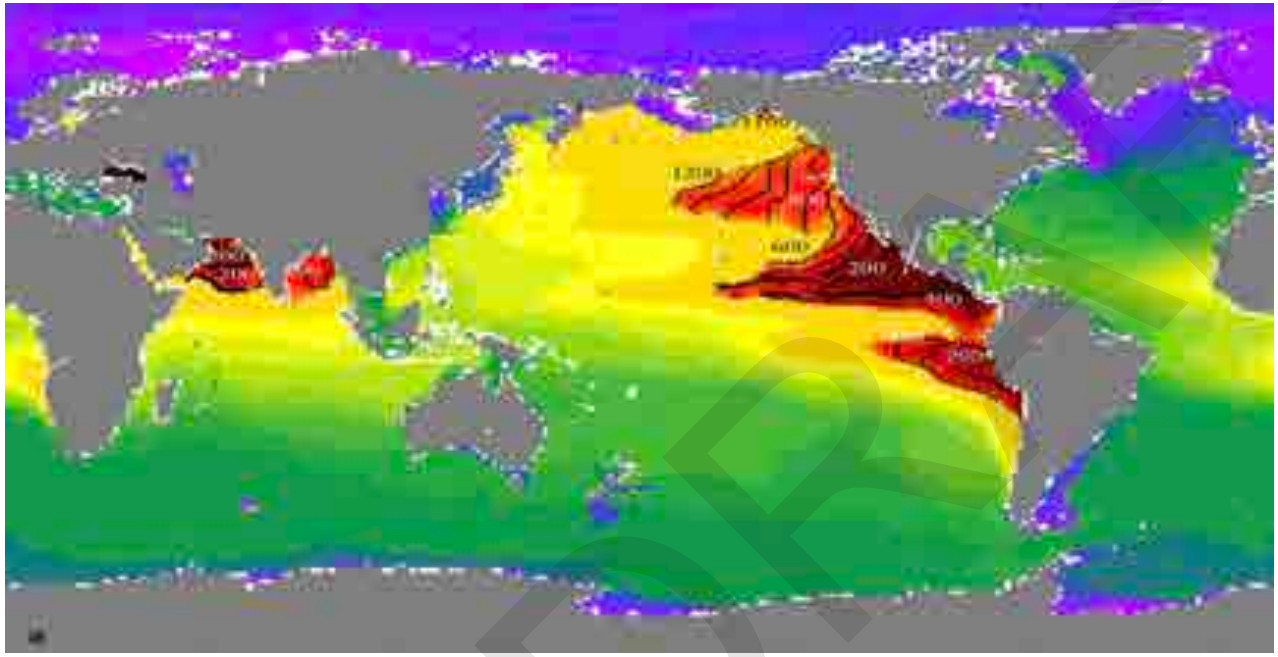


World upwellings

By NOAA - http://oceanservice.noaa.gov/education/kits/currents/media/upwelling_image1.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=5717898

DRAFT

T008 Oxygen minimum zone



From A. Paulmier, D. Ruiz-Pino / Progress in Oceanography 80 (2009) 113–128. O2 distribution (IM) at depth where O2 concentration is minimal, indicating the extent of the OMZs (in red) according to the WOA2005 climatology

DRAFT

Wet Paper

Syllabus statement

The syllabus says ... you should be able to recognise how thermoclines and nutrients produce the oxygen minimum within the open ocean

Recognise - identify or recall particular features of information from knowledge; identify that an item, characteristic or quality exists; perceive as existing or true; be aware of or acknowledge

DRAFT

Definition

The Oxygen minimum zone (OMZ), is the zone in which oxygen saturation in seawater in the ocean is at its lowest.

This zone occurs at depths of about 200 to 1,500 m depending on
A. Nutrient production in the ocean surface layer
B. Pycnocline bacterial stability
C. Nutrients from upwellings affected by thermoclines

Reference
Oxygen minimum zonehttps://en.wikipedia.org/wiki/Oxygen_minimum_zone

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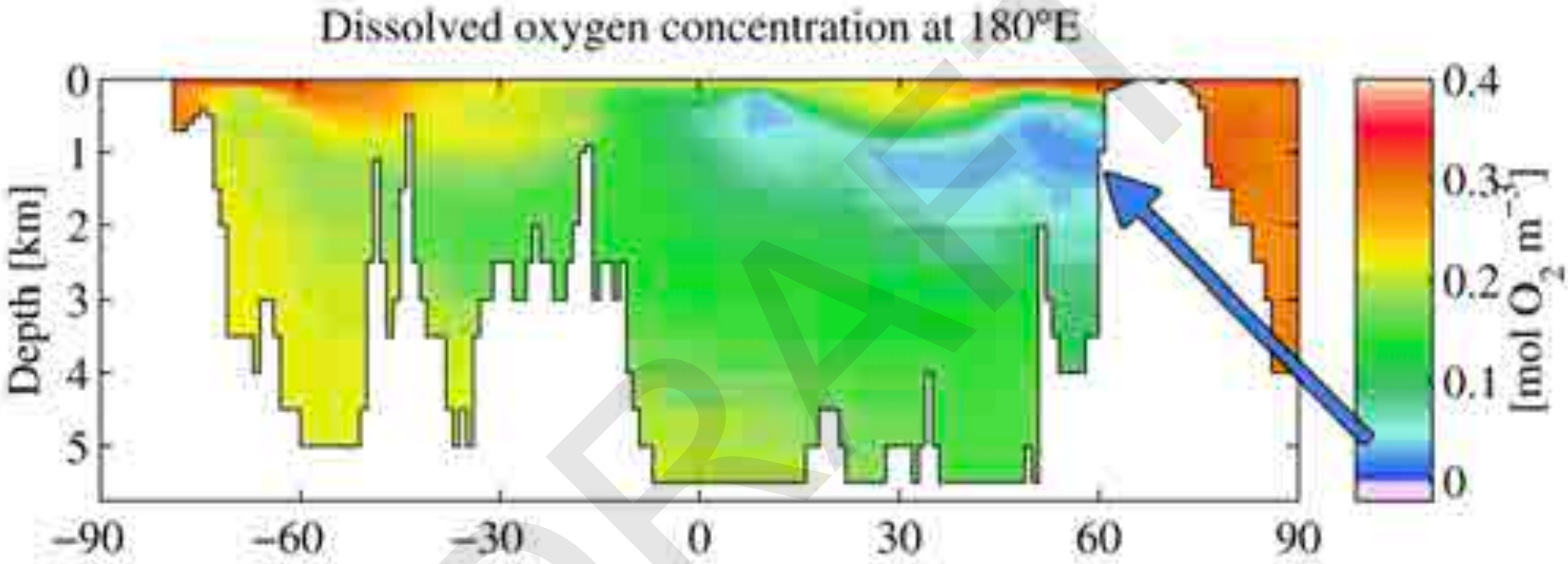

Oxygen minimum zone

By Plumbago [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons In the upper panel a minimum in oxygen content is indicated by light blue shading between 0° (equator) and 60°N at an average depth of ca. 1,000 m (3,300 ft).

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Question

How do thermoclines and nutrients produce an oxygen minimum zone within the open ocean?

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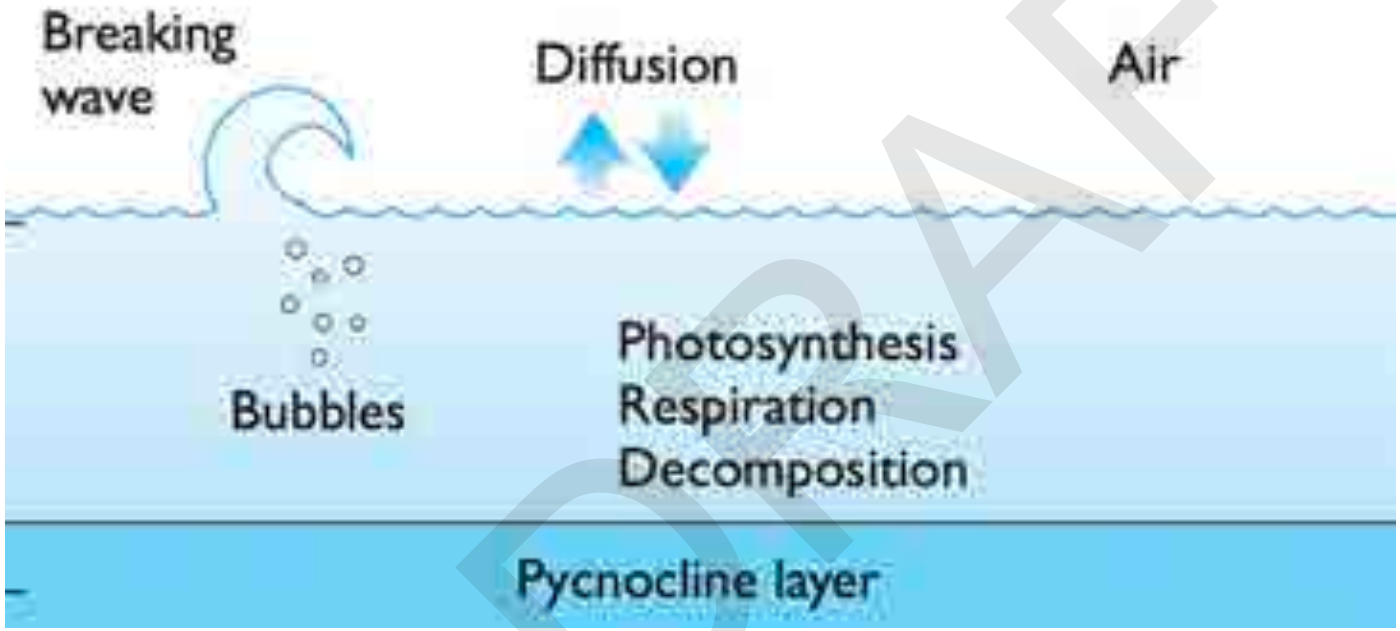
Surface ocean layers and nutrient production

In the surface layers, oxygen is supplied by diffusion with the atmosphere.



Oxygen at the surface

From Jones and Bartlett Chapter 4

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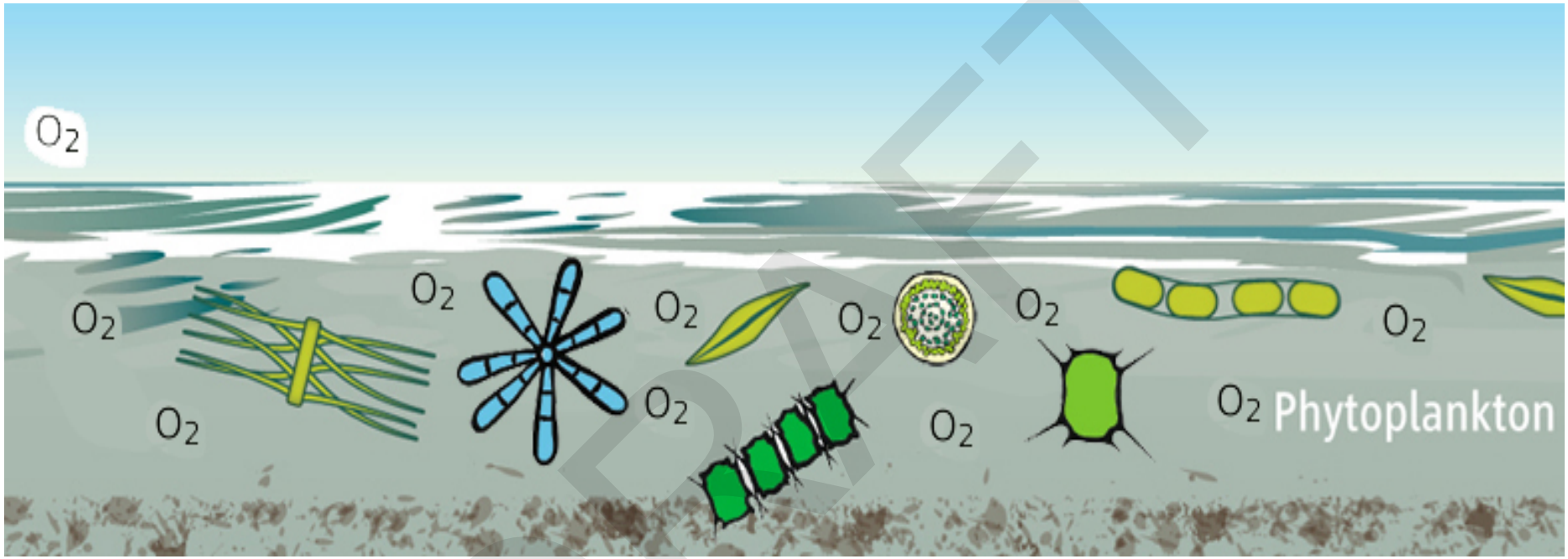
Phytoplankton also produce large amounts of oxygen and die



Phytoplankton in surface layers

Illustration Bob Moffatt

DRAFT

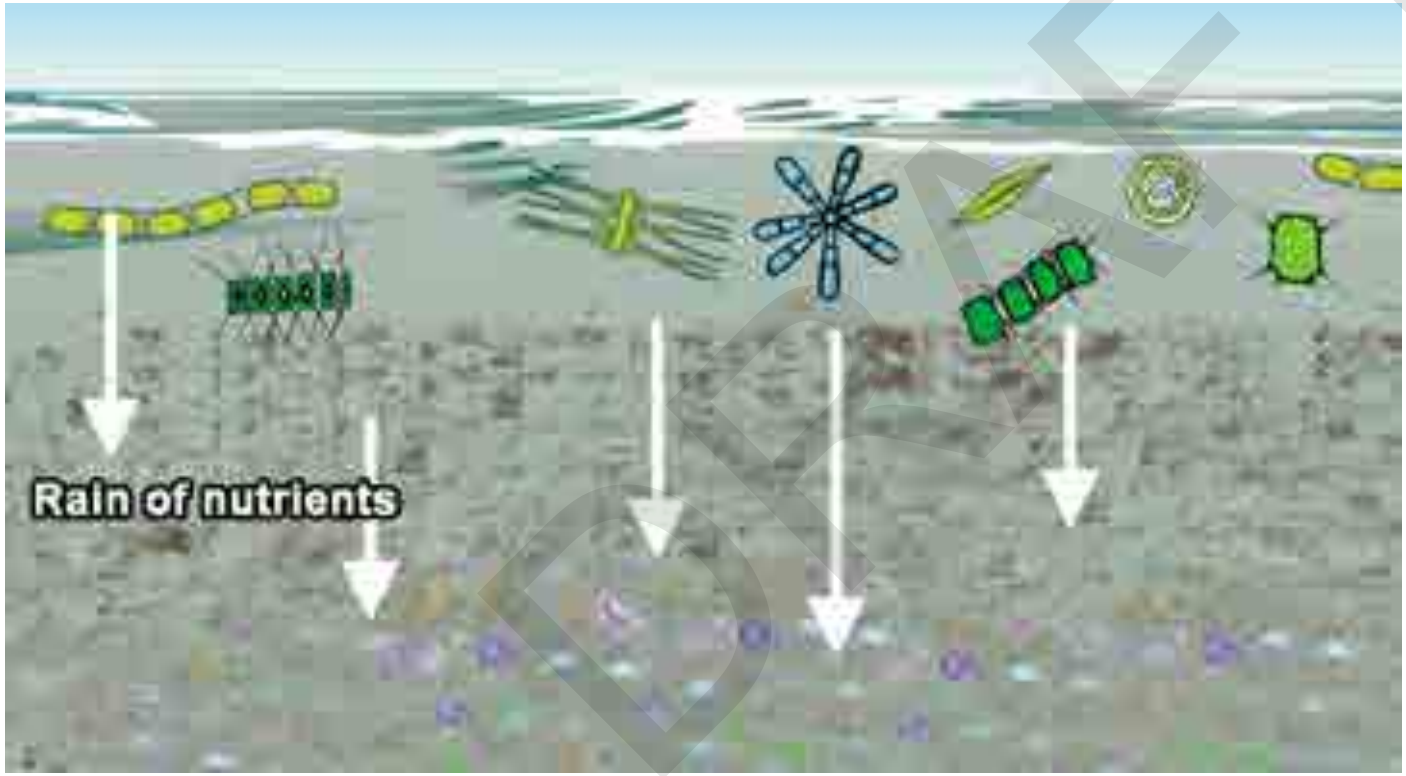
Zooplankton feed on phytoplankton, produce carbon dioxide for phytoplankton and die leaving bacteria to use up the oxygen.

Phyto and zoo plankton in surface layers
Illustration Bob Moffatt

DRAFT

Photosynthesis produces high concentrations of oxygen, animals use this to respire then die and decompose creating more nutrients.

A rain of nutrient is produced from this layer comprising phytodetritus, dead organisms, fecal pellets, excretions, shed shells, scales, and other parts.



Nutrient rain

Illustration Bob Moffatt

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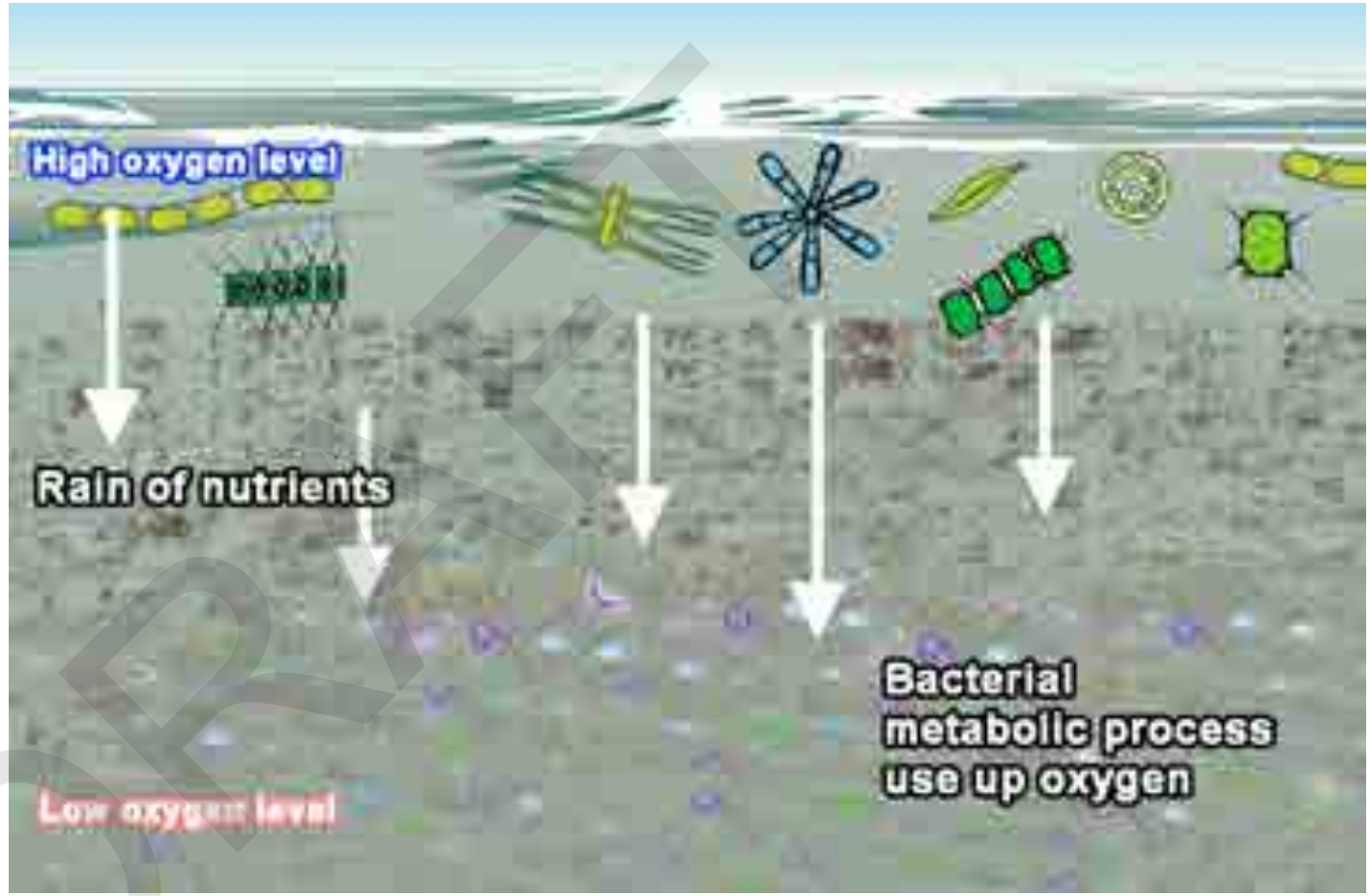
Pycnocline stability

The sharp pycnocline indicates that the water column is stable and that vertical mixing of water is minimal at these intermediate depths.

Aerobic bacteria feed on a rain of nutrient matter from above.



Decomposer layer and OMZ

Illustration Bob Moffatt

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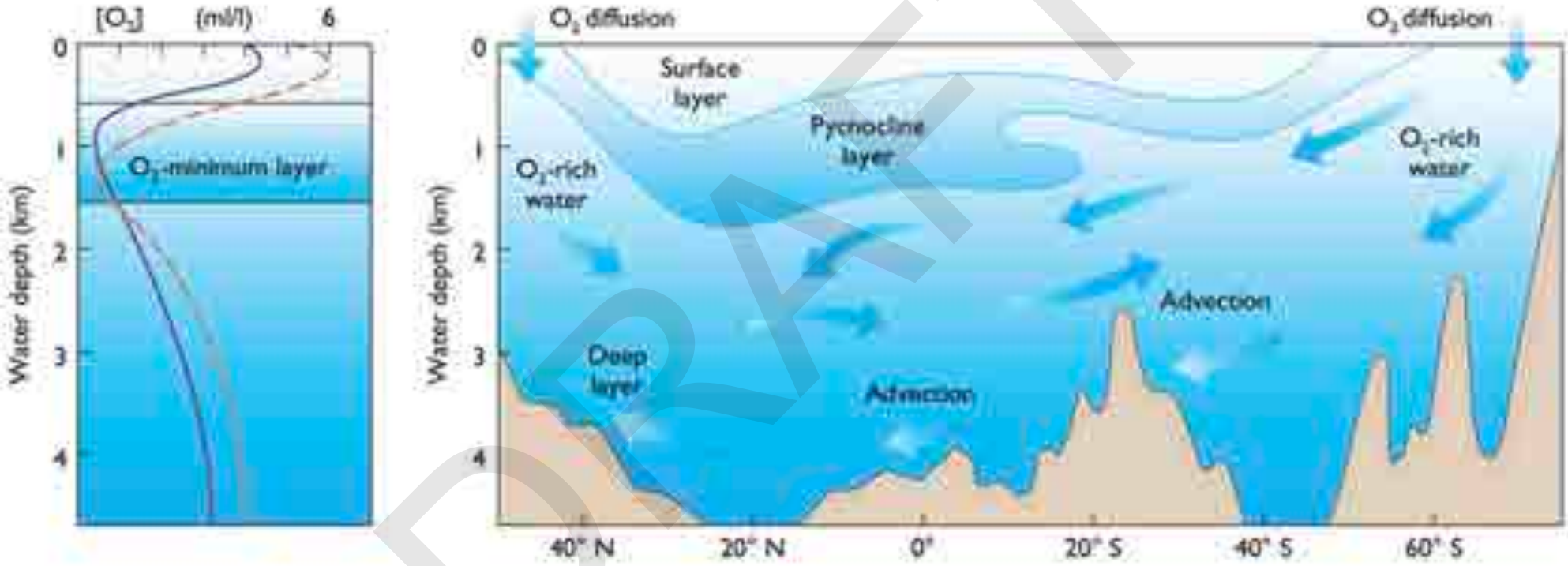
Oxygen is used as part of the bacterial metabolic process lowering its concentration within the water creating the oxygen mimimum layer (OMZ).



Oxygen mimimum layer and pycnocline

From Jones and Bartlett Chapter 4

DRAFT

Upwelling nutrients and thermoclines

Nutrient-rich water rise from deeper levels to replace the surface water that has drifted away due to Ekman transport. The increased nutrients support phytoplankton blooms, zooplankton grazing, and an overall productive food web at the surface.

Upwelling and Ekman transport

Illustration Bob Moffatt

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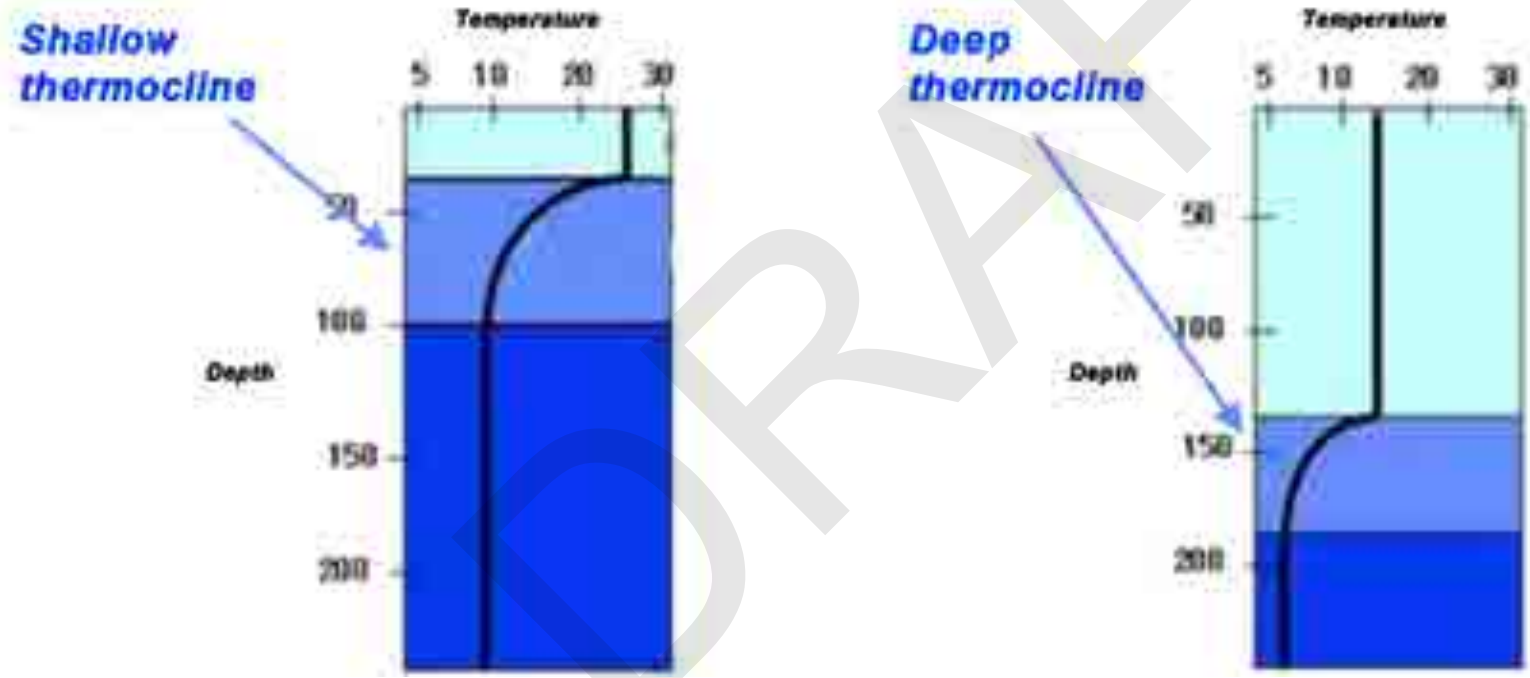
The effectiveness of upwelling and its ability to support abundant sea life is greatly dependent upon the depth of the thermocline.

A deeper thermocline limits the amount of nutrients brought to shallower depths by upwelling processes.

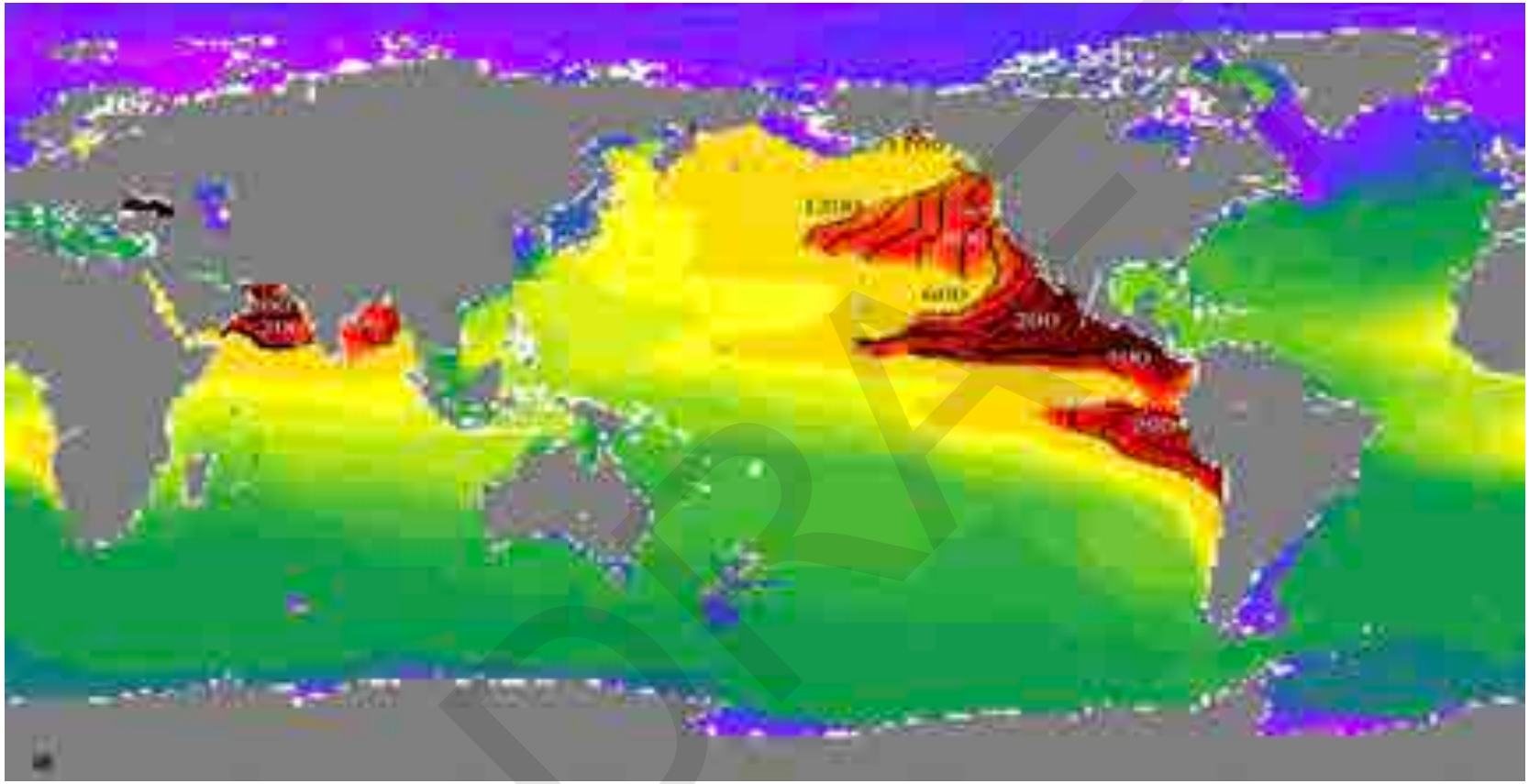


Deep and shallow thermoclines

Illustration Bob Moffatt

DRAFT

The distribution of the open-ocean oxygen minimum zones is controlled by the large-scale ocean circulation as well as local physical as well as biological processes.

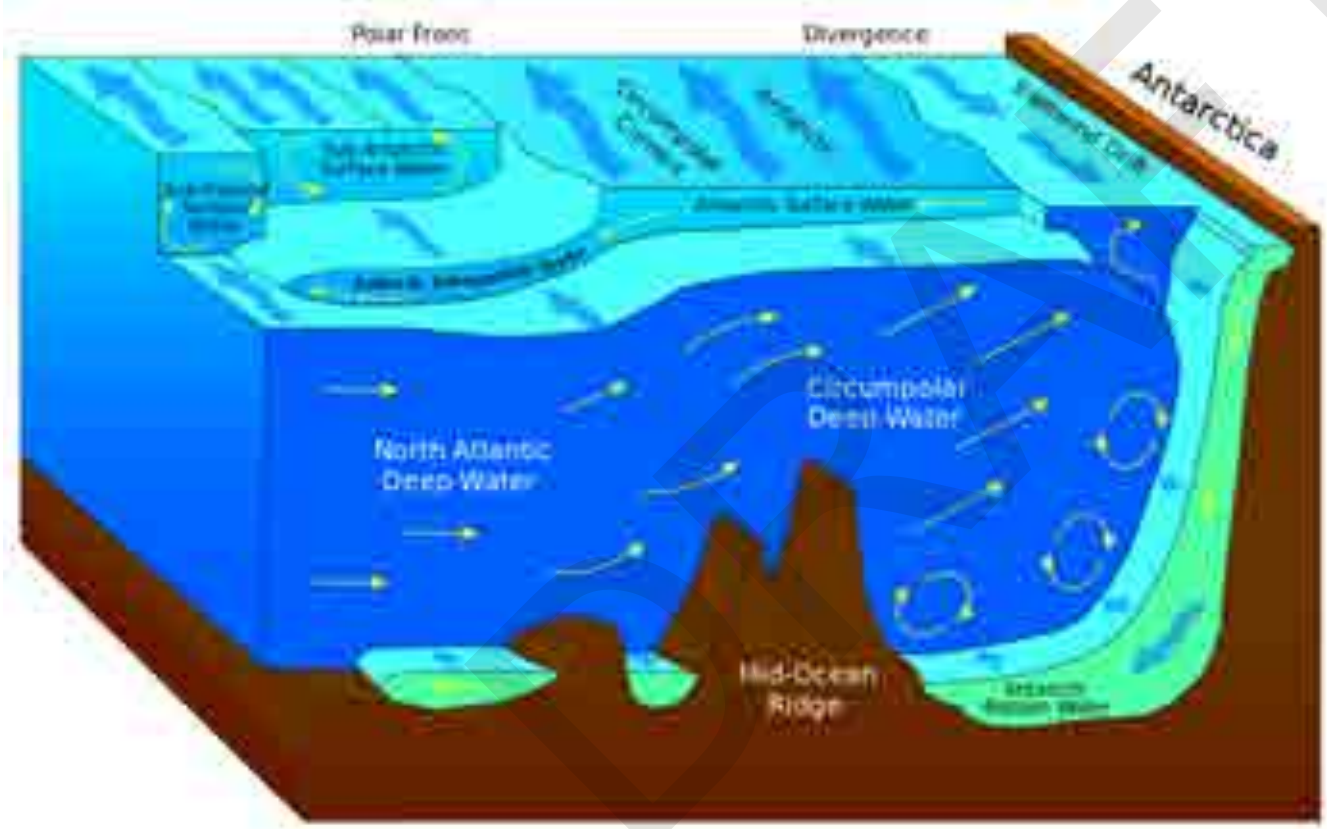


Oxygen minimum zones

From A. Paulmier, D. Ruiz-Pino / Progress in Oceanography 80 (2009) 113–128. O2 distribution (lM) at depth where O2 concentration is minimal, indicating the extent of the OMZs (in red) according to the WOA2005 climatology

DRAFT

T009 Deep ocean circulation



•By Fred the Oyster [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia commons

Wet Paper

Syllabus statement

The syllabus says ... you should be able to

explain how thermohaline circulation in the deep ocean is affected by salinity and water density

Explain- make an idea or situation plain or clear by describing it in more detail or revealing relevant facts; give an account; provide additional information.

DRAFT

Question

Describe how deep ocean circulation is affected by salinity and water density as it travels along the ocean conveyor belt.

DRAFT

Density differences

As water currents pass through the tropics higher temperatures cause pure water to evaporate increasing salt concentrations. Density increases and water starts to sink.

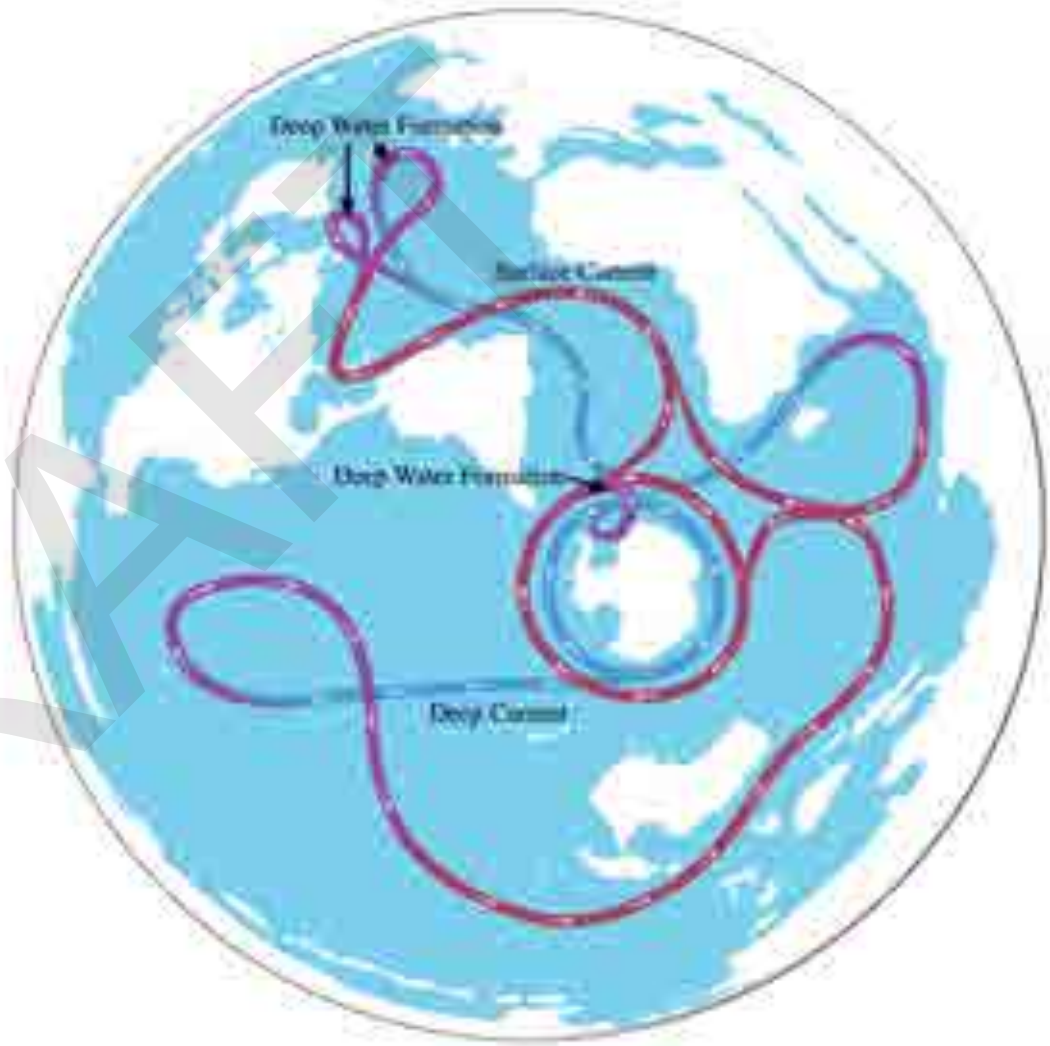
Density increases in lower latitudes

by Avsa - Own workThis file was derived from:Oceans-image.svg, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=8385268

DRAFT

Cold water in polar zones sinks relatively rapidly over a small area, while warm water in temperate and tropical zones rise more gradually across a much larger area.

Great quantities of dense water sinking at high latitudes are offset by equal quantities of water rising elsewhere in the ocean causing a conveyor belt of warm and cold water.



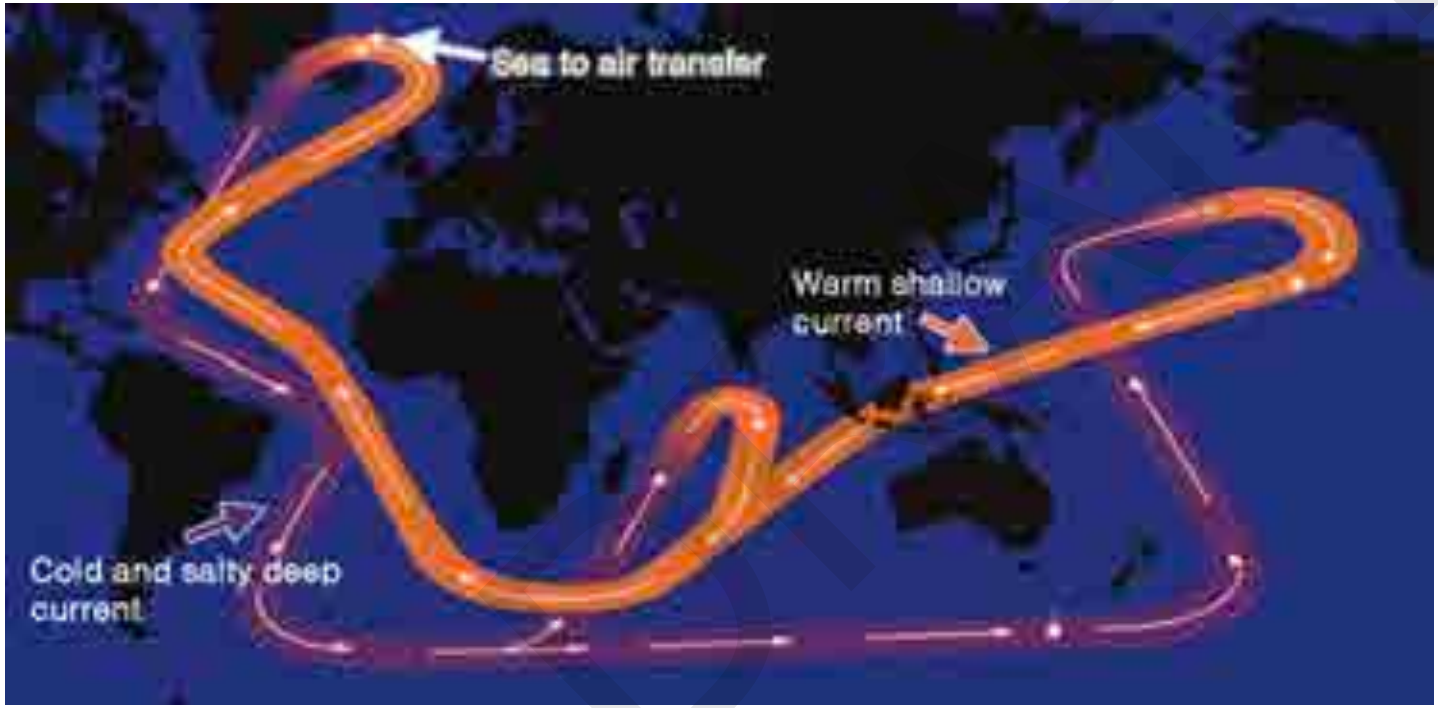
Conveyor belt

By Avsa - Own workThis file was derived from:Oceans-image.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=8385268

DRAFT

Thermohaline circulation is mainly vertical.

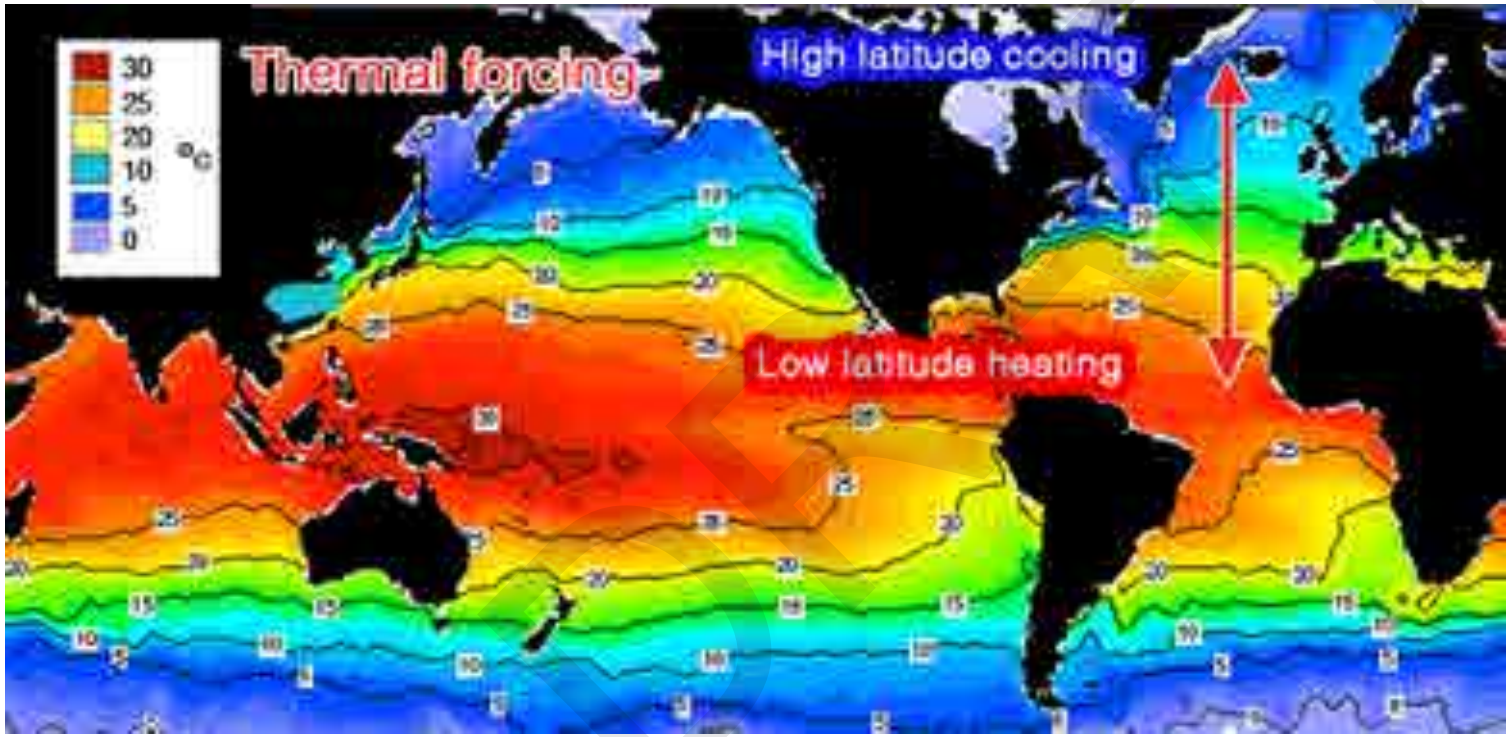
It is driven by the formation and sinking of deep water in the Greenland-Iceland-Norwegian Sea, and is probably responsible for the large flow of surface water past Indonesia, from the Pacific to the Indian Ocean.



Deep and shallow currents

Adapted from http---www.rapid.ac.uk-sis-popups-currents_thc.php.jpg

The North Atlantic conveyor belt is controlled by thermal forcing (differences in temperature due to high latitude cooling and low-latitude heating) drives
- the flow northwards at the surface, and
- southwards at depth.



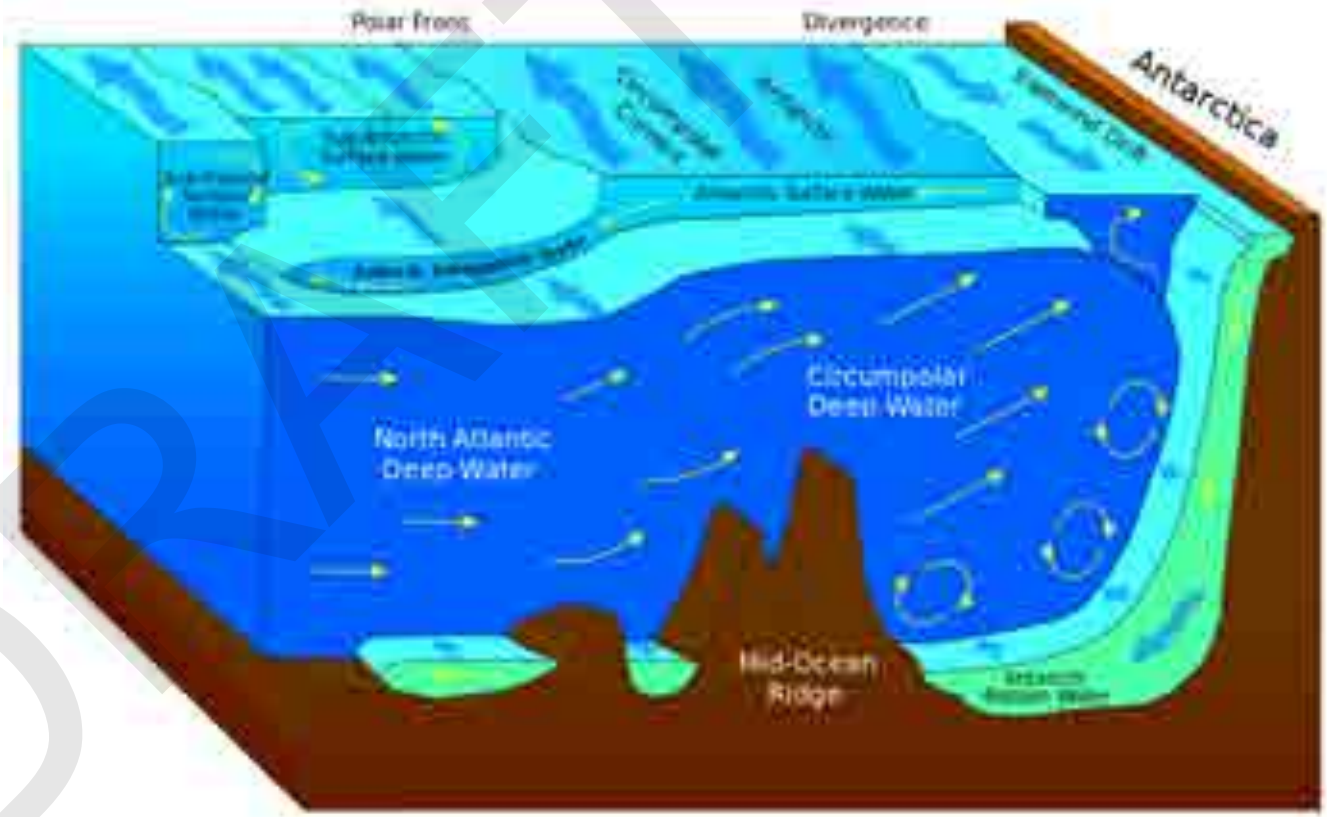
Thermal forcing

Adapted from http---www.rapid.ac.uk-sis-popups-currents_thc.php.jpg

Water movement

From the North Atlantic, it flows very slowly into the deep abyssal plains of the Atlantic toward Antarctica where the water mass joins the Antarctic Circumpolar Current.

Flow from the Arctic Ocean Basin into the Pacific is blocked by the narrow shallows of the Bering Strait.



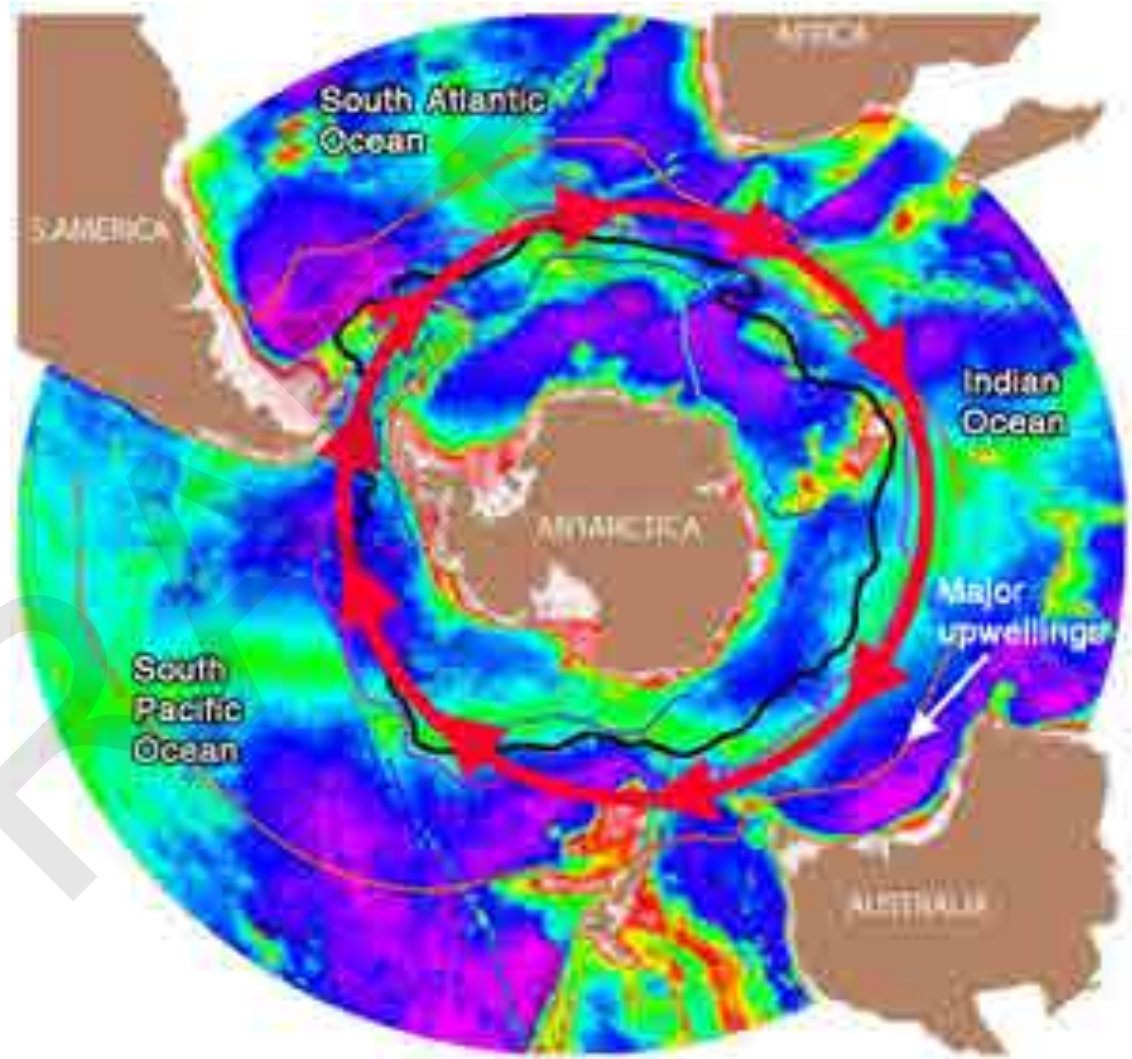
Water mass bodies of the Southern Ocean

By Fred the Oyster [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia commons

DRAFT

In Antarctica the combined effect of evaporative cooling and brine exclusion cause the density of the Antarctic bottom water to be so high, that it in fact underflows the current in the Atlantic Basin.

Flow of the current into the Pacific is blocked by the Drake Passage between the Antarctic Peninsula and the southernmost tip of South America.

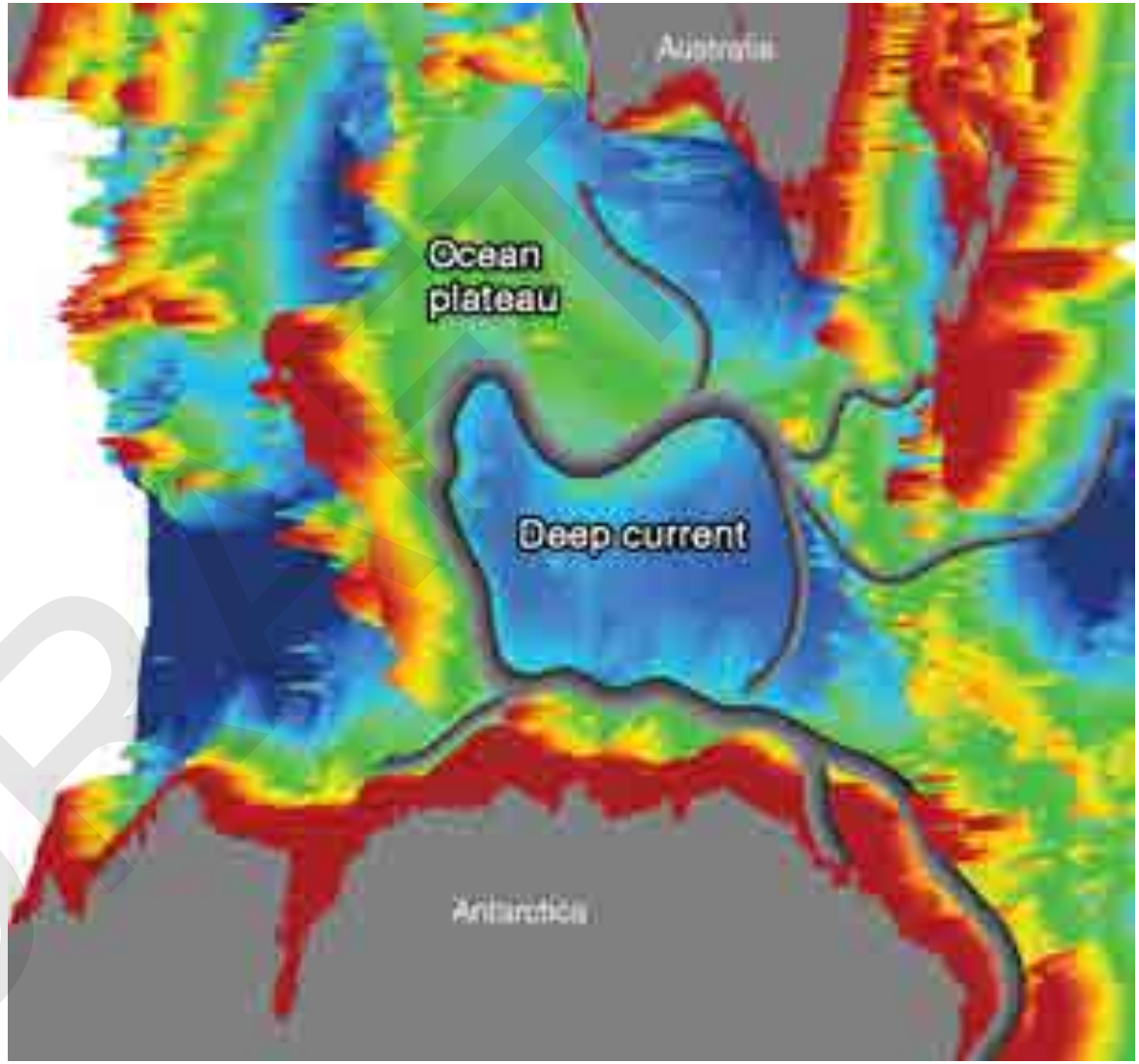


Antarctic circum polar current

By NASA (NASA) [Public domain], via Wikimedia Commons

DRAFT

CSIRO has recently discovered deep ocean currents found between Australia and Antarctica on an ocean plateau.



Kerguelen plateau deep ocean current

By CSIRO, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=35497339

DRAFT

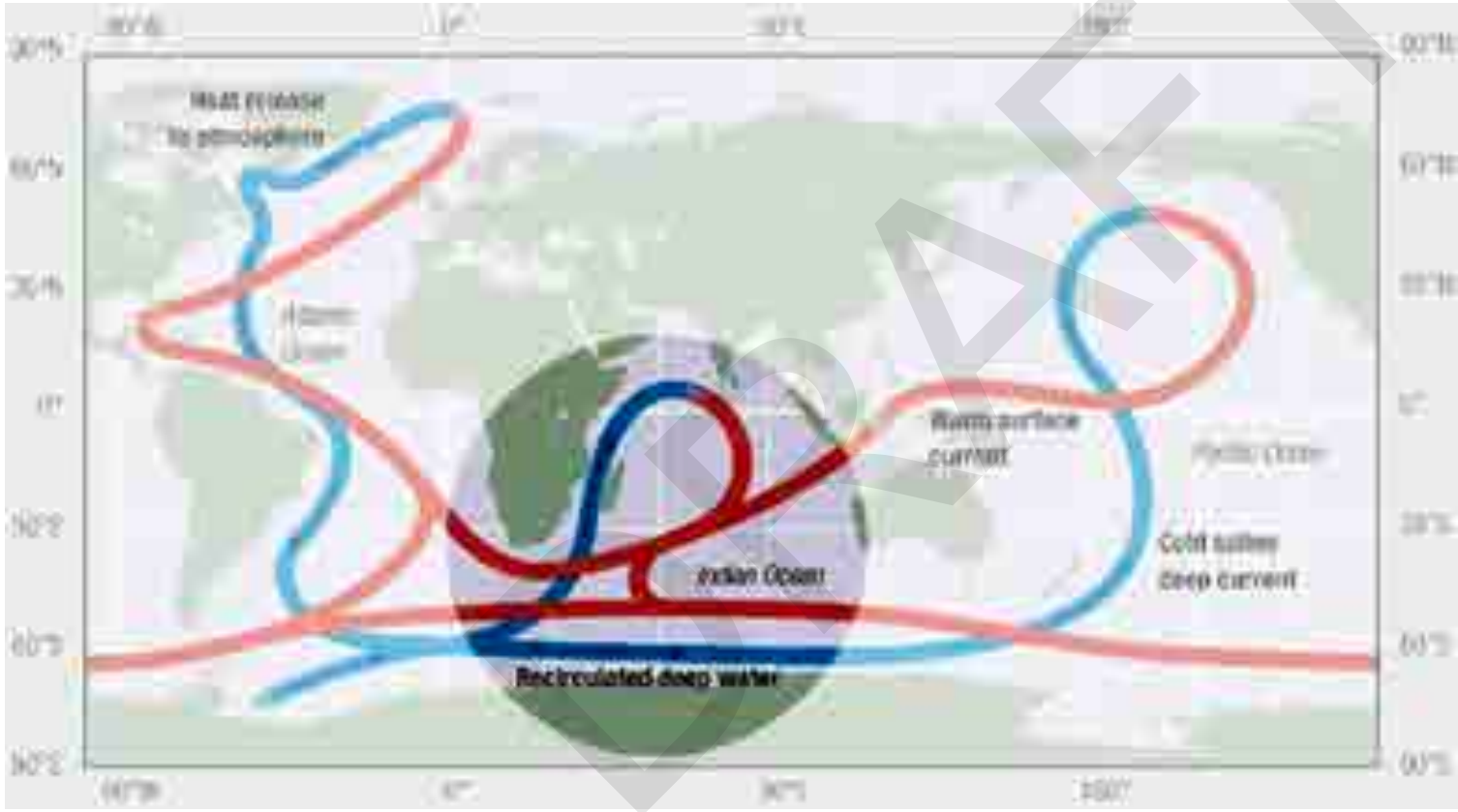
Antarctic Circumpolar Currents are mixed to create the so-called “Common Water” which flows northward, around Southern Africa where it is split into two routes: one into the Indian Ocean and the other past Australia into the Pacific.

Common water rising

Adapted from http---www.rapid.ac.uk-sis-popups-currents_thc.php.jpg

Salinity

In the Indian Ocean, some of the cold and salty water from the Atlantic are refreshed, by means of vertical exchange, with the warmer upper ocean water from the tropical Pacific

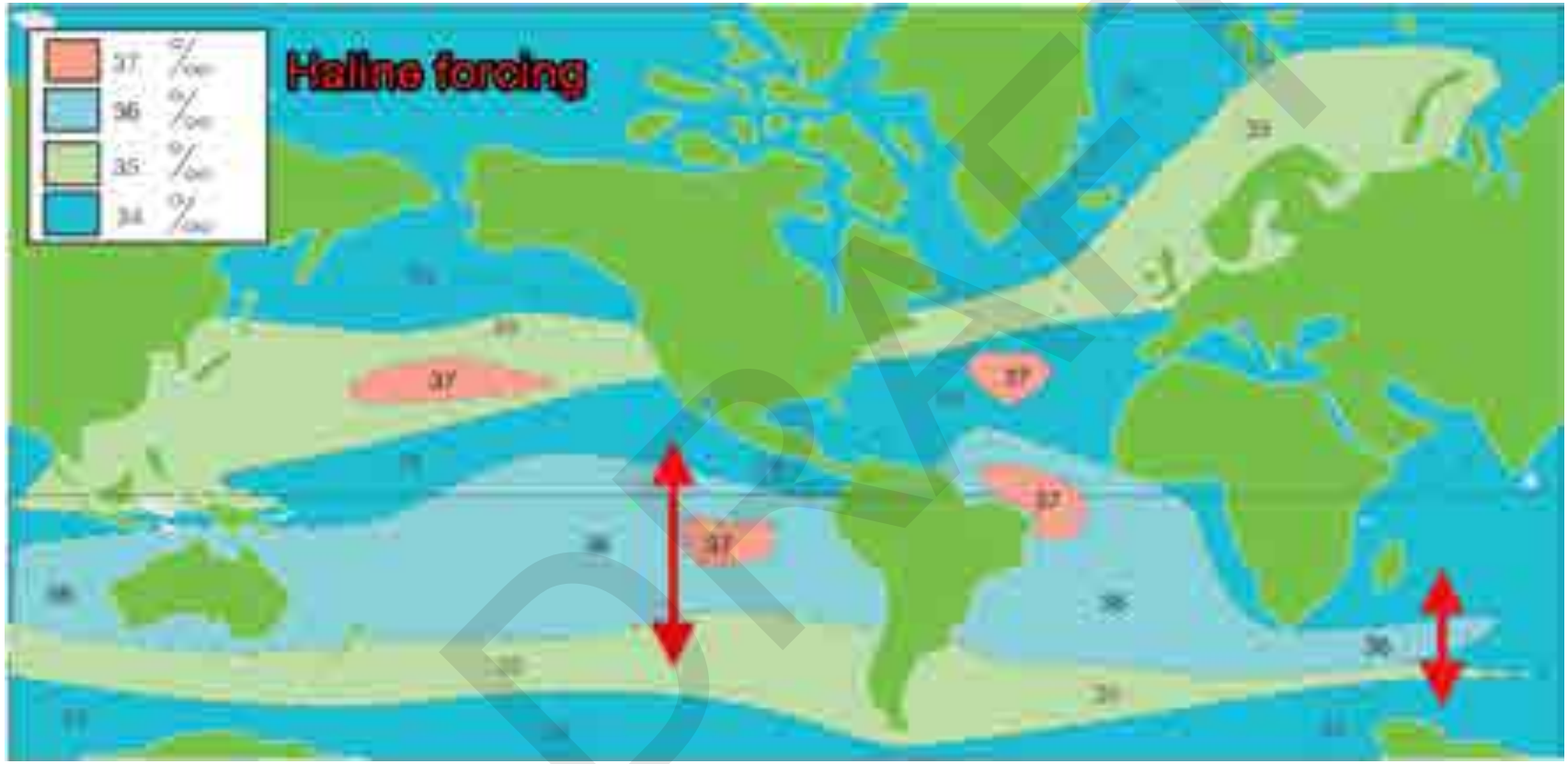


Indian Ocean deep water refreshment

http://www.marbef.org/wiki/Thermohaline_circulation_of_the_oceans

DRAFT

Within the Pacific Ocean, the remaining cold water undergoes **Haline forcing** (net high latitude freshwater gain and low latitude evaporation) and slowly becomes warmer and fresher.



Haline forcing

Illustration Bob Moffatt

DRAFT

Haline forcing

(differences in salinity due to high-latitude freshwater gain and low-latitude evaporation)

Drives current flow south at the surface

And northwards at depth.

DRAFT

The outflow of bottom water makes the sea level of the Pacific Ocean 20 cm higher than the Atlantic Ocean.

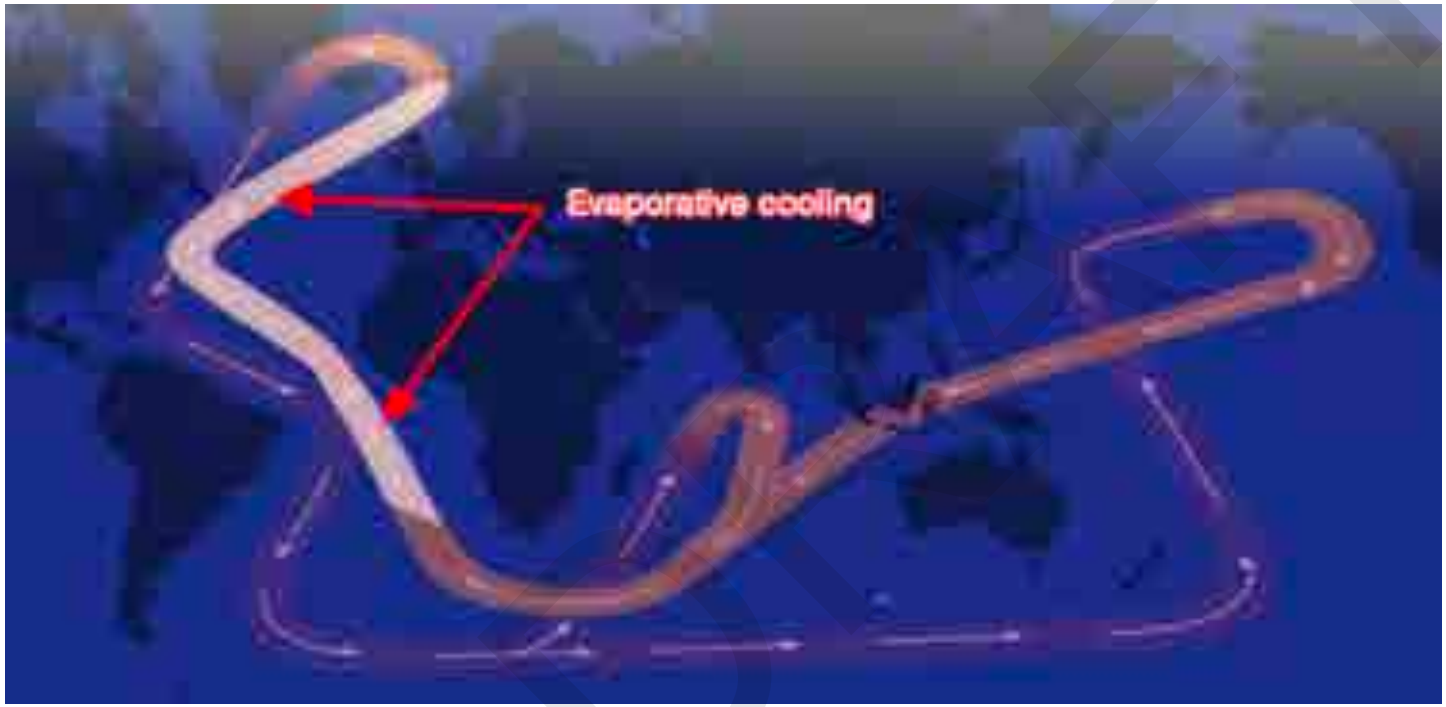
Combined with the difference in salinity, this generates a large flow of warmer upper ocean water from the tropical Pacific to the Indian Ocean through the Indonesian Archipelago.

Indonestian flow thru

https://creativecommons.org/licenses/by-sa/4.0-3.0-2.5-2.0-1.0)], from Wikimedia Commons. Right Adapted from CSIRO Commonwealth of Australia

From there, the water flows up through the South Atlantic towards the tropics.

The heated tropical waters of the Atlantic proceed until Greenland, where it once more undergoes evaporative cooling, thereby creating a continuous global thermohaline circulation.



Evaporative cooling

Adapted from http---www.rapid.ac.uk-sis-popups-currents_thc.php.jpg

DRAFT

Review

Temperature, wind and gravity drive this conveyor belt in four ways.

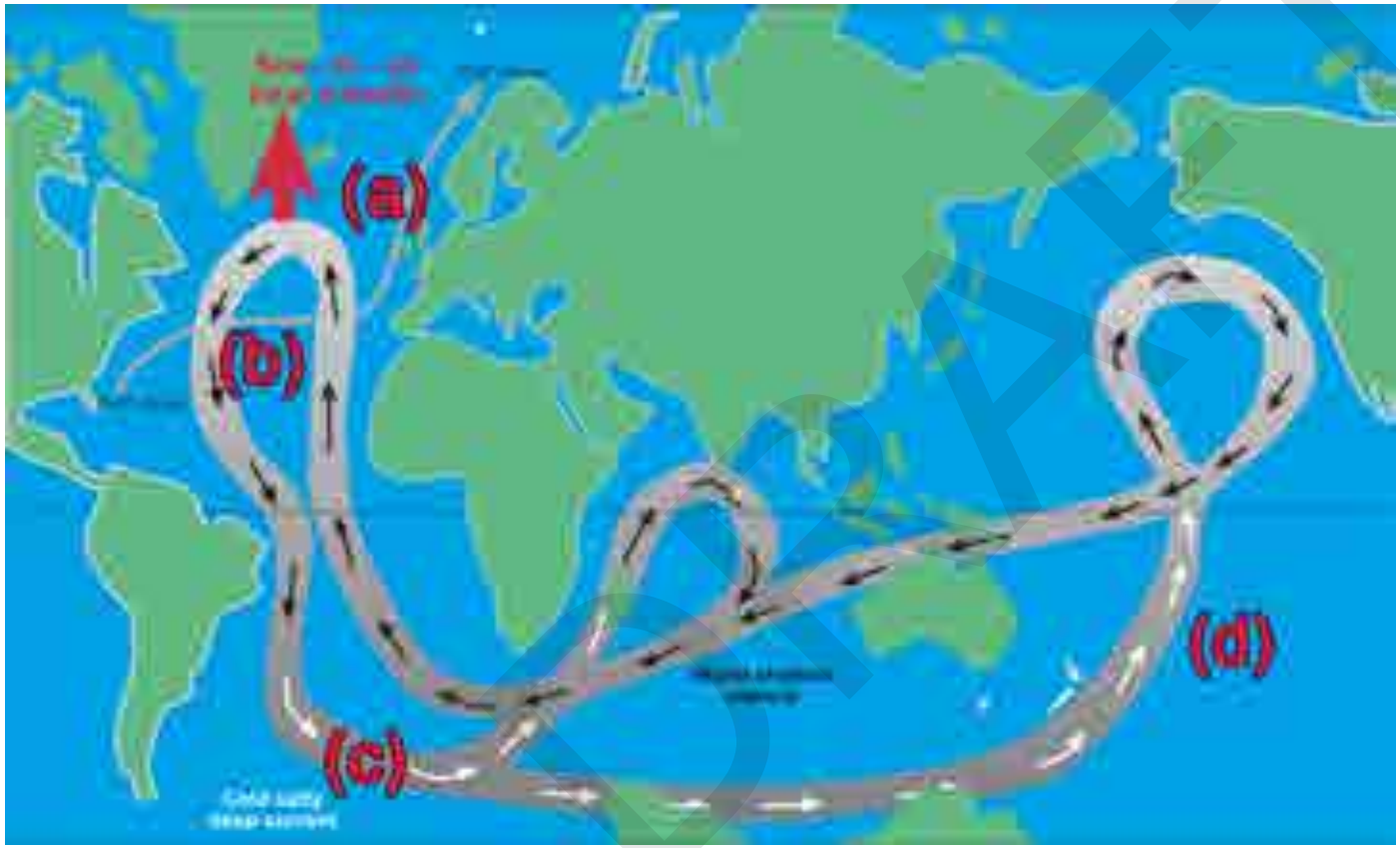
a) The sun heats water north of the equator in the Atlantic Ocean and drives it from the Gulf Stream north heats the atmosphere in the cold northern latitudes. This loss of heat to the atmosphere makes the water cooler and denser.
b) Gravity then causes it to sink to the bottom of the ocean. As more warm water is transported north, more cooler water sinks and pushes this water along the ocean floor.

Ocean current conveyor belt a and b

Illustration Bob Moffatt

DRAFT

c) This cold bottom water flows south of the equator all the way down to Antarctica.
d) Eventually, the cold bottom waters returns to the surface through mixing and wind-driven upwellings, continuing the conveyor belt that encircles the globe.



Ocean current conveyor belt
Illustration Bob Moffatt

DRAFT

T010 Oceans need further investigation

NOAA Explorer at sea

By NOAA - http://www.moc.noaa.gov/oe/index.htm, Public Domain, https://en.wikipedia.org/w/index.php?curid=23922866

DRAFT

Wet Paper

Syllabus statement

The syllabus says ... you should be able to argue that knowledge of the oceans is limited and requires further investigation

DRAFT

Argue - give reasons for or against something; challenge or debate an issue or idea; persuade, prove or try to prove by giving reasons

Question

Argue the case for further ocean research

DRAFT

Despite the fact that the ocean plays a role in everything from the air we breathe to daily weather and climate patterns, we know more about the surface of Mars than we do about the depths of our oceans.

Mars

By ESA - European Space Agency & Max-Planck Institute for Solar System Research for OSIRIS Team ESA/MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA - http://www.esa.int/spaceinimages/Images/2007/02/True-colour_image_of_Mars_seen_by_OSIRIS, CC BY-SA 3.0-igo, https://commons.wikimedia.org/w/index.php?curid=56489423

DRAFT

Most of our knowledge of the ocean lies in shallower waters.
Deeper waters remain a mystery even though we are relying more and more on these areas for food, energy, and other resources.

Students in reef pools
Photo Len Zell

DRAFT

Ocean exploration is about making discoveries, searching for things that are unusual and unexpected.

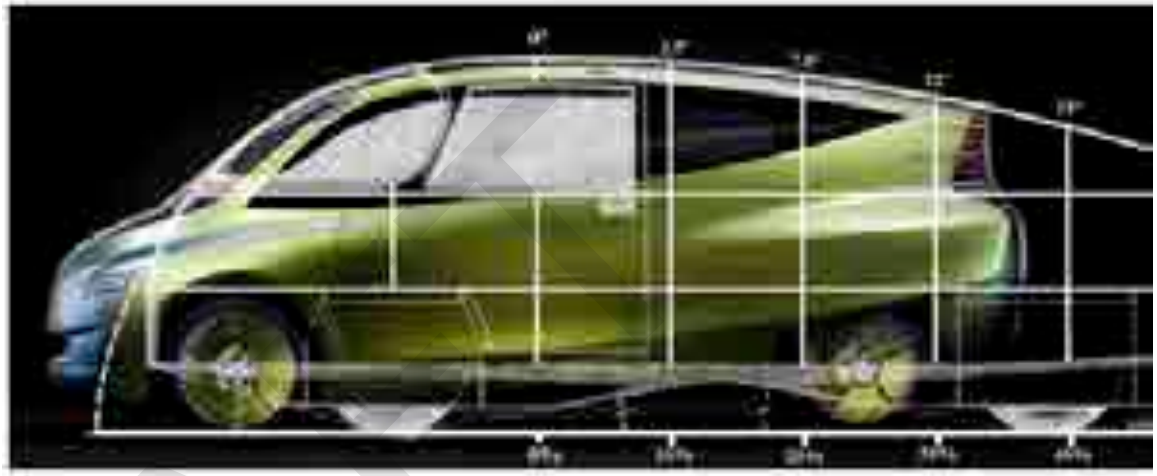
NOAA Explorer at sea

By NOAA - http://www.moc.noaa.gov/oe/index.htm, Public Domain, https://en.wikipedia.org/w/index.php?curid=23922866

DRAFT

Particular qualities found in marine species are being used to develop technologies that serve our everyday needs.

For example a car shape inspired from a species of fish for its hydrodynamic properties

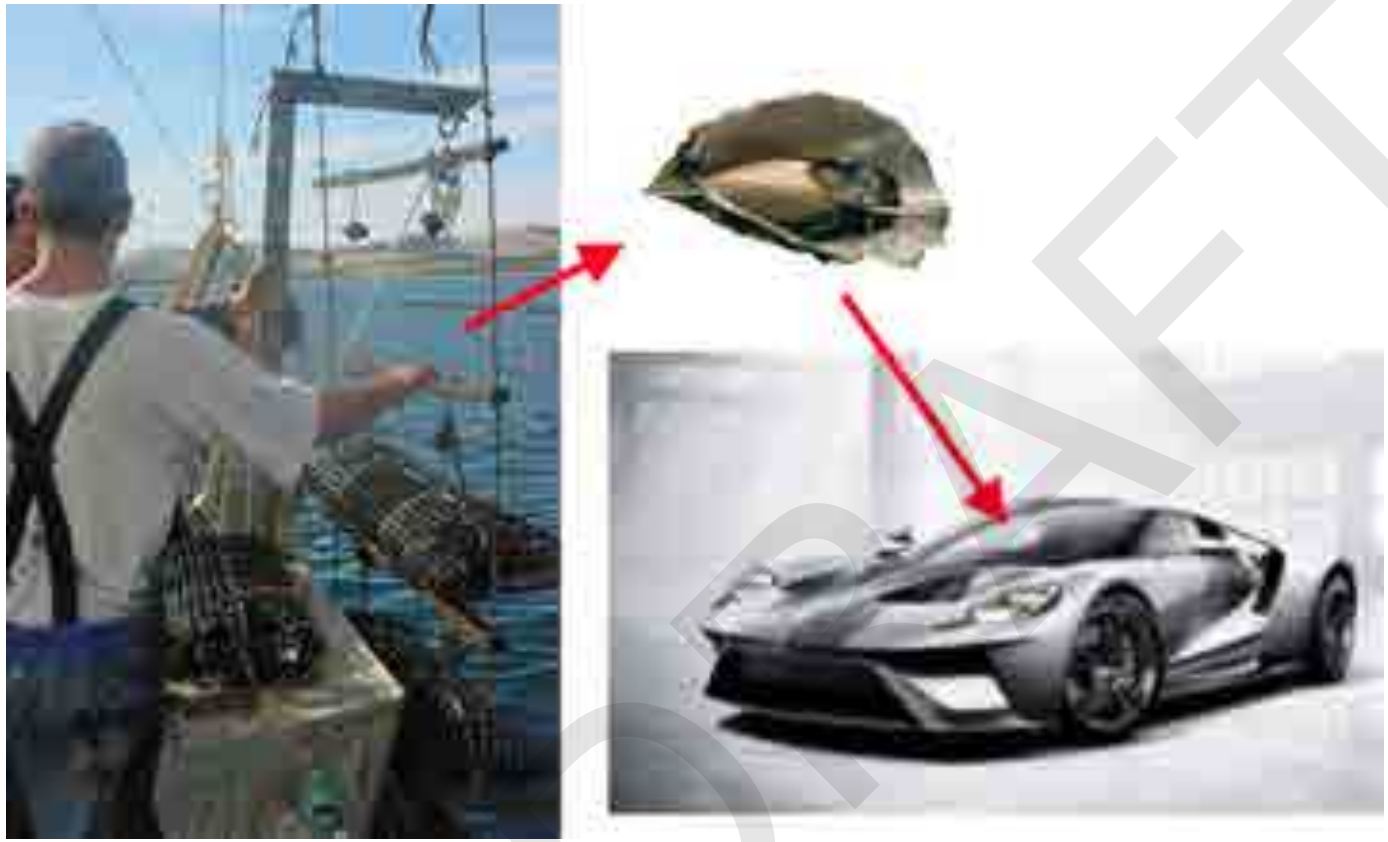


Yellow box fish and Mercedes-Benz-Bionic

Fish By Norbert Potensky - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2594309Car By Ryan Somma - http://commons.wikimedia.org/wiki/File:Mercedes-Benz_bionic_car.jpg, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=26016953

DRAFT

Unbreakable windshields derived from oyster shell bioassays.

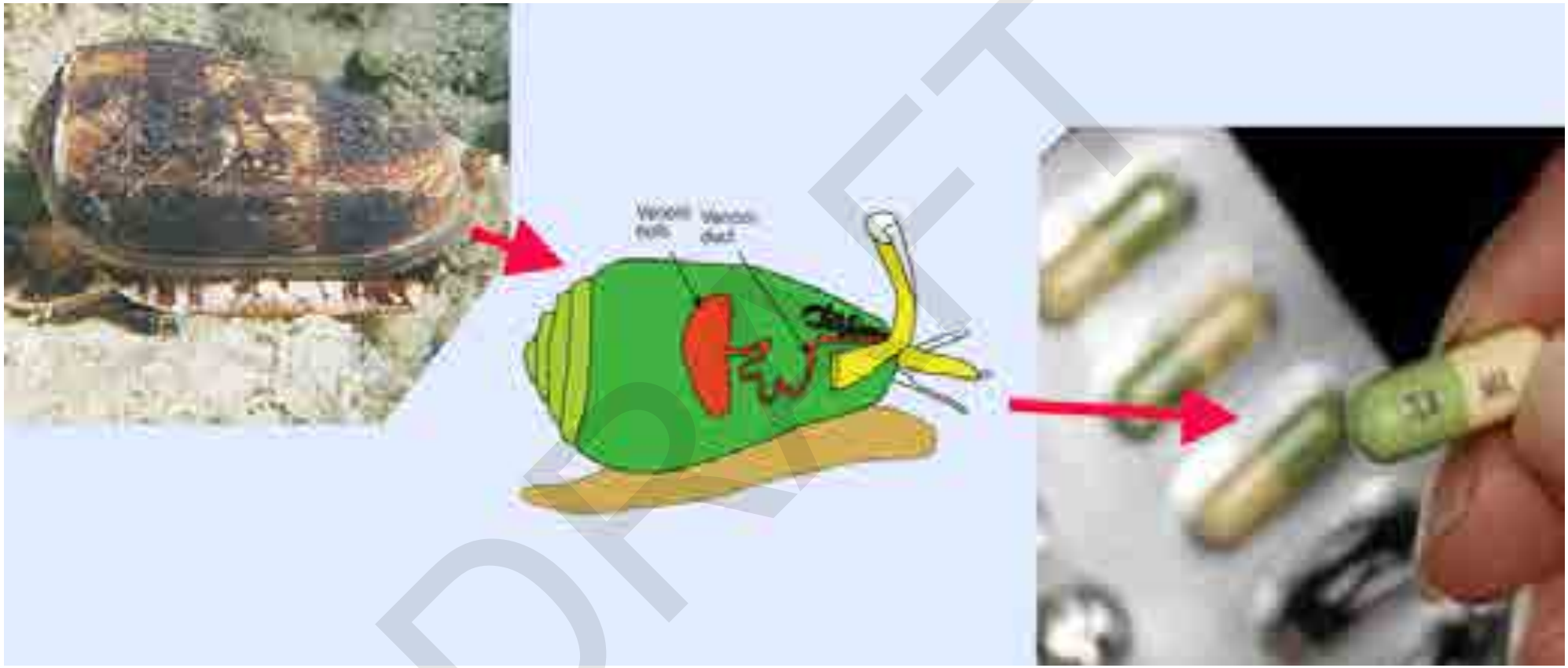


Oyster and car windscreens

Oyster and students Bob Moffatt Car http://gpcaraudio.com/gp-shatter-proof-windshields/

DRAFT

Marine venoms are providing bioassays for new drugs.



Cone shell venom gland drugs

Photo Neville Coleman, Illustration Bob Moffatt

DRAFT

Ocean exploration, however, is not randomly wandering in hopes of finding something new.

It is disciplined, systematic, and includes rigorous observations and documentation of

- Biological
- Chemical
- Physical
- Geological and
- Archaeological aspects of the ocean.

CSIRO Current meter

Illustration CSIRO

DRAFT

Findings made through ocean exploration are fundamental to reducing unknowns in deep-ocean areas and providing high-value environmental intelligence needed to address both current and emerging science and management needs.

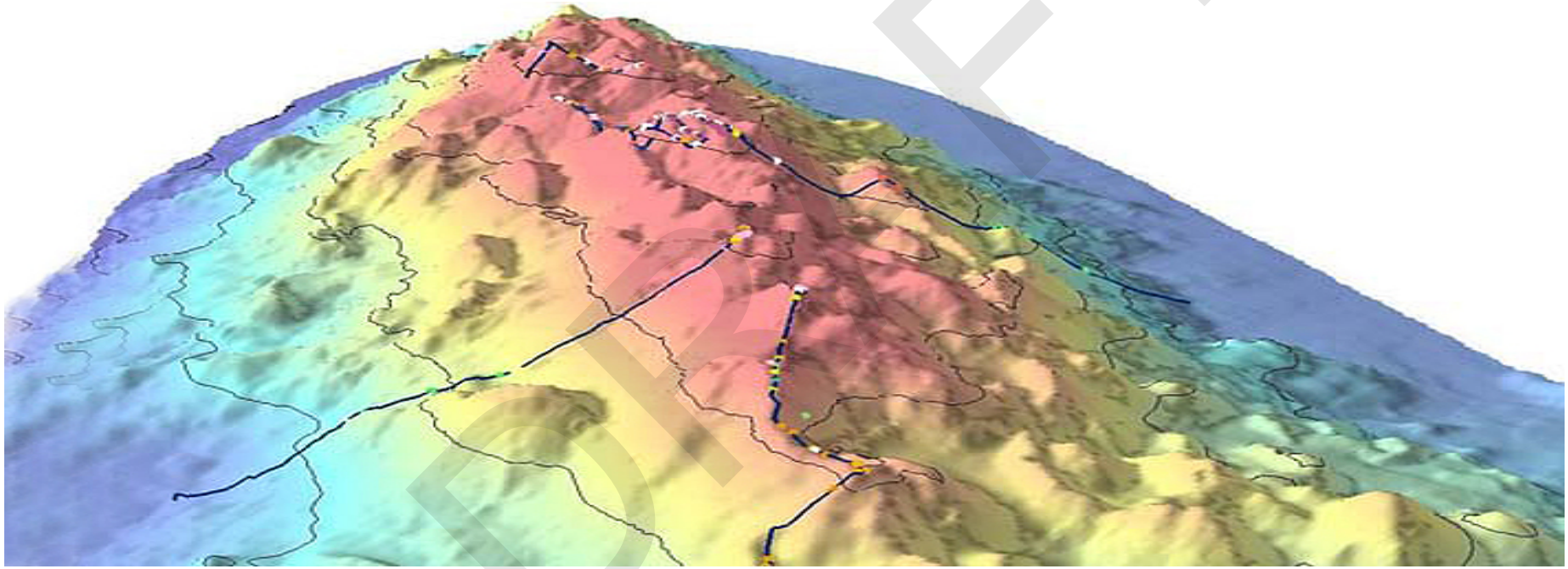
Deep sea smokers

By NOAA - http://oceanexplorer.noaa.gov/explorations/04fire/logs/hirez/champagne_vent_hirez.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3597762 and Wet Paper

DRAFT

Exploration helps to ensure that ocean resources are not just managed, but managed well, so those resources are around for future generations to enjoy.

For example significant coral nurseries have been found on seamounts which might lead to seamount tourism expeditions in the future.



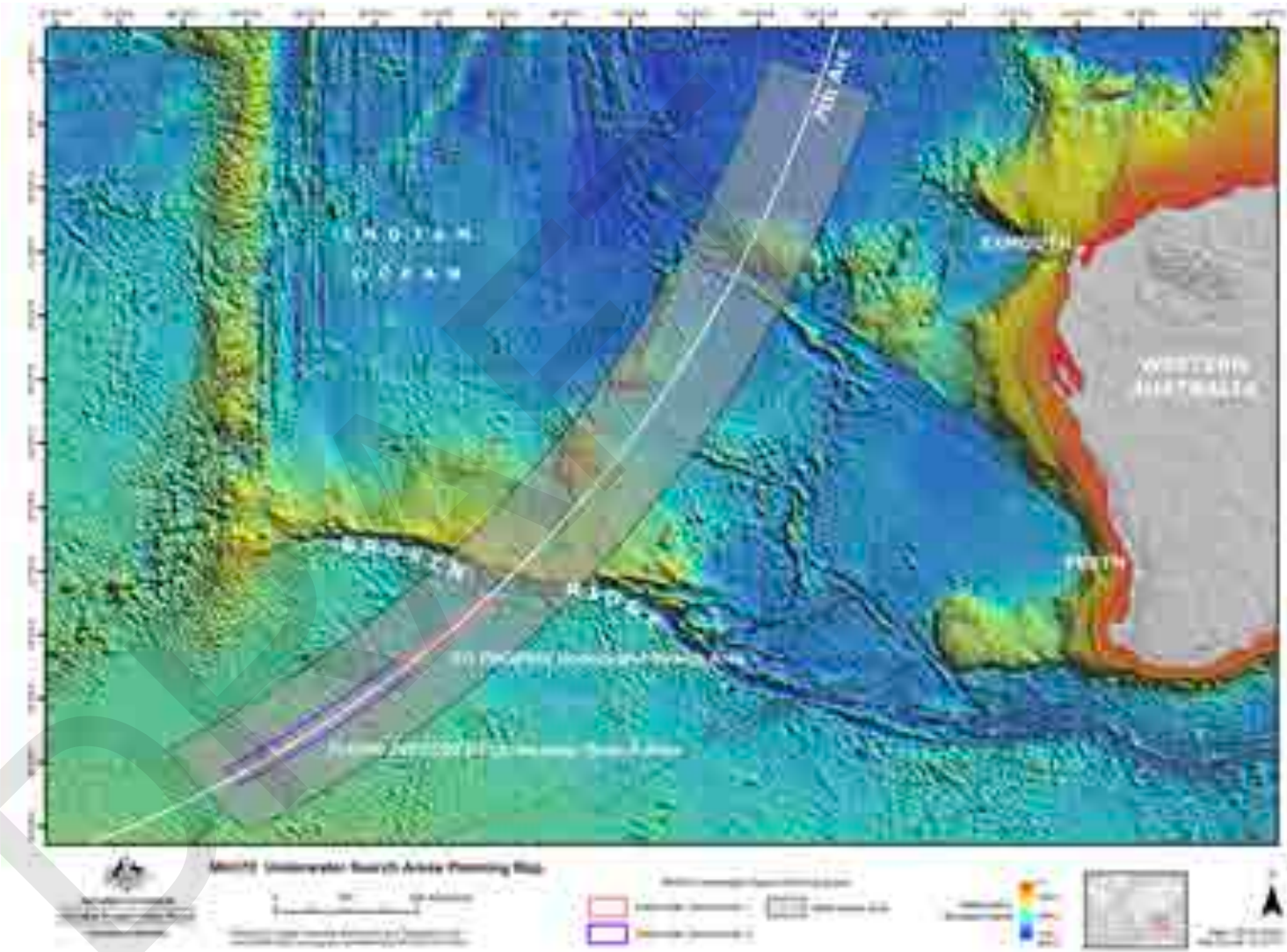
Davidson expedition seamont

By C. King/[1]/[2] - Direct link File page, Public Domain, https://commons.wikimedia.org/w/index.php?curid=11919009

DRAFT

Through ocean exploration, we can establish the baseline information needed to better understand the sea floor.

This knowledge is often the only source for basic information needed to respond appropriately in the face of deep-sea disasters.



Search area MH370

https://upload.wikimedia.org/wikipedia/commons/0/04/MH370_SearchAreaMap_October_2014.jpg

DRAFT

Information from ocean exploration is important to everyone. Unlocking the mysteries of deep-sea ecosystems can reveal new sources for medical drugs, food, energy resources, and other products.

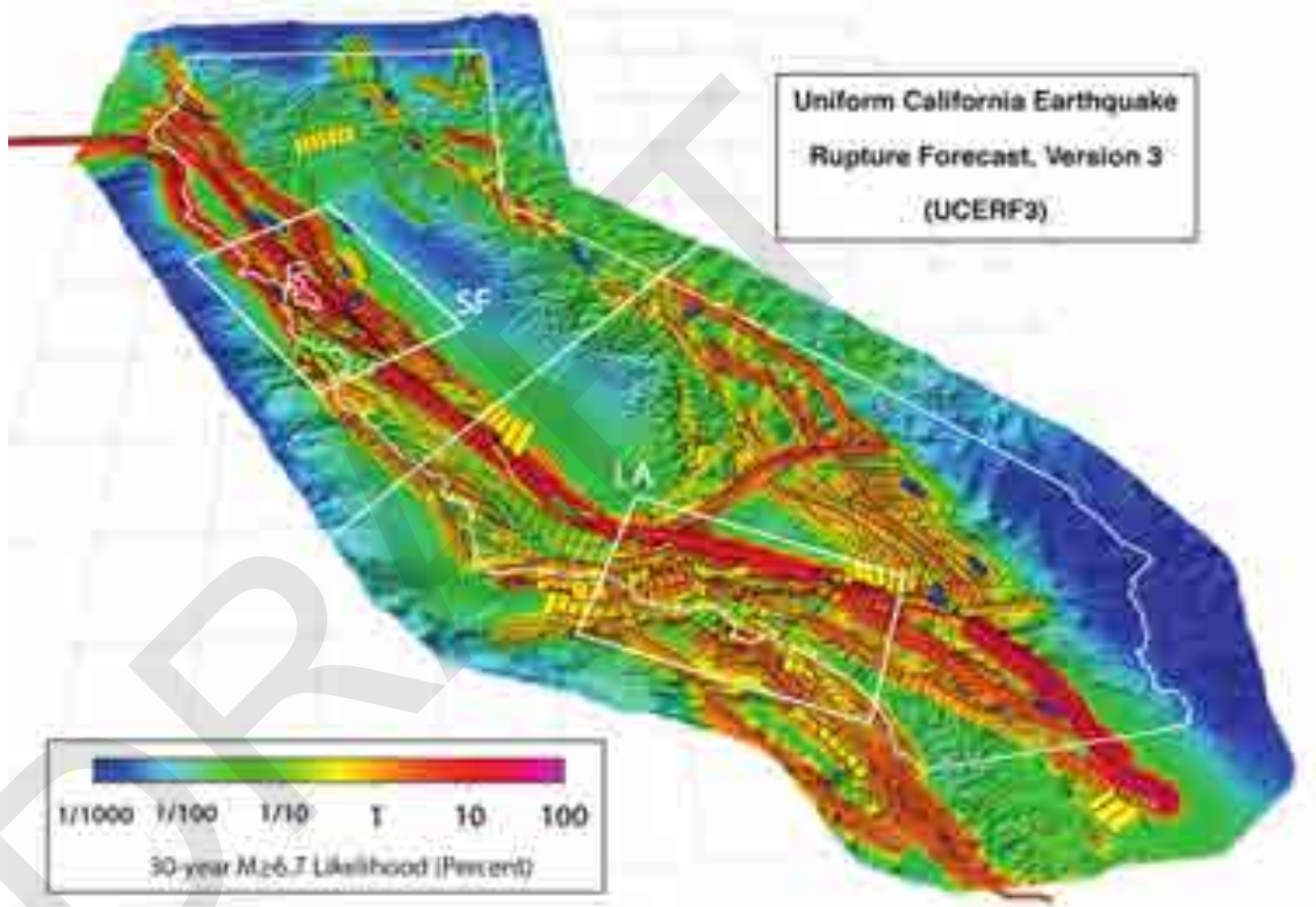
Could conefish venom contain a cure for cancer?

Cone shell and venom gland

Photo Neville Coleman, Illustration Bob Moffatt

DRAFT

Information from deep-ocean exploration can help predict earthquakes and tsunamis and help us understand how we are affecting and being affected by changes in Earth's climate and atmosphere.



Earthquake predictions

By Created by the WGCEP 2014 team, a collaboration of the U.S. Geological Survey, the California Geological Survey, and the Southern California Earthquake Center. - http://pubs.usgs.gov/fs/2015/3009/pdf/fs2015-3009.pdf, Public Domain, https://commons.wikimedia.org/w/index.php?curid=48272904

DRAFT

Ocean exploration can improve ocean literacy and inspire young people to seek careers in science, technology, engineering, and mathematics.

University places

From: Griffith, AMC and University of Queensland welcome pages

DRAFT

The challenges of exploring the deep ocean can provide the basis for technology and engineering innovations that can be applied in other situations.

Wave converter

By JamesMCP [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], from Wikimedia Commons

DRAFT

Yet even as the importance of deep areas of the ocean in our everyday lives continues to increase, our knowledge of these areas remains limited

In many instances, we are "flying blind" when it comes to management, regulation, and resource use in deep-water areas.

Yellowfin tuna
https://upload.wikimedia.org/wikipedia/commons/f/f9/Yellowfin_tuna_nurp.jpg

DRAFT

Acknowledgement

The text for this topic was taken from the NOAA website

https://oceanexplorer.noaa.gov/backmatter/whatisexploration.html

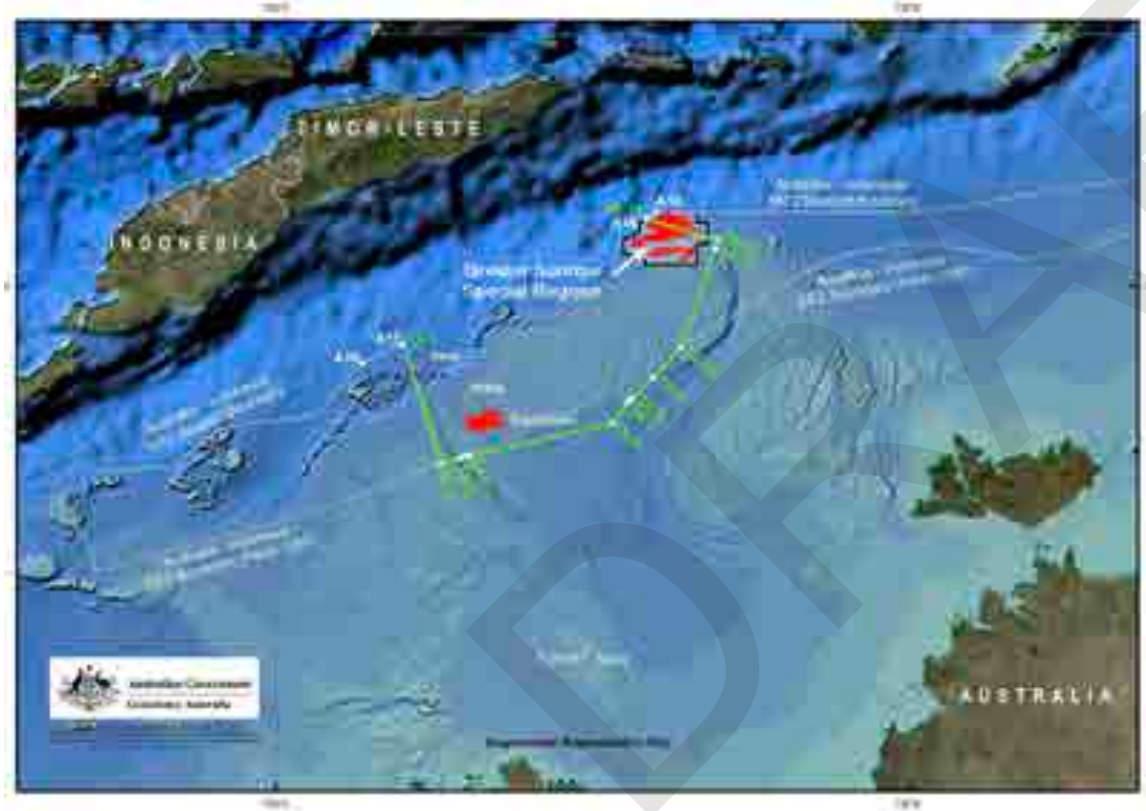
The NOAA Office of Ocean Exploration and Research is the only federal organization currently dedicated to exploring our unknown ocean.

On the Ocean Explorer website, you can learn more about who we are and what we do.

You can follow ocean explorations as they are happening, learn about the tools and technology used during these explorations, and discover opportunities for people of all ages to expand their understanding of the ocean environment.

DRAFT

T011 Resource management and economic values



Timor Sea agreement

Illustration Geoscience Australia

DRAFT

Wet Paper

Syllabus statement

At the end of this topic you should be able to ... understand that the economic development of a nation and the value placed on marine environment, including the Exclusive Economic Zone (EEZ), affects decisions relating to resource management.

Understand - perceive what is meant by something; grasp; be familiar with (e.g. an idea); construct meaning from messages, including oral, written and graphic communication

DRAFT

Question

How are marine resource management decisions affected by the following issues?

A. Sovereign rights
B. Developing energy resources
C. Food resources
D. Biosecurity
E. Climate change

DRAFT

Sovereign rights

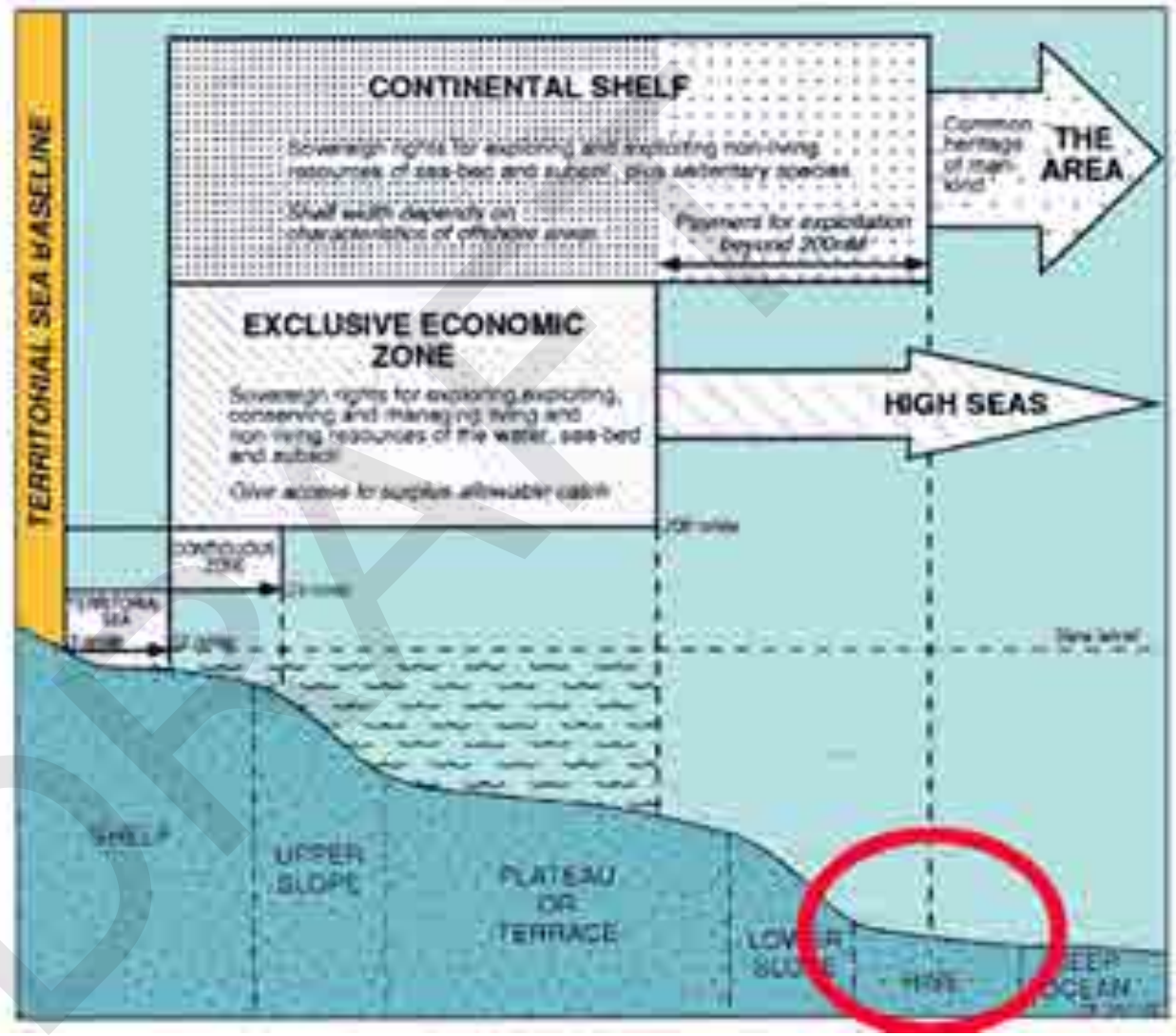
International laws have granted each nation sovereign rights creating exclusive economic zones.

World's exclusive economic zones, shown in dark blue

By B1mbo - Own work based on: World location map.svgBorders based on VLIZ Maritime boundaries and Internationalwaters.png, CC BY-SA 3.0 cl, https://commons.wikimedia.org/w/index.php?curid=17194739

DRAFT

Our EEZ starts at the base of the rise of our continental shelf.

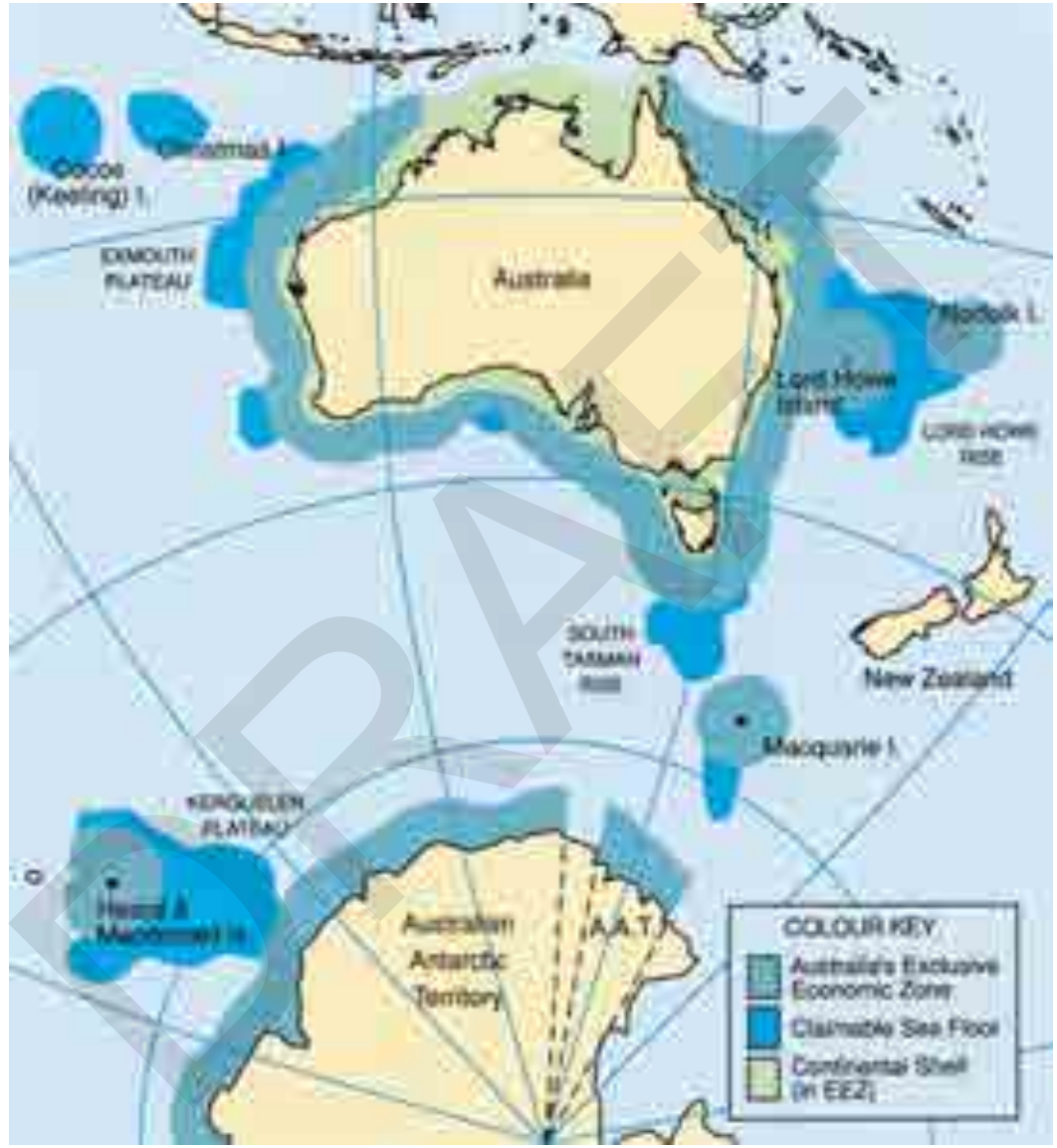


Continental rise and EEZ

Illustration Geoscience Australia

DRAFT

As a result we can draw maps of our EEZ.



Australia EEC

Illustration Geoscience Australia

DRAFT

The decision to draw maps is based on the United Nations Convention on the Law of the Sea (UNCLOS).

This law defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources.

United Nations Headquarters in New York

By Neptuul - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=31552107

DRAFT

Developing energy resources

Oil and gas extracted from our seas provides electricity for our nation.

Quadrant energy oil and gas facilities WA

https://www.quadrantenergy.com.au/our-business/production-facilities/

DRAFT

Gas platforms drill deep into the ocean floor extracting natural gas offloading to ships or undersea pipelines that is processed on shore.

Harriet A gas platform
Image CSIRO

DRAFT

Gas is then delivered to our homes

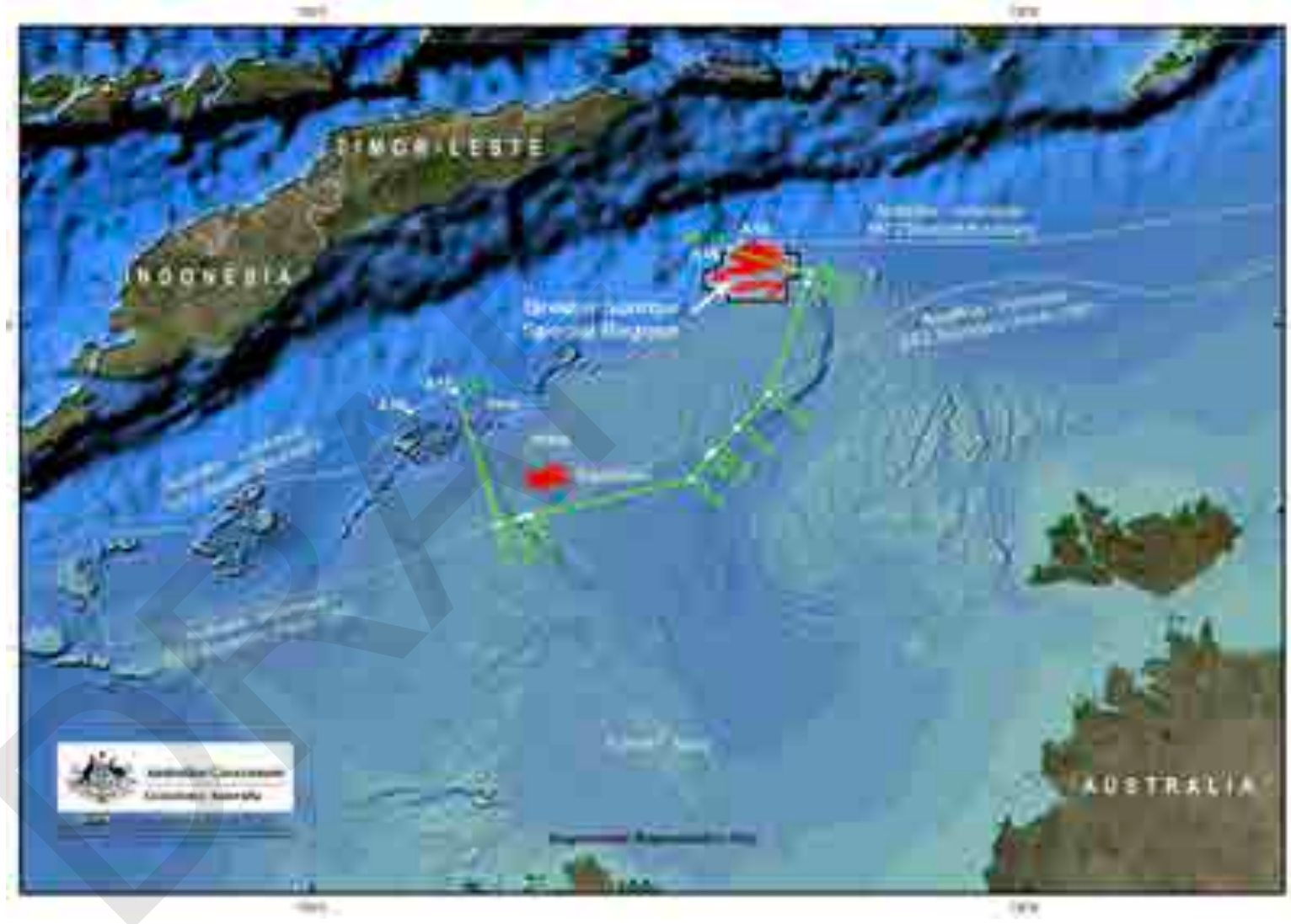
Crown gas truck

http://crowngasny.com/delivery/crown-gas-truck/

DRAFT

To safeguard our resources treaties are drawn up between nations.

For example the Timor Sea oil and gas Treaty.



Timor Sea agreement

Illustration Geoscience Australia

DRAFT

The decision to share the resources of the Greater Sunrise oil and gas field was brought on by politicians.

The treaty was based on seafloor mapping.

DRAFT

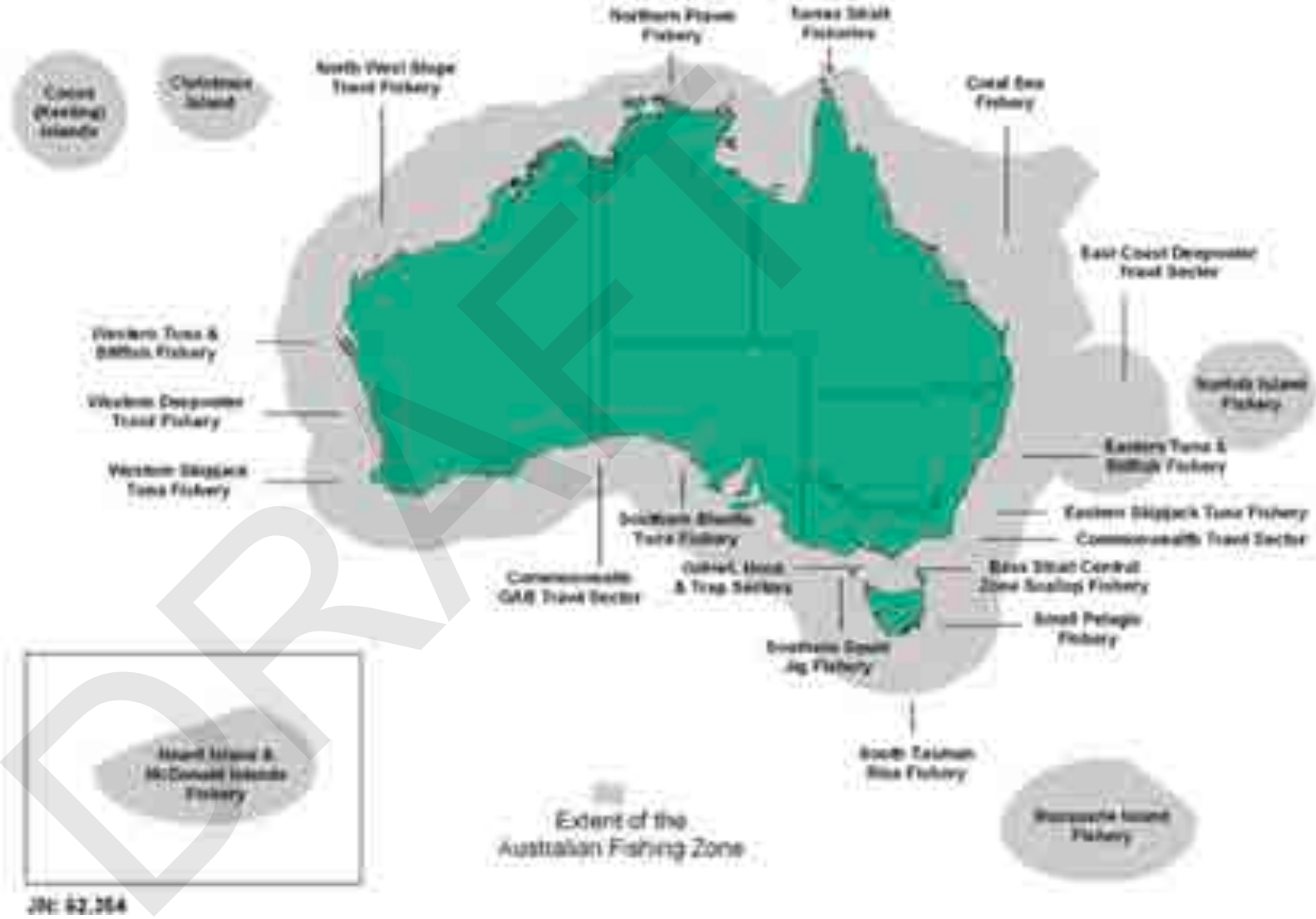
Food resources and security

Australians love seafood with good profit margins when supply is maintained

Seafood for sale
Photo Fisheries Queensland

DRAFT

Fishing resources however are limited and need to be managed to provide seafood for the future.



Australian Fishing Zone showing the location of Commonwealth fisheries

Australian fish management authority

DRAFT

Australian has prawn industries in each state.

Australian prawn industry map

Source AFMA

DRAFT

These fisheries provide valuable income to our economy $263 million to the economy.

State	Tonnes (2015)	Value (2015)	No. Allocations [1] (2015)
NSW	1,306	$19 million	946 shareholdings
VIC	159 (2014)	$1.8 million (2014)	n/a
QLD	5,424	$63 million	475 licence holders
SA	2,097	$36 million	52 licence holders
WA	2,979	$37 million	47 licence holders
ACT & NT	7,145	$107 million	114 vessels (NPF and Torres Strait)

[1] Australian fisheries & aquaculture statistics 2015

Prawn fishery values by State

http://australianwildprawns.com.au/australian-prawn-fisheries/

DRAFT

Decisions to protect this industry are made by government agencies. The end result is a raft of management strategies.

For example seasonal closure directives.

NORTHERN PRAWN FISHERY (GEAR REQUIREMENTS) DIRECTION No. 174

Direction not to engage in fishing

http://www.afma.gov.au/wp-content/uploads/2017/03/Final-NPF-Directions-and-Closures-2017.pdf

DRAFT

Biosecurity

Disease can also decimate prawn aquaculture industries

Prawn white spot disease

http://www.outbreak.gov.au/current-responses-to-outbreaks/white-spot-disease

DRAFT

Decisions to drain ponds, kill affected prawns and restrict movements of species are made by governments to protect the industry.

White spot biosecurity area

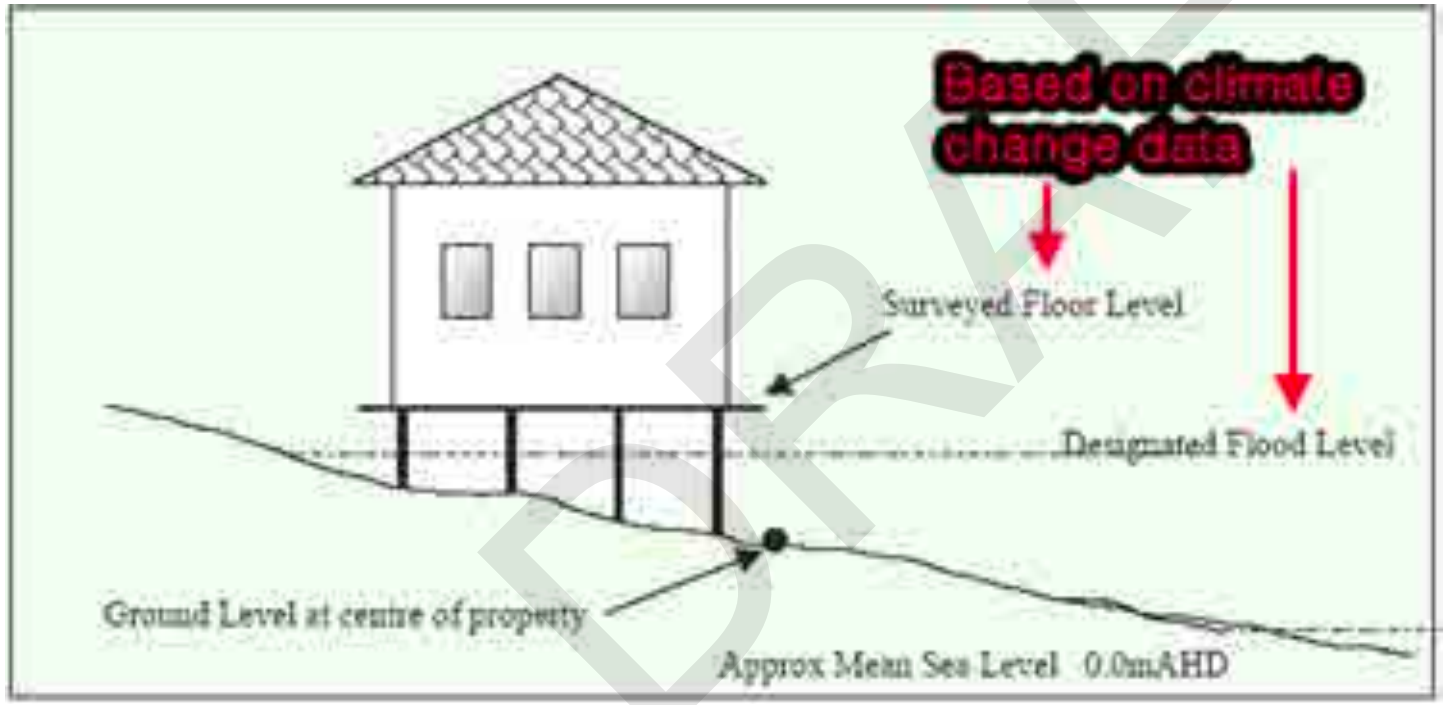
https://www.daf.qld.gov.au/__data/assets/pdf_file/0007/1255525/white-spot-biosecurity-area1.pdf

DRAFT

Climate change

The threat to ocean and coastal ecosystems and human habitats may also increase as result of climate change.

Decisions have been made by councils now to require building surveyed floor levels to take into account sea level rise.

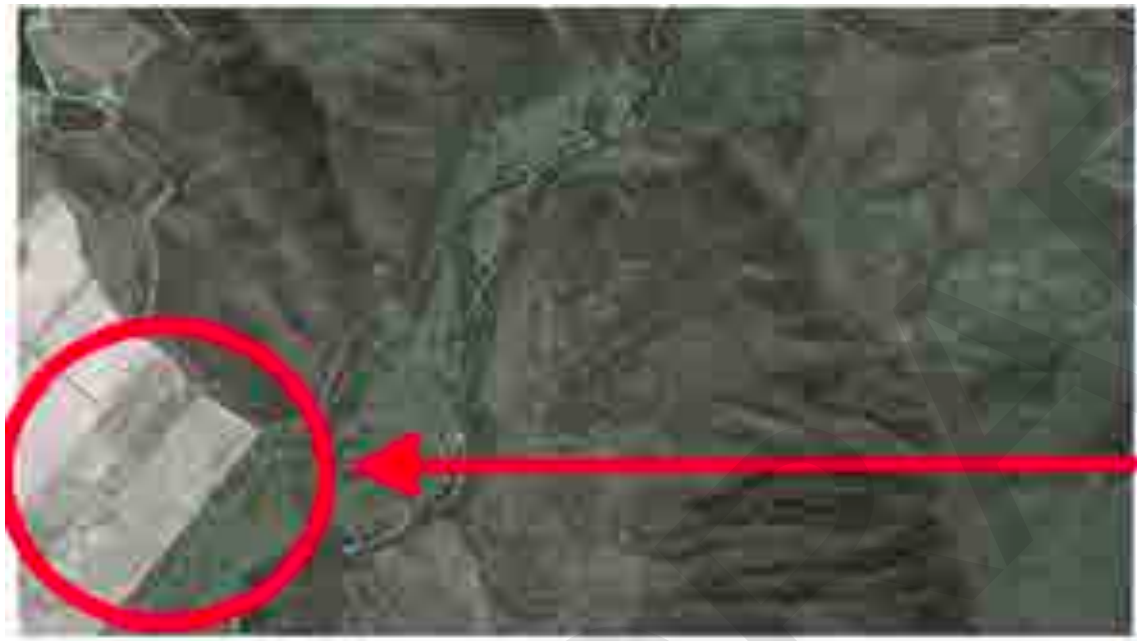


Surveyed level for buildings

Illustration Gold Coast City Council

DRAFT

Decisions to protect the Great Barrier Reef involving tree clearing legislation are political.



Drone footage taken this week by WWF shows the trees clearly bulldozed over.

▲ Aftermath of land clearing in Great Barrier Reef catchment – video

Tree clearing Mackay region

ImageWorld wildlife fund, Image Martin Taylor

DRAFT

Marine Biology power point series

T051 Abiotic limiting factor

Fish cat comparison
Illustration Steven Byers

Please, if you find better web references and videos, we would love to put them in future versions

DRAFT

At the end of this topic you should be able to –

understand that marine ecosystems are influenced and limited by abiotic factors in ways that may be different from terrestrial ecosystems due to the different physical and chemical properties of water compared to air.

Understand is defined as to know the meaning of something or to grasp the situation; recall or remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind.

DRAFT

Introduction

The sea is very different from the land

If you climb a mountain on the Great Dividing Range what do you see

Clouds, valleys, rivers, hills and plains

In the abiotic factors you can feel, smell, touch, taste and hear each day, every day.

Land look out

Photo Bob Moffatt

DRAFT

If you go to your local headland or beach and look out at sea - what do you see?

All you see is water and although 80% of us all live within a hours drive of the sea, we experience the abiotic factors less.

So the study of abiotic factors in the sea, is more difficult than on land.

Sea look out
Photo Bob Moffatt

DRAFT

On land wind and water affect the cattle in a field.

If there is a drought water and food can be provided and they can be fenced in.

Cattle behind a fence
https://www.freeimages.com/search/beef-cows

DRAFT

However the ocean knows no boundaries.

Species are free to move without fences and it is difficult to provide food.

Fish in a school

Photo Viewfinder

DRAFT

Unless the fish are enclosed in a pen.

Sea cages in Tassie
Photo Bob Moffatt

DRAFT

If a disease breaks out on land, you can quarantine an area by stopping movement of people and animals.

Queensland Fruit Quarantine sign

Photo Queensland Government

DRAFT

But in the sea marine pests can spread spread from country to country in water carried by ships.

Marine pest transport

Illustration Bob Moffatt Japanese sea star pestPhoto Mike Sugden

Japanese sea star pest

Photo Mike Sugden

DRAFT

The largest animals in the world are found in the sea.

This is because sea water can support a greater weight therefore sea creatures have a completely different skeleton.

Whale
Illustration Kerry Kitzelman

DRAFT

Terrestrial animals have hollow bones to keep their weight to a minimum

Femur of cat

Photo Bob Moffatt Illustration By Sunshineconnelly at en.wikibooks [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], from Wikimedia Commons

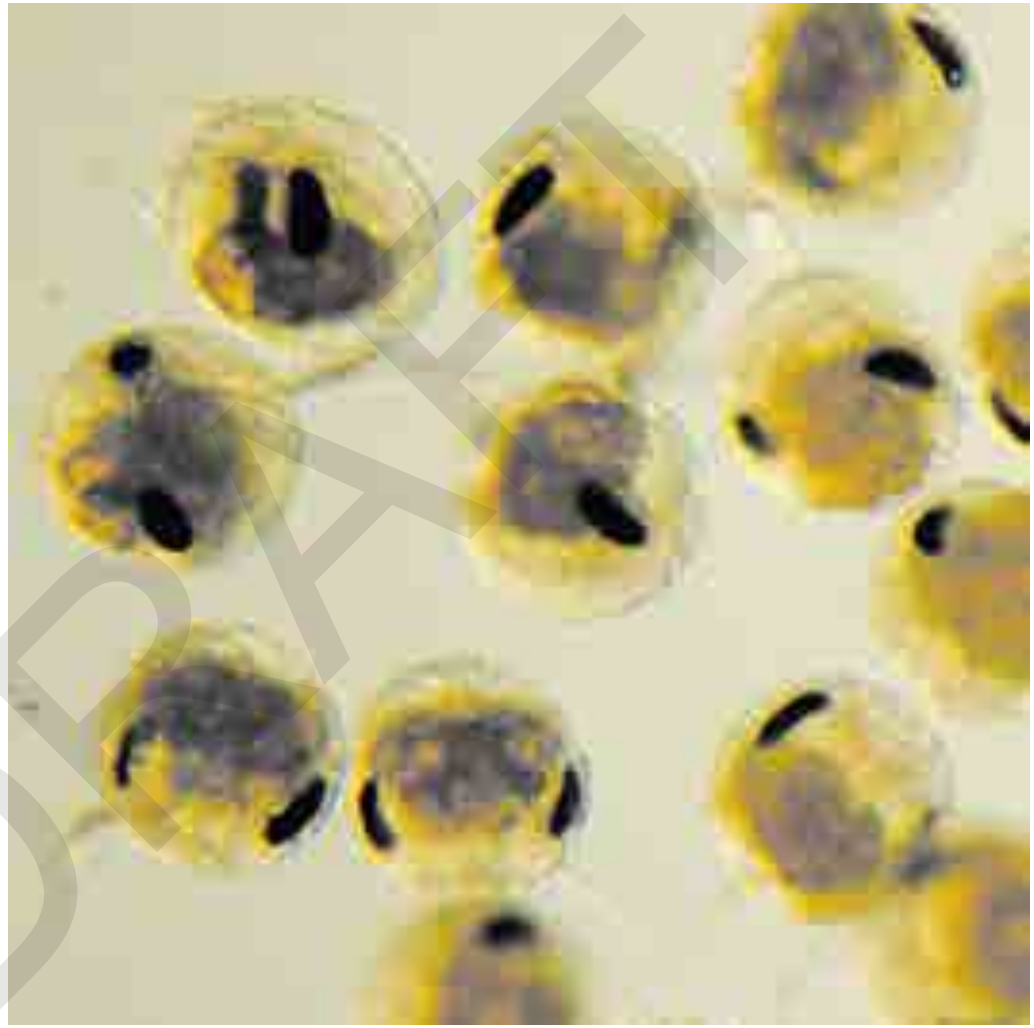
DRAFT

Whereas aquatic animals mostly have solid bones because the upthrust of the water reduces their weight.

Whale skeleton and Gentoo penguins
Photo Auora expeditions

DRAFT

Water allows eggs and sperm to fertilise easier and development in the sea. Downsize, mortality of reproductive effort is very high.



Crab eggs
Photo Fisheries Queensland

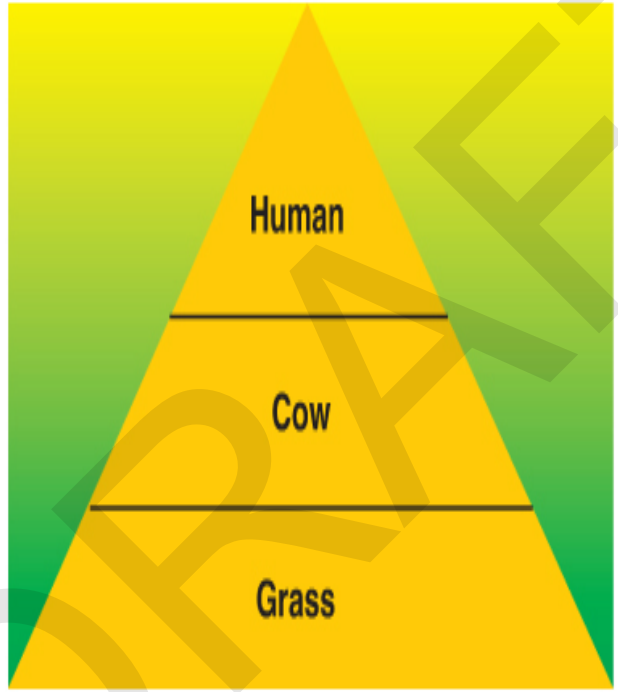
DRAFT

Water allows higher biomass to increase at higher trophic levels.

You can read more at

https://en.wikipedia.org/wiki/Biomass_(ecology)

Air restricts food pyramid biomass at the top.



Land food pyramid
Illustration Bob Moffatt

Marine food pyramid
Illustration Bob Moffatt

DRAFT

What you need to know

You are asked to understand that marine ecosystems are influenced and limited

by abiotic factors in ways that may be different from terrestrial ecosystems due to the different physical and chemical properties of water compared to air.

So how is water so different from air in affecting life in the sea?

DRAFT

For land vertebrates, oxygen is taken into blood through lungs.

Lungs are supported by a skeleton and we can go most places and create normally.

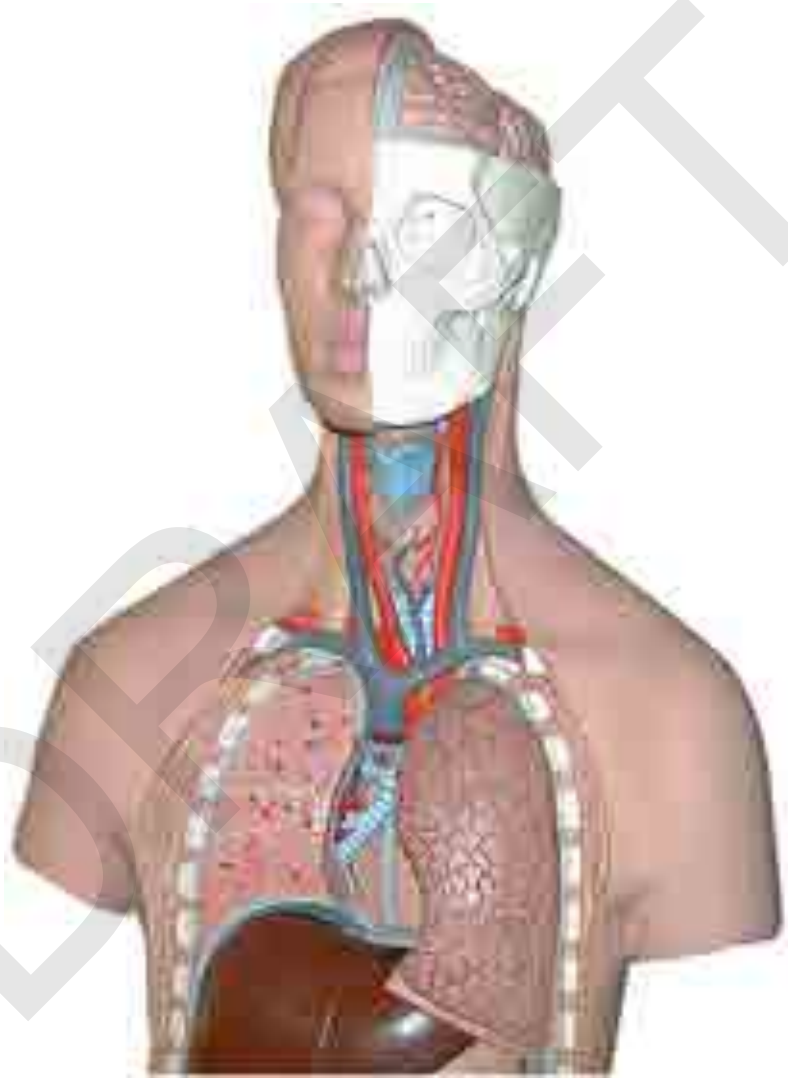


Figure Human lungs
Photo Bob Moffatt

Human skeleton
Photo Amazon.com

DRAFT

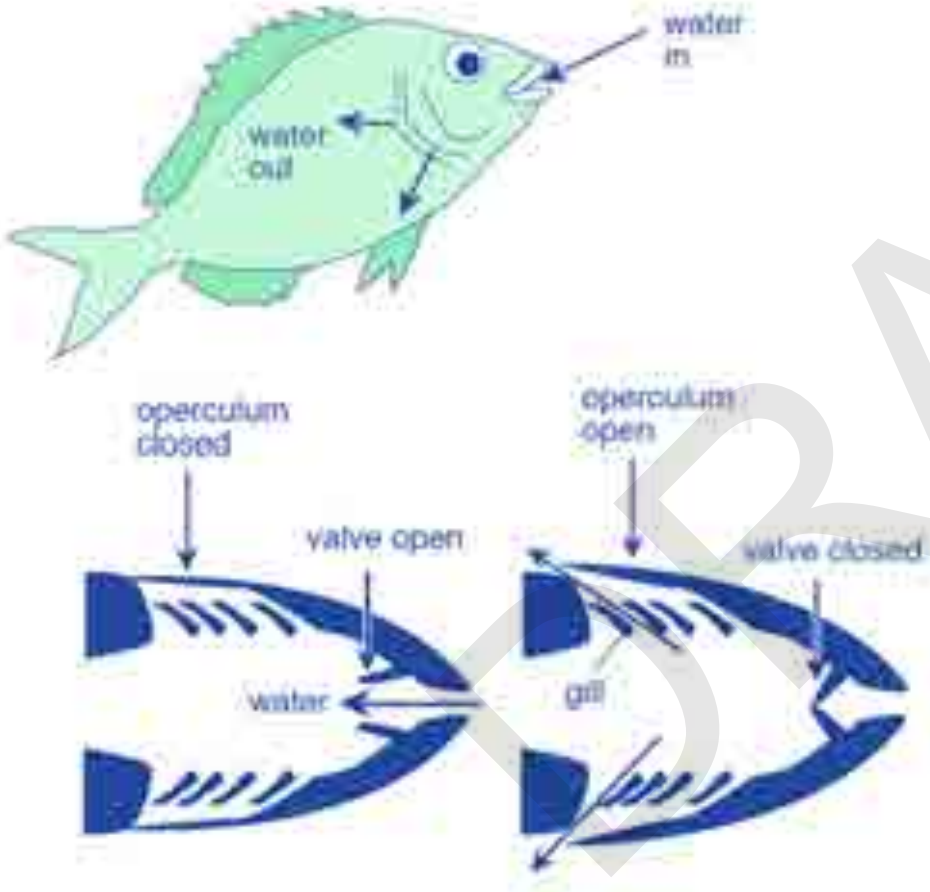
Just like us fish need oxygen to live but water has a different molecular structure.

A piece of cloth spreads out in water quite well, but take it out and it collapses.

Gills and cloth demonstration
Photo Bob Moffatt

DRAFT

So fish have gills and their structure is much different than lungs.



Gills fish and operculum

Illustration Bob Moffatt

DRAFT

Water and air have great differences when it comes to respiration

Comparision of water and air as a respiratory medium	Air	Water
Density	1	1000
Viscosity	1	100
Oxygen content	21%	.8%
Diffusion rate	10,000	1

Air and water comparison for respiration
Illustration Bob Moffatt

DRAFT

Air allows us to see long distances and our eyes are encased on a skull which directs them forward.

Eyes in air look to distance
Photo Bob Moffatt

Human skull
By Sklmsta (Own work) [CC0], via Wikimedia Commons

DRAFT

But the distance light can travel in water is greatly reduced and marine life needs to see in all directions

We compensate it with the use of other highly developed sensory systems.

So we need to wear a face mask

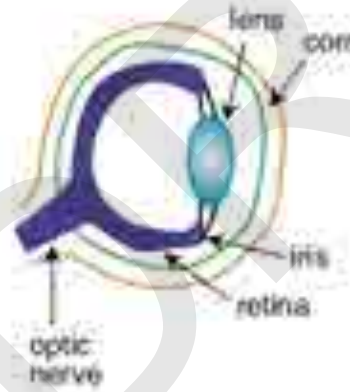
Face and mask
Photo Underwater Rhelms

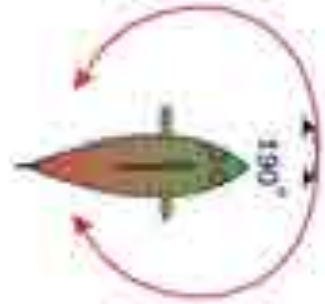
DRAFT

The eye of the fish varies from the eye of land mammals in that the lens does not change shape but changes position.

The lens moves in and out to focus rather than change shape as it does in humans.

Puffer fish
Photo Mike Sugden





Fish eye and vision
Photo Underwater helms, Illustration Bob Moffatt

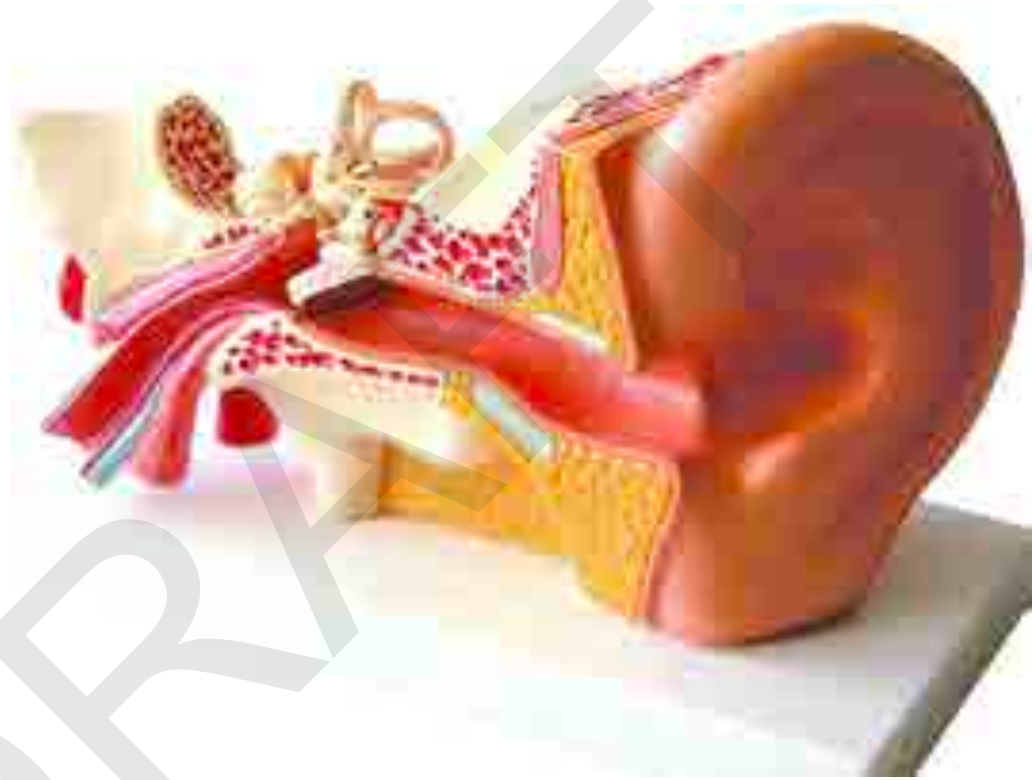
DRAFT

Insert stomatopod

- With eyes

DRAFT

Land vertebrates hear by way membranes that vibrate in their ears.



Model ear
https://www.tts-group.co.uk/4x-life-size-human-ear-model/1003811.html

DRAFT

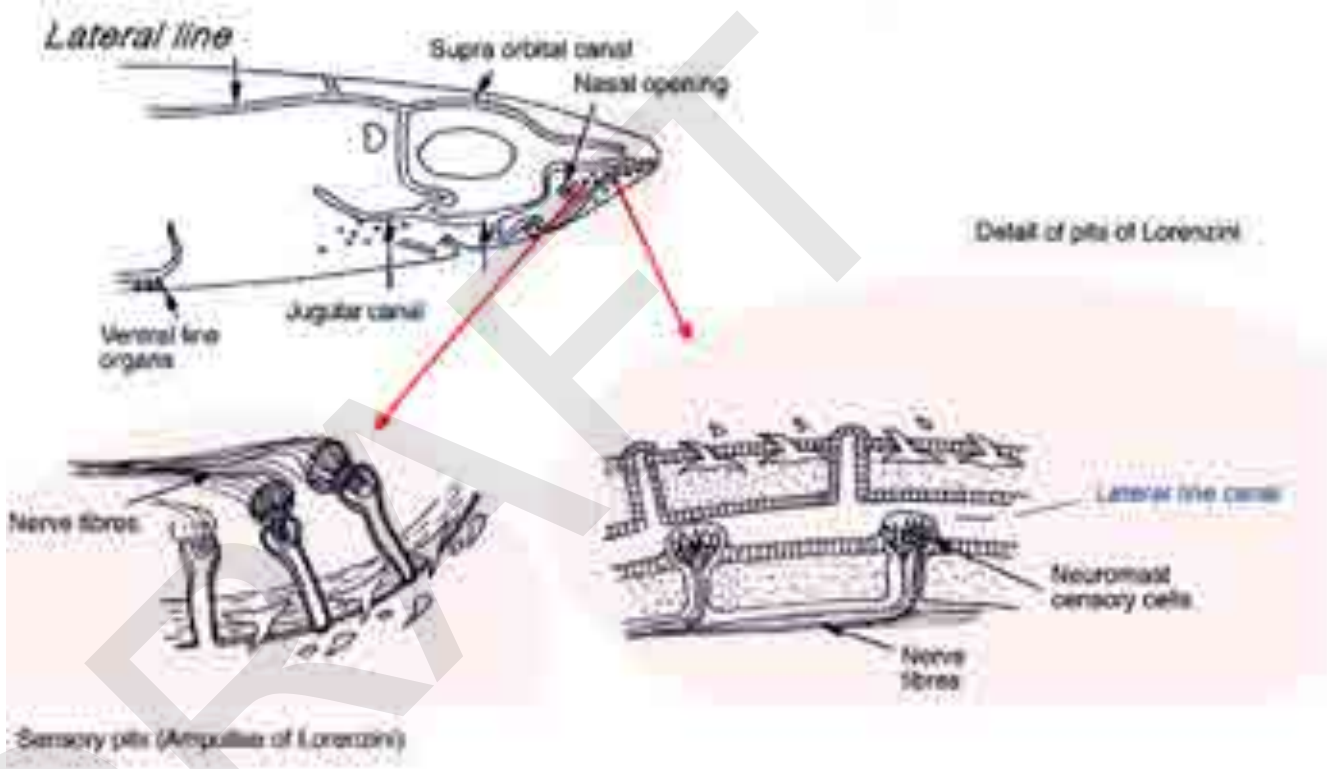
Water creates a different set of abiotic factors to which physiological solutions have had to be made.

Sharks use their lateral line to locate their prey

Blue planet fish talking to each other

Maybe tjher coast onbe

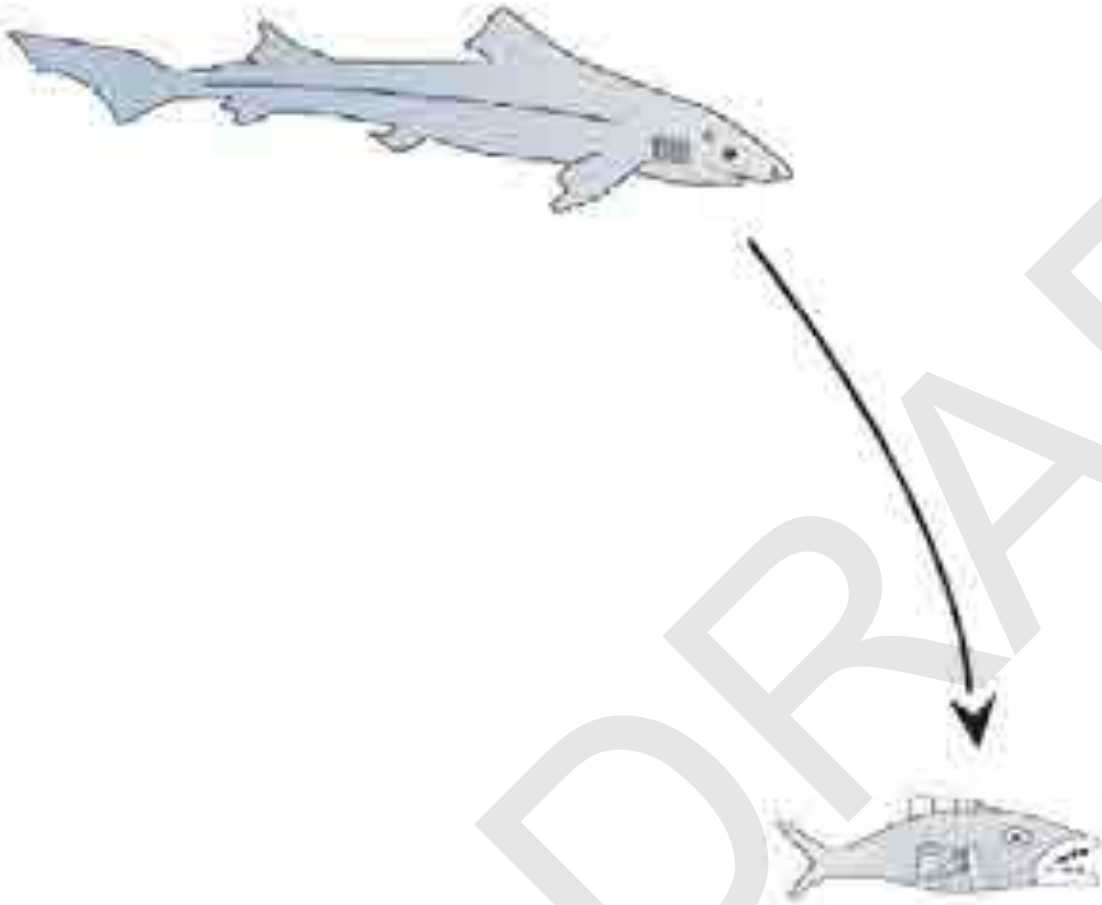
Clowfish with patch



Shark lateral line

Illustration Tom Hailstone

DRAFT



Shark and fish detection

Illustration Bob Moffatt

DRAFT

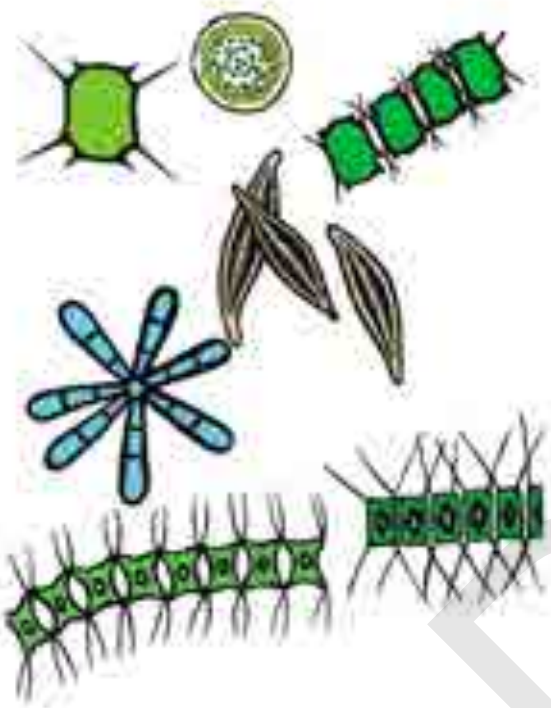
Plants capture the Sun’s energy and use it to make food from raw materials.

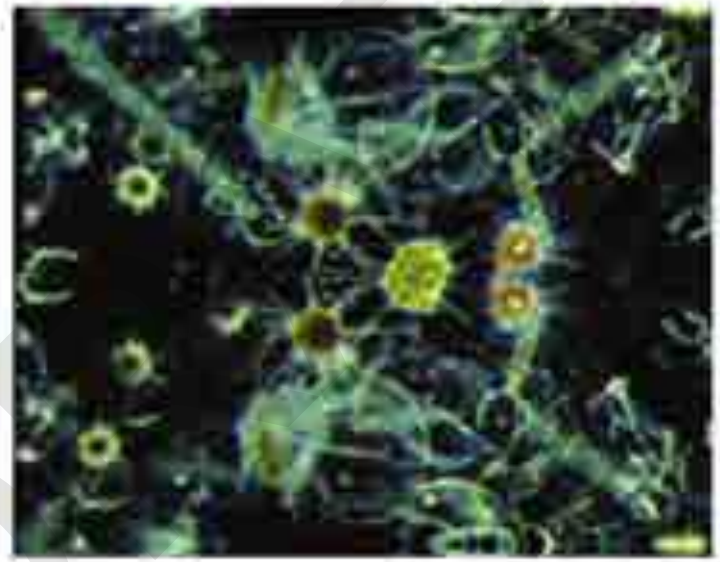
Both land and marine plants use carbon dioxide, water, and minerals.

Air allows the gases to be absorbed in the land plants leaves which in turn are held up by a woody trunk and stem.

Figure Gum tree
Photo Bob Moffatt

Water contains marine plants nutrients and dissolved gases so marine plants do not have vascular tissue to accommodate photosynthesis or to carry its products to each cell.





Phytoplankton

Photo Jack Marsh
Illustration Sharyn Madder

DRAFT

In addition, marine plants do not need support structures because they are held up by the buoyant force of the water.

Marine algae
Photo Mike Sugden

Since water in the ocean is always moving, the bodies of marine plants are flexible, permitting them to go with that movement.

Some marine plants secrete a holdfast to keep them in one place.

Algae and holdfast
Photo Bob Moffatt

So can you now

recall that marine ecosystems are influenced and limited by abiotic factors in ways that may be different from terrestrial ecosystems due to the different physical and chemical properties of water compared to air.

Understand

DRAFT

Related syllabus topics

T006 Seawater properties introduced you to the following abiotic factors of seawater.

A. Chemical properties

B. Physical properties
   - Heat capacity
   - Density
   - Viscosity
   - Surface tension

T052 Distinguishes abiotic components of marine ecosystems

Abiotic components of marine ecosystems
- light availability
  - Penetration

Need to add to power point

- depth
- stratification
- temperature
- currents (water and wind)
- tides
- sediment type
- nutrient availability

DRAFT

Additional web references

https://courses.lumenlearning.com/boundless-biology/chapter/aquatic-biomes/

DRAFT

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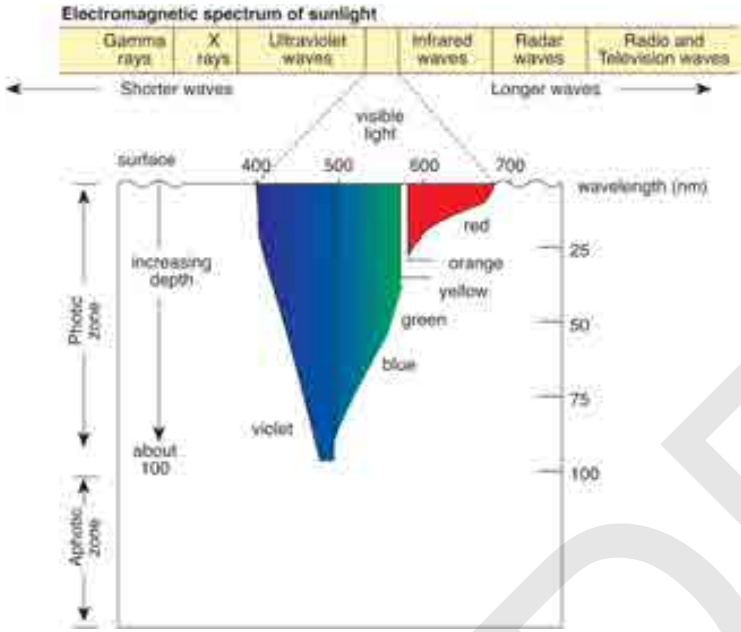
DRAFT

Marine Biology power point series

T052 Distinguish abiotic factors



Light penetration

Illustration Trent Moffatt

DRAFT

The syllabus askes you to:

distinguish abiotic components of marine ecosystems:

Light availability
Depth
Stratification
Temperature
Waves and wind
Currents
Tides
Sediment type
Nutrient availability

DRAFT

The given definition is

distinguish – to recognise as distinct or different; note points of difference between; discriminate; discern; make clear a difference/s between two or more concepts or items

Introduction

You may want to see what one high school class from Pinelands High School from South Africa thought of the abiotic factors on their rocky shore.

https://www.youtube.com/watch?v=yLVkffjtG-g

Effects of Abiotic Factors on the Rocky shore (DO's class)

4.52 minutes

DRAFT

What you need to know

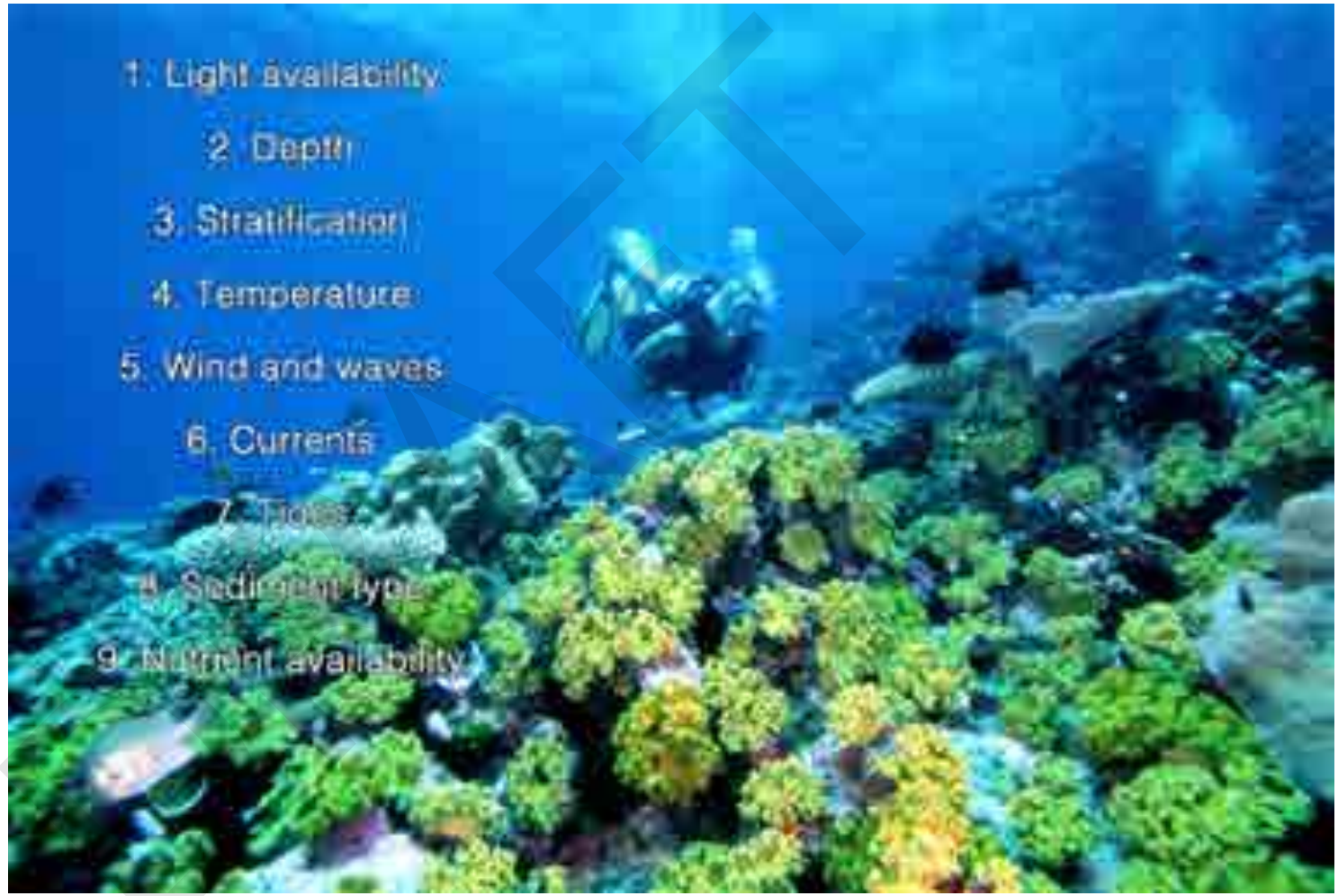
You are asked to distinguish, (assuming between), the following abiotic components of marine ecosystems

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Wind and waves
6. Currents
7. Tides
8. Sediment type
9. Nutrient availability

DRAFT

So

How do these these 9 abiotic factors impact on animals and plants in a marine ecosystem



Diver and abiotic factors

Photo Viewfinder and Bob Moffatt

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves
6. Currents (water and wind)
7. Tides
8. Sediment type
9. Nutrient availability

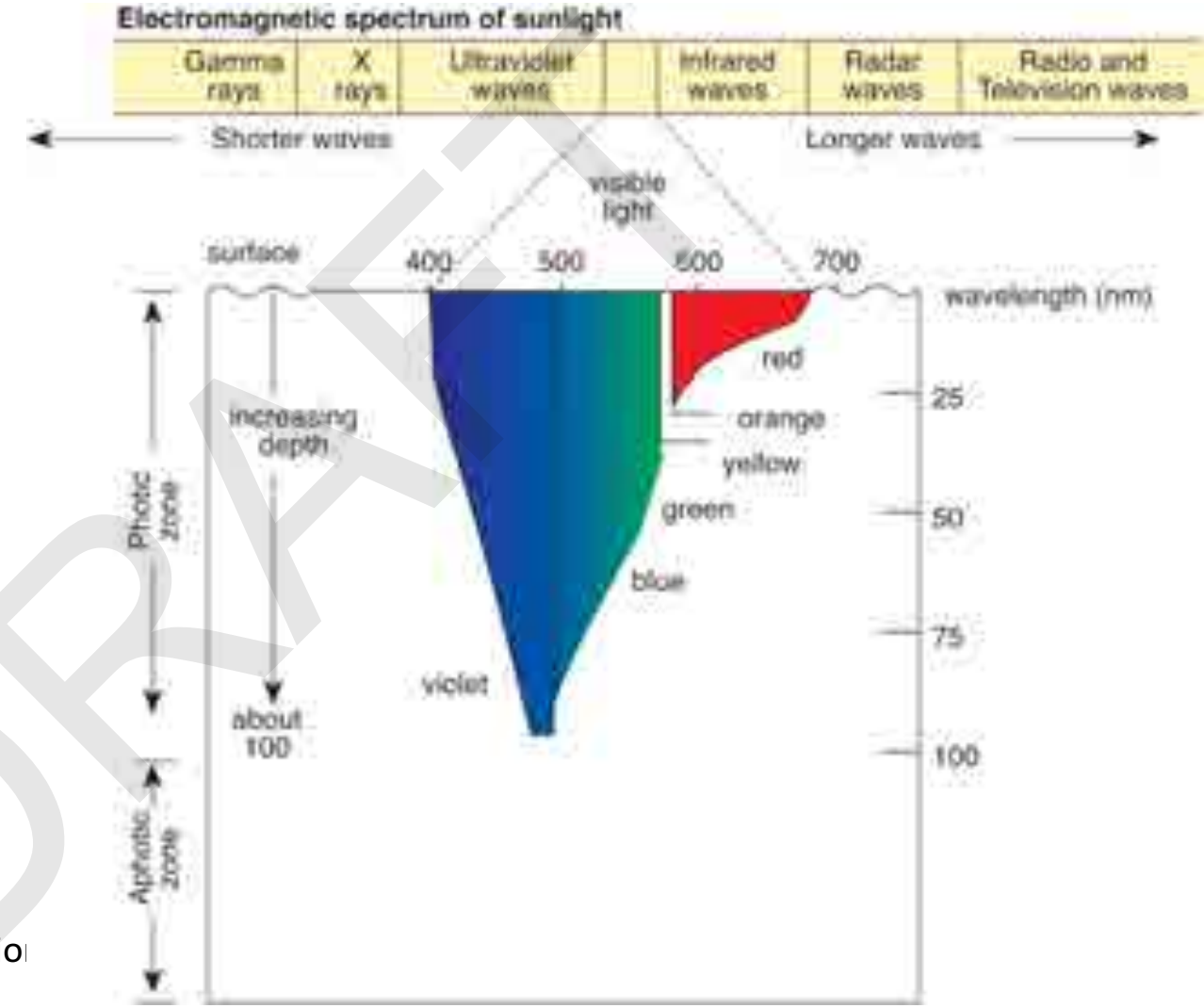
Diver decends to darkness
Photo Viewfinder Australia

DRAFT

White light is made up of the full spectrum of colours of the rainbow.

Red light is absorbed first by the water and does not penetrate as far as the blue or violet light.

This is because the shorter the wavelength of light, the greater the depth it penetrates.



Light penetratio

Illustration Trent Moffatt

DRAFT

Since an object will be the colour of light it reflects, a red fish at a depth of 30 m will reflect little red light.

So a red emperor will appear dark at depth.

Red throat emperor and reef scene

By Jean-Lou Justine (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons, photoshoped scene by deep voyage

But a lot brighter when brought into the air.

Red throat emperor at surface

By Jean-Lou Justine (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

DRAFT

The impact is that there is also a limit to the depth to which light can penetrate into the sea (usually the top 100 m of the ocean).

This results in three distinct zones with different types of marine life.

Distance light travels in the sea

Citation: NOAA. How far does light travel in the ocean?
National Ocean Service website,https://oceanservice.noaa.gov/facts/light_travel.html

DRAFT

In the sunlight zone, the amount of light that penetrates the water depends on dissolved minerals, silt and detritus material contained in it.

Blue water indicates that the surface water contains very few minerals and so has little plant life, so it can be considered a ‘desert’ area.

Green sea water contains large concentrations of ions, which in turn cause an abundance of plant growth, which in turn attracts large numbers of animals.

You can read more at https://en.wikipedia.org/wiki/Ocean_color

Blue seawater
Photo Viewfinder

DRAFT

Colour can also depend on the amount of suspended matter.

Sand disturbed by breaking waves cause the colour to change.

Colour of water in surf
Photo Bob Moffatt

DRAFT

When it rains in cities and coastal towns pollution from the land flows through stormwater pipes and into the sea.

This changes the quality and colour of the water significantly.

Blue creek water with drains
Photo Bob Moffatt

DRAFT

Fast flowing rivers can also carry soil and fertilisers into the sea.

Coupled with wave action and tides, this can reduce light penetration significantly.

Mangroves close to farmland

Photo Bob Moffatt

DRAFT

So light availability in the sea is impacted by sediments from the land.

Sediments from the land impact on light availabilty the sea
Photo Bob Moffatt

DRAFT

Light availability also impacts on an animal's vision in the sea.

Most fish have well developed eyes to detect light penetrating the water.

Blue eye fish
Photo Fisheries Queensland

DRAFT

The lens of the eye of the fish is spherical and protrudes out of the iris, giving the fish a good peripheral vision.

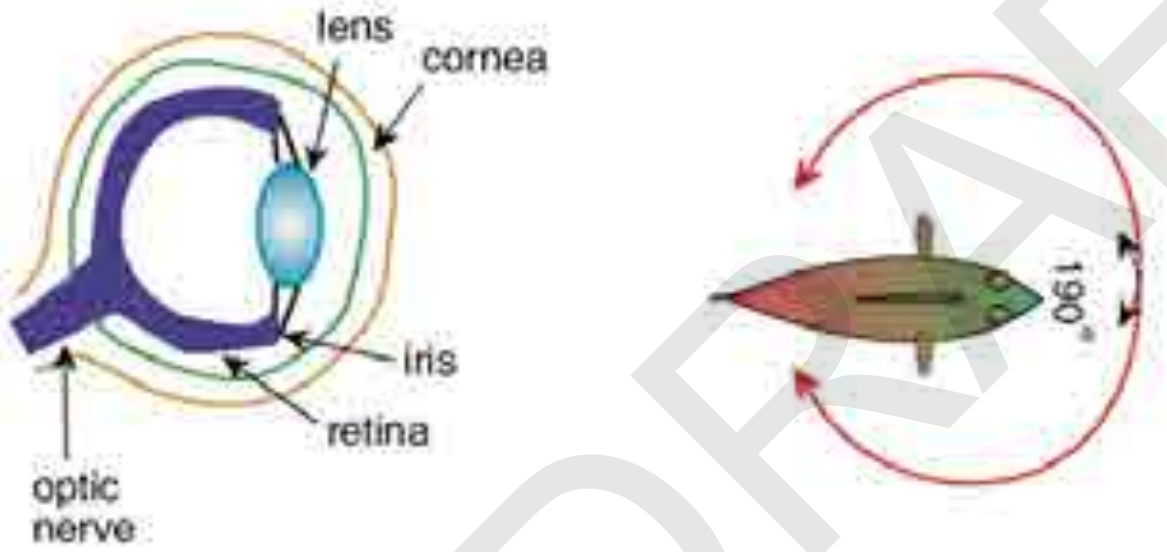
It is possible for the light to enter the eye from wide angles. This allows the fish to have nearly 360° or total field of view.

Fish eye

Photo Underwater Rhelms

DRAFT

This is especially helpful for fish because the prey or the predators can be seen above, below, in front of or behind their body.



Fish eye and vision
Illustration Bob Moffatt

DRAFT

Light availability also impacts on reproduction.

Fish must be able to see colour because of their own colouration and courtship behaviour.

Zebrafish

By Azul (Own work) [Copyrighted free use], via Wikimedia Commons

In the midnight zone fish can only detect the intensity of the light or the light from other sea creatures.

Their eyes are well developed with a large pupil and a special golden pigment that is sensitive to blue light.

Some of the species found in the deep have tubular eyes that can concentrate or better focus the light.

Viperfish

By Forgerz (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons Unknown (R)

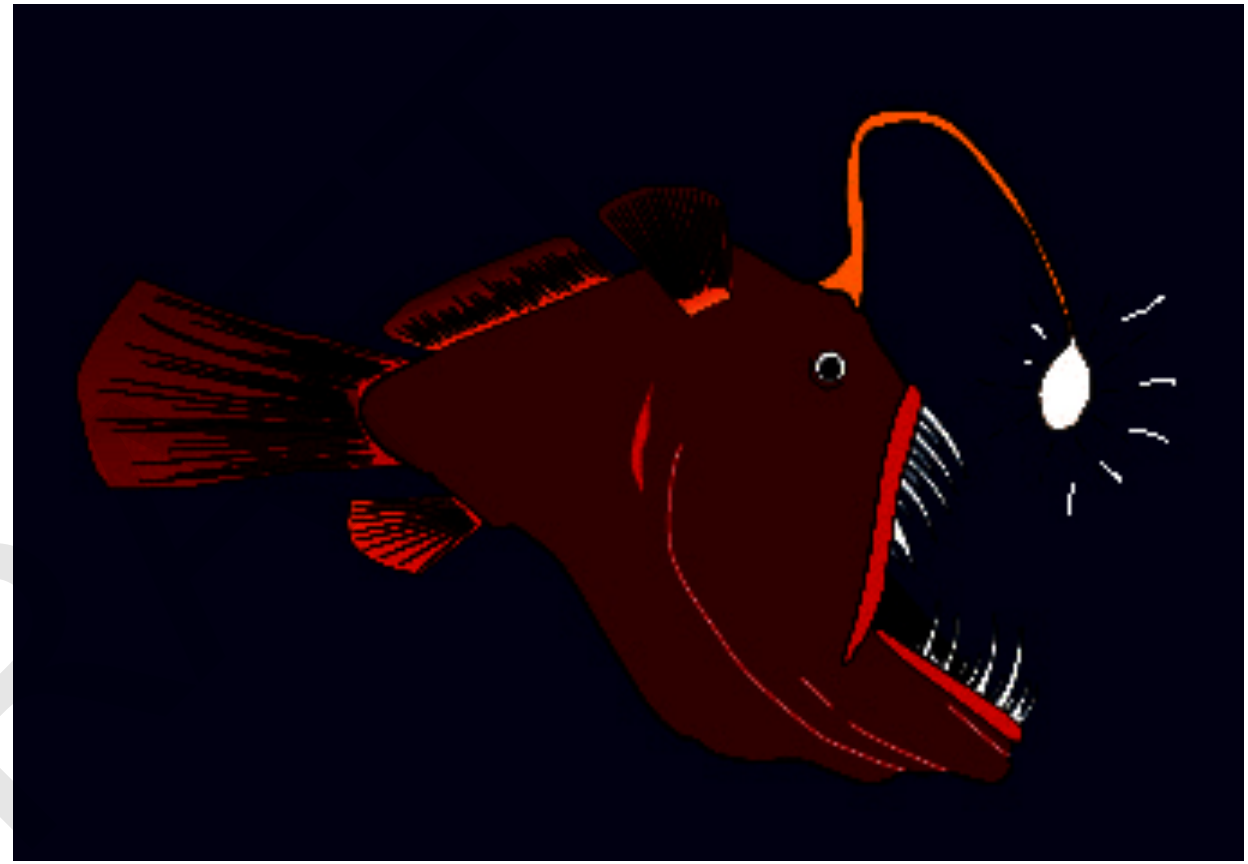
DRAFT

Fish that live below 1000 m have small eyes or no eyes.

The exception being the Lantern fish which uses its eyes to find its mate.

The male anglerfish has an organ that can produce light to attract the female.

There are over 600 different species of fish living below 1000 m that possess light producing organs.



Lantern fish
Illustration Kerry Kitzelman

DR

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves
6. Currents (water and wind)
7. Tides
8. Sediment type
9. Nutrient availability

Web Reference

https://oceanservice.noaa.gov/facts/pressure.html

DRAFT

1. Light availability
2. Depth

- Pressure
- Density

3. Stratification
4. Temperature
5. Waves
6. Currents (water and wind)
7. Tides
8. Sediment type
9. Nutrient availability

DRAFT

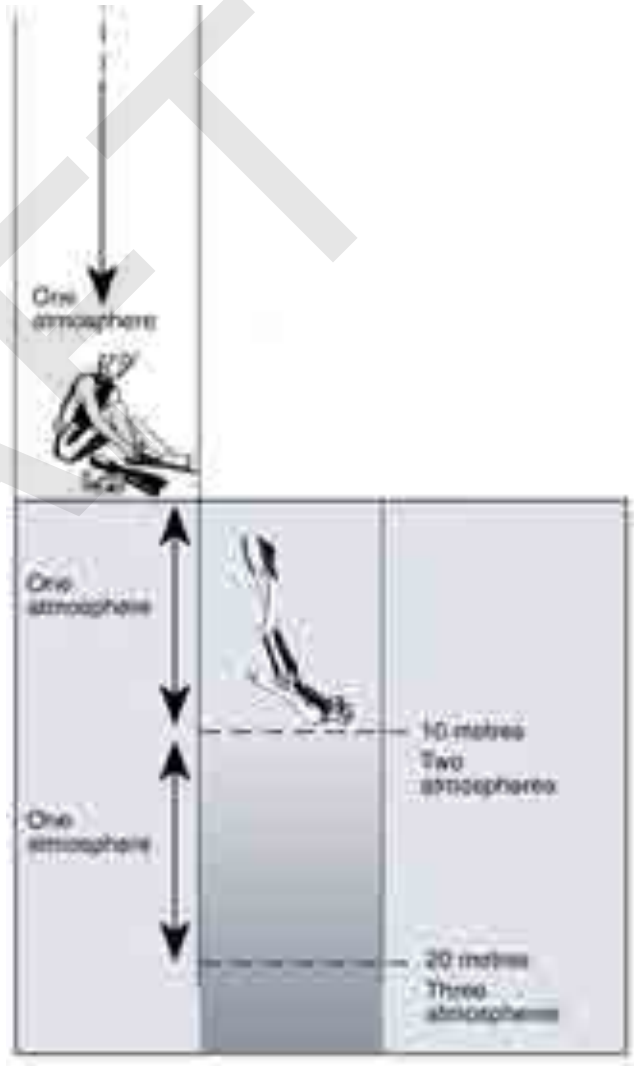
Pressure increases with depth in a simple experiment with a bottle as shown.

Pressure and depth in a bottle
Photo Bob Moffatt

DRAFT

Marine scientists need to be aware of this increase as they dive to study marine biology.

Pressure on the surface is 1 atmosphere but triples at 20 meters.



Pressure and depth on a diver
Illustration Bob Moffatt

DRAFT

Pressure impacts on se creatures such as jellyfish who have to adjust the pressure in their tissues to that of the water outside their body.

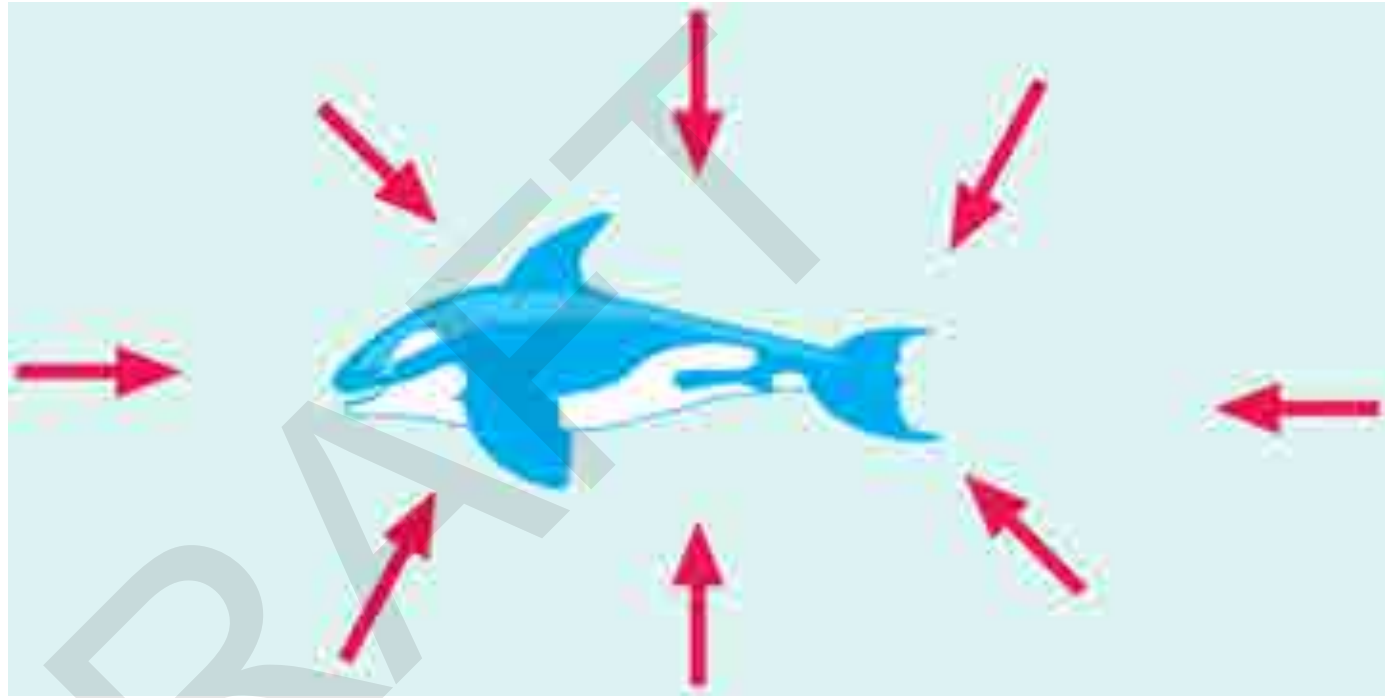
Sea jelly
Photo Bob Moffatt

DRAFT

Fish and whales of the great depths have very dense bony bodies and lack air-bladders to cope with pressure changes as they hunt for food at a range of depths.

There was a whale that dives for three kilometers.

Blue planet.



Pressure on a whale
Illustration Bob Moffatt

DRAFT

Whales have special adaptations to allow them to dive to great depths.

They have lungs and because these will collapse at great depths, they have a special network of blood vessels that carry extra oxygen.

They also have fatty emulsions that carry extra oxygen.

Whale echolocation

Illustration Steven Byers

DRAFT

These same fatty emulsions absorb nitrogen from the blood stream at depth.

This impacts on marine scientists who have to allow time when ascending from depth to stop nitrogen forming bubbles in their blood – or getting the bends.

Diver ascending and decompressing

By Peter Southwood (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Figure Dolphin and diver

Photo Neville Coleman

DRAFT

Depth and density

Since density increases with depth, fish tend to float back to a depth where its density equals that of the water.

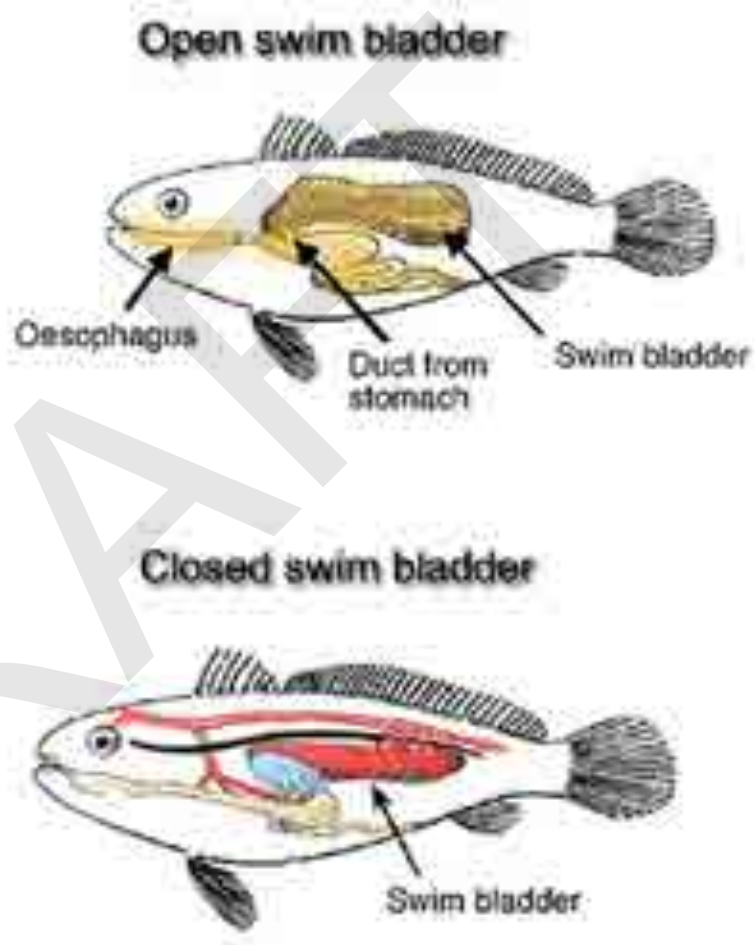
They have developed a swim bladder to move through different depths to hunt for food or escape prey.

NOT A GOOD ONE

Have a Dissected one

Sharks have a fatty liver.

Swim bladder out moyth



Fish swim bladder open and closed

Illustration Jack Marsh

DRAFT

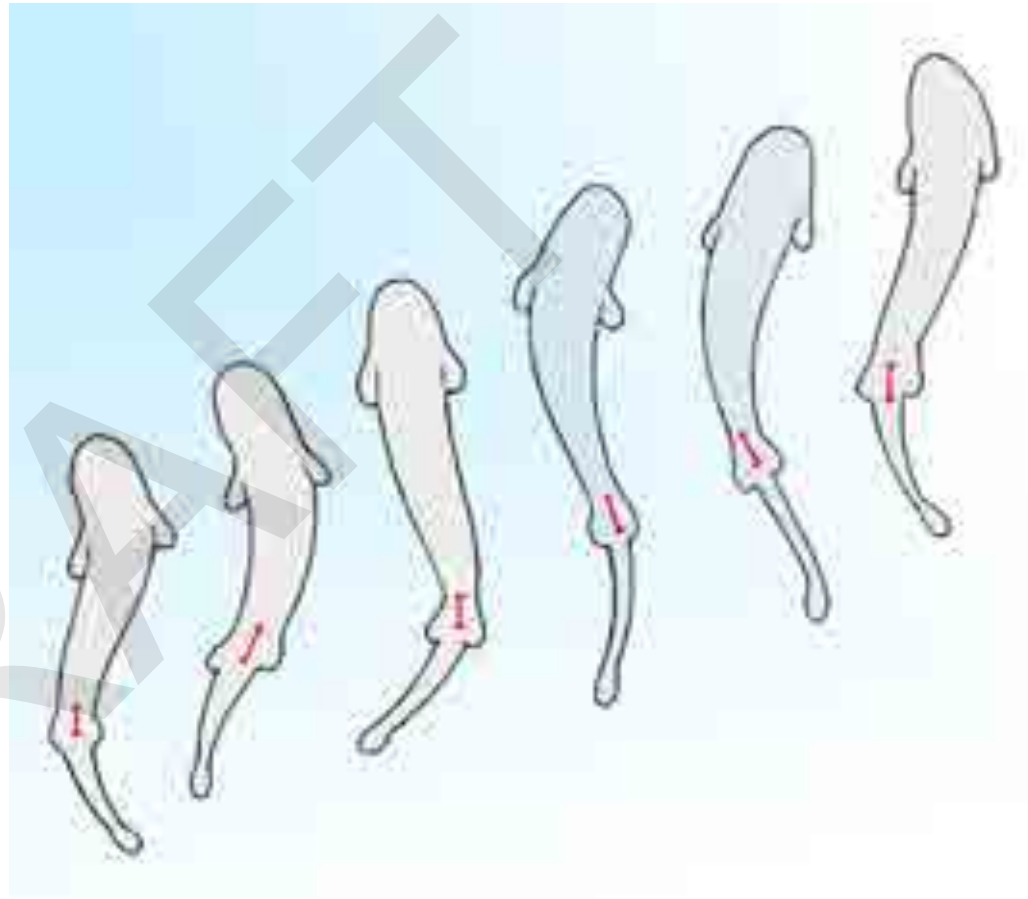
The density of water impacts on the ability of a fish to move.

Aquatic fish also require fewer interlocking structures on the vertebrae of the dorsal backbone.

This allows a greater flexibility of the backbone permitting the wave-like swimming motions that most fish exhibit.

Viscosity

Streamlining



Shark swimming motion

Illustration Bob Moffatt

DRAFT

Depth impacts on the height

Aquatic organisms require fewer supporting structures in their bodies.

An aquatic plant does not require a stem made of tough cells cemented together to hold it upright.

The brown kelp in the photo remains upright while suspended in water

Giant kelp brown algae
Photo Mike Sugden

DRAFT

If an aquatic plant such as algae (slime) is removed from water it forms a claggy mess, but in water it is supported and has a feathery appearance.

Algae on rocks
Photo Bob Moffatt

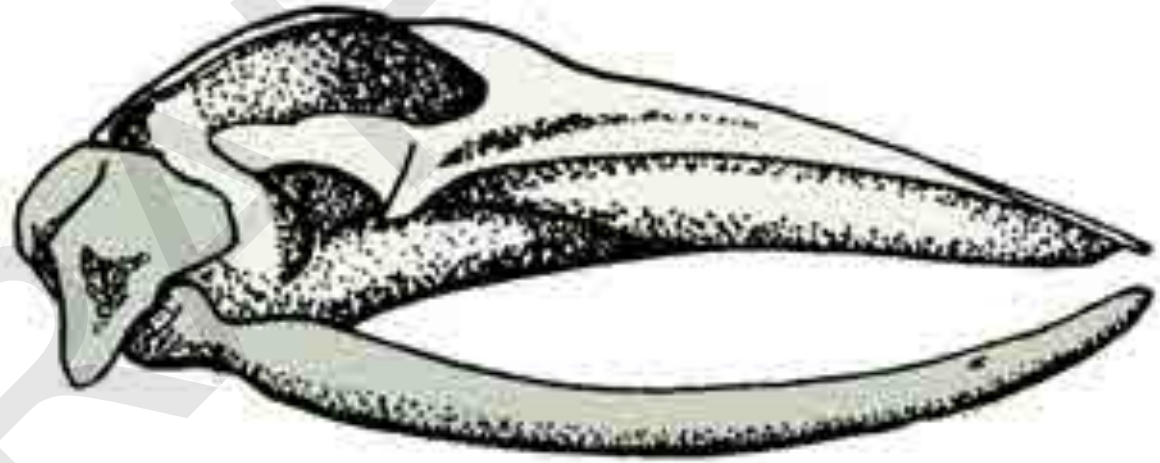
DRAFT

Depth also impacts on bone structure.

The bones in the skeletons of aquatic animals are very different from those in terrestrial (land-living) animals.

The terrestrial animals need to have hollow bones to keep their weight to a minimum.

Aquatic animals mostly have solid bones as they have the water's upthrust reducing their weight.



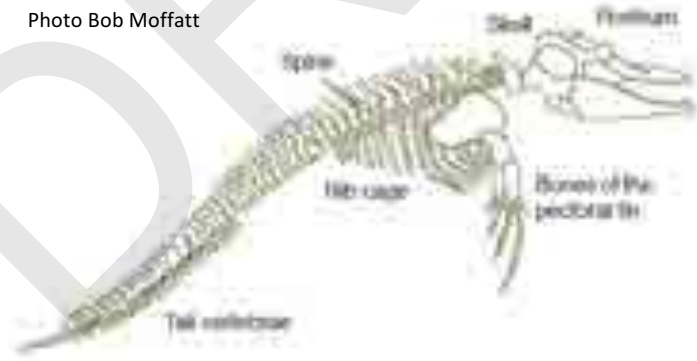
Whale jaw
Illustration Steven Byers

DRAFT

Another example of how the water supports the aquatic animals is seen when large marine animals such as whales and dolphins are beached.

These animals often suffer broken rib bones, as the water no longer supports their weight.

Whale on a beach
Photo Bob Moffatt



Dolphin skeleton
Illustration Kerry Kitzelman

DRAFT

1. Light availability
2. Depth - pressure and density
3. Stratification
4. Temperature
5. Waves
6. Currents (water and wind)
7. Tides
8. Sediment type
9. Nutrient availability

Note:
Stratification due to differences in temperature, currents, density, salinity, light and even pressure were discussed in T007 Cline definitions

DRAFT

Stratification in the field of **ecology** refers to the vertical layering of a habitat.

This is wrong

We should have stratification like
Salinoity
Light
Oxygen
Temperature

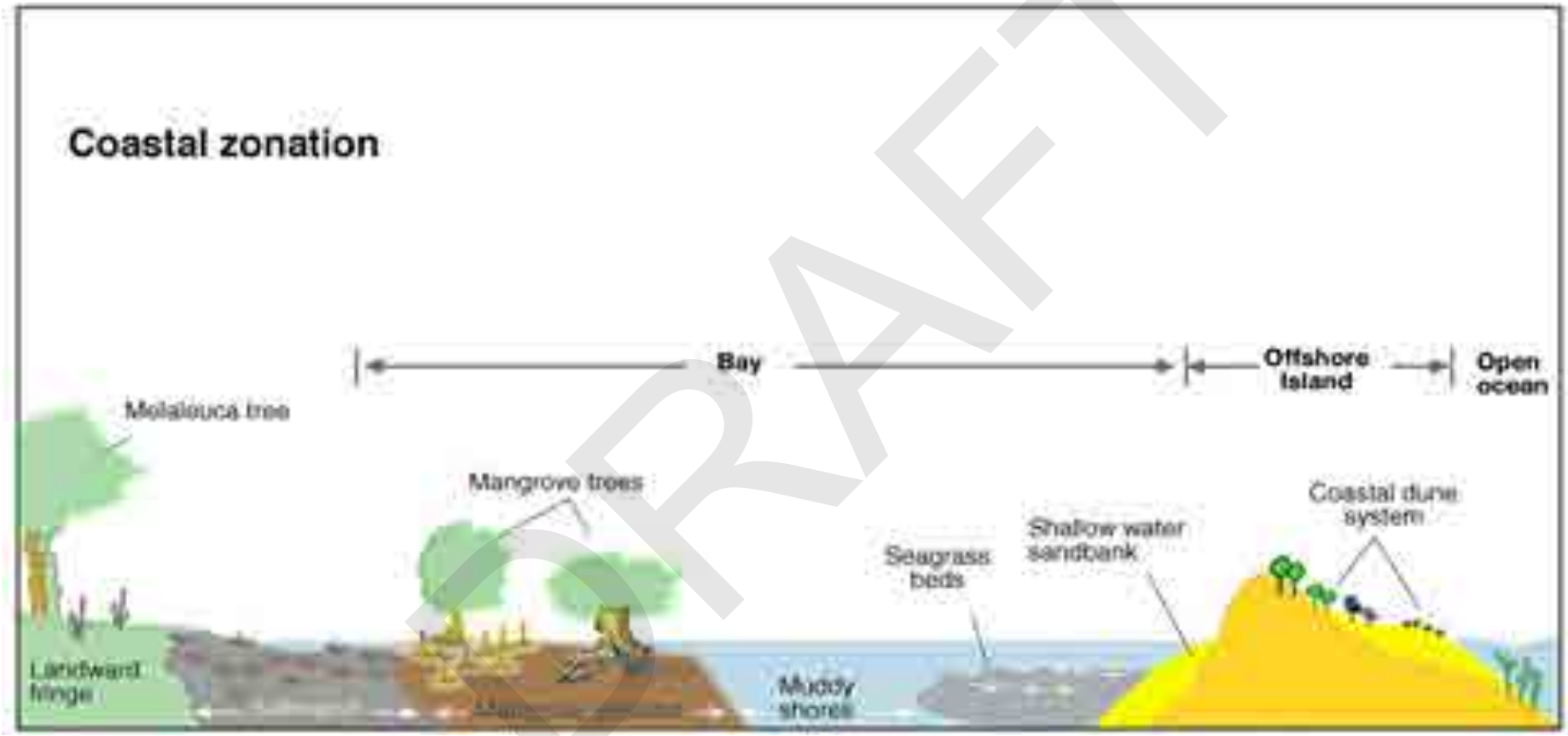
An excellent set of slides can be found at

https://www.slideshare.net/sumaiahalghamdi/stratification-of-water-environments

Stratification slide share pic
https://www.slideshare.net/sumaiahalghamdi/stratification-of-water-environments

DRAFT

Local stratification in Queensland close to your school occurs in coastal sand dunes, mangroves, estuaries and rocky shores.



Zonation on the coast

Illustration Bob Moffatt

DRAFT

In rocky shores the vertical stratification can be seen on rocks.

wrong

Zonation stratification rocky shore

Photo Bob Moffatt

DRAFT

Wave action plays a big role in this stratification.

Waves break on rock
Photo Bob Moffatt

DRAFT

Temperature, salinity, availability of dissolved gases also play a big role in the stratification of habitat

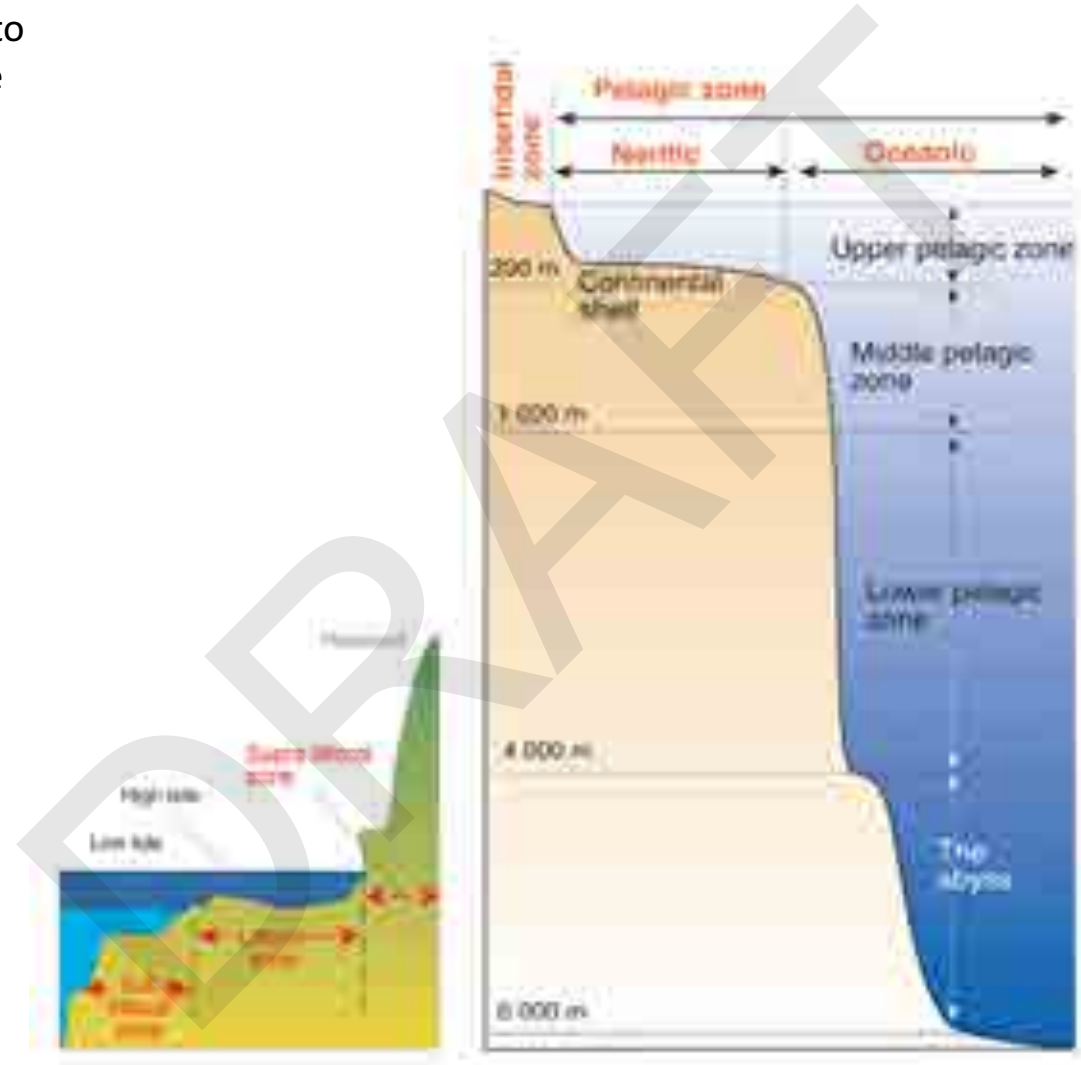
- especially in rock pools

Rock pools with arrow showing place of high salinity and temperature

Photo Bob Moffatt

DRAFT

These abiotic factors lead to the stratification of marine life into zones.



Zones in the sea

Illustrations Bob Moffatt

DRAFT

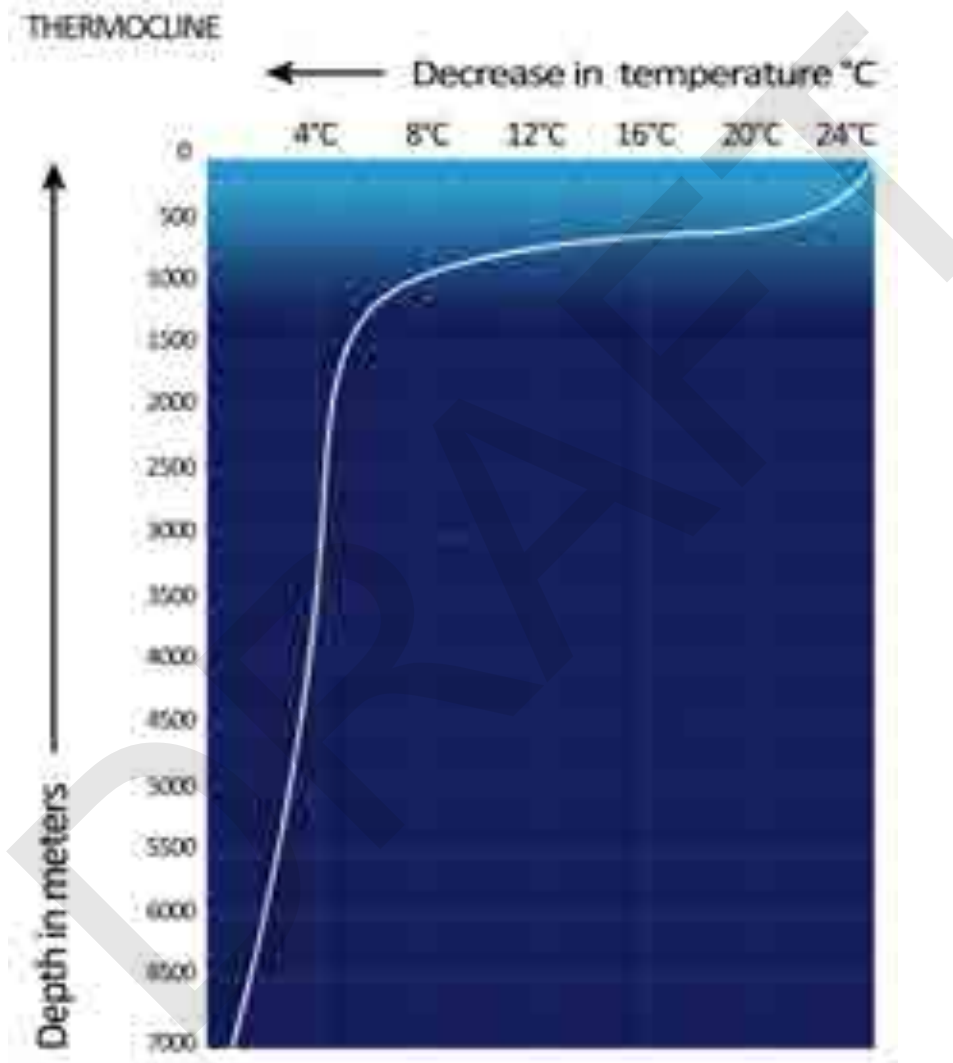
1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves
6. Currents (water and wind)
7. Tides
8. Sediment type
9. Nutrient availability

Sun on coral from above
Photo Viewfinder Australia

DRAFT

Link - Topic T007
Clines in the sea

The temperature of the ocean decreases as you go to the bottom of the ocean



Thermocline

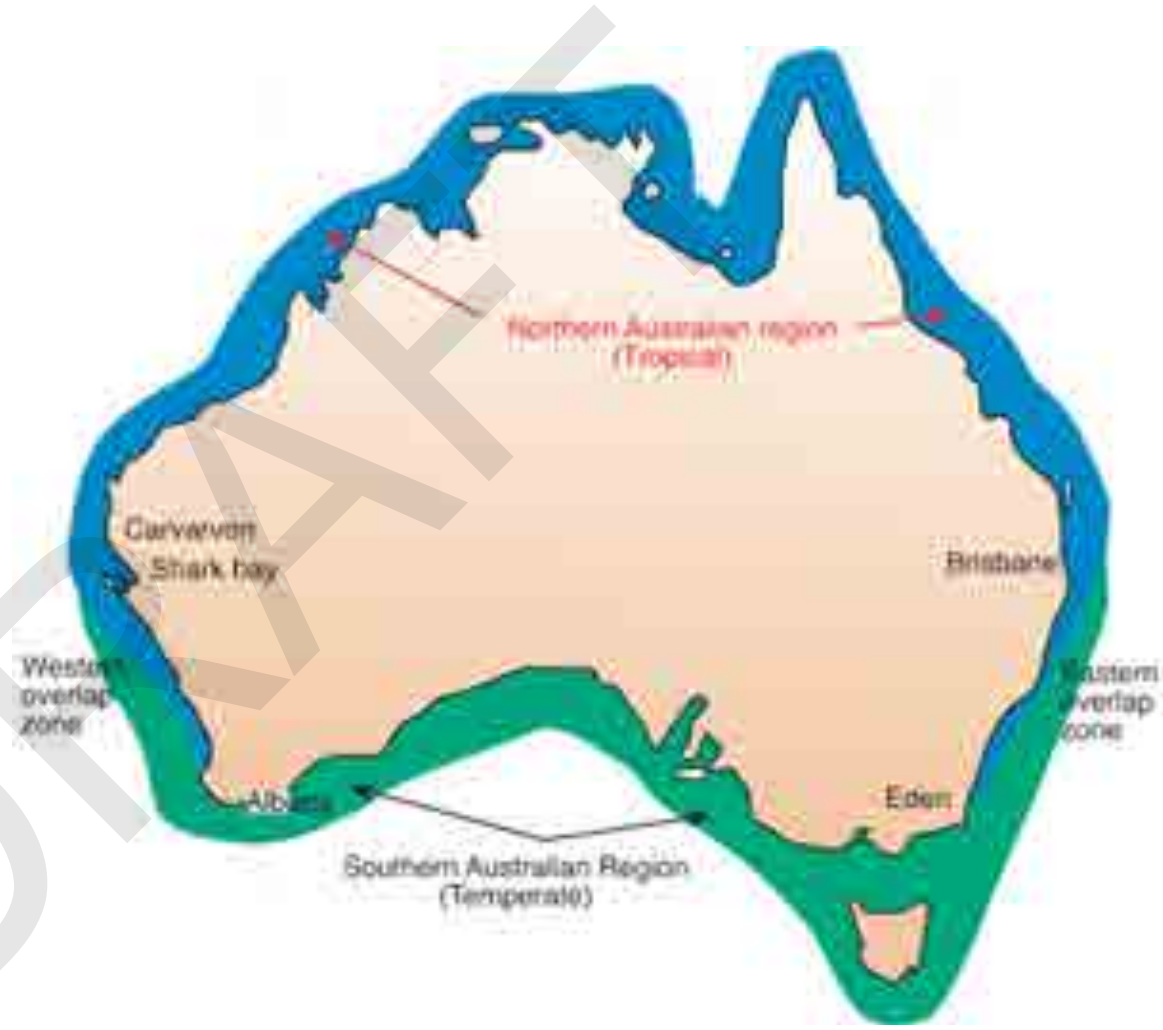
By Praveenron (Own work) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

DRAFT

However in Ecology

Australia has TWO marine biomes divided by temperature.

These are tropical and temperate regions.



Australian bioregions
Illustration Bob Moffatt

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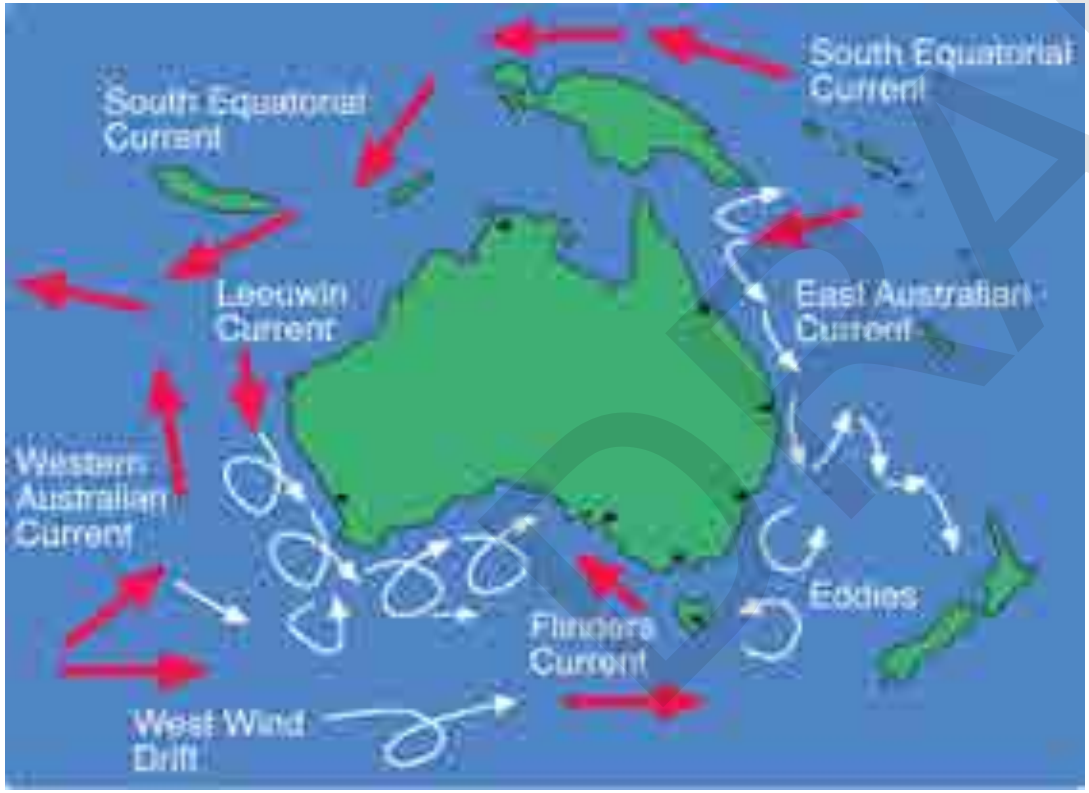
The boundary between the tropical and warm temperate provinces coincides approximately with 18-20oC winter minimum surface temperature.

This is variable and dependant on the influence of the East Australian Current and the Leeuwin Current.



Australian currents
Illustration Bob Moffatt

DRAFT

Open shores in northern Australia are typified by extensive growths of coral reefs.

Sheltered shores support over 30 species of mangrove and have little salt marsh vegetation.

Northern coral reefs have a high diversity of fish and invertebrates.

However, only 10% to 15 % of northern Australian marine species are endemic (found only in that part of the world).Southern Australian Region

Australian coastal zone ecosystems

Source SOMER 1998 G Ryan Illustrator reproduced with permission

DRAFT

Southern Australian Region

Rocky shores in southern Australia are typified by extensive growths of massive brown seaweeds, called kelps.

Sheltered shores support extensive salt marshes and only one species of mangrove.

These shores have the world's highest diversity of seaweeds and some invertebrate groups. 80% to 90% of southern Australian marine species are endemic.

Fairy penguins
Photo Gould League

DRAFT

The range of temperatures a marine organism has to endure depends also on the volume of water in which it is found - the smaller the volume of water the larger the range of temperatures.

A rock pool will only require a small amount of energy from the sun to cause a temperature fluctuation of 10°C

Rock pools

Photo Bob Moffatt Illustration Sharryn Madder

DRAFT

But a reef or ocean requires a large amount of energy to cause the same temperature fluctuation.

Reef aerial
Photo Viewfinder

One impact of temperature is that fish can detect these changes in temperatures with receptors that are located all over their body.

Fish are also cold-blooded or poikilothermic, which means that their body temperature varies in response to the temperature of their environment.

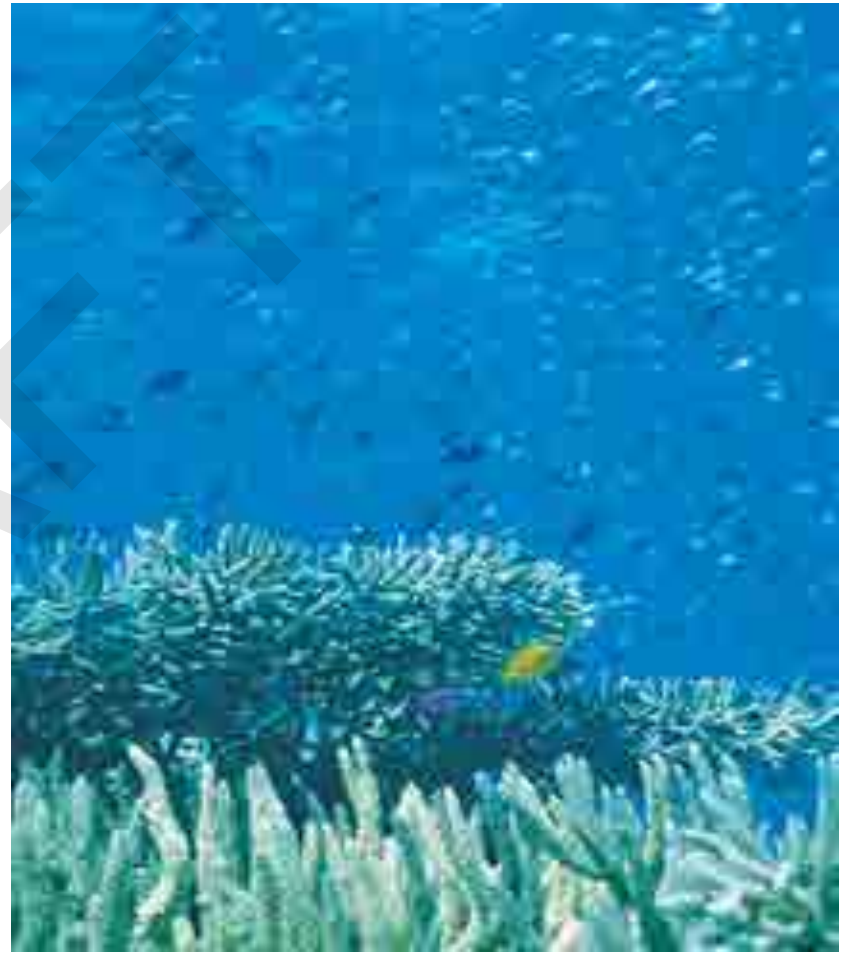
As a result their activity tends to become sluggish if the water temperature drops.

The change in temperature also causes the chemical reactions that take place in their body to speed up or slow down.

Many scientists believe that the stimulus for breeding of many species of fish is a change in water temperature.

Some fish migrate to areas that have different water temperatures to breed.

Could goi



Fish on reef

Photo Below H20

DRAFT

In tropical waters, water temperature also exerts a major control over the distribution of marine organisms.

Rocky shore and pool
Photo Bob Moffatt

DRAFT

On a rocky shore, higher temperatures restricts animal size and so you see a decrease in shell size the hotter it gets.

Figure Nodular periwinkle on rocks
Photo Bob Moffatt

Temperature and can also affect growth rates in fish.

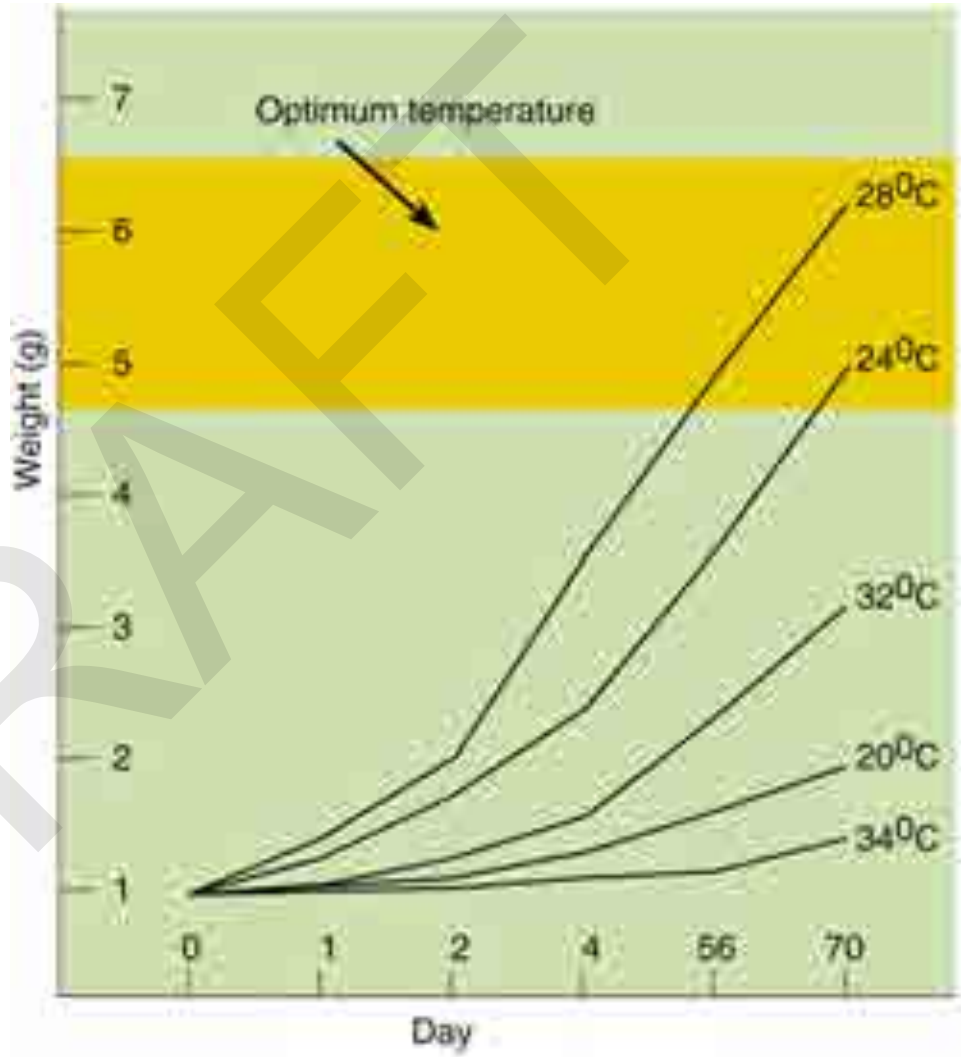


Figure Growth rates and temperature
Illustration Dave Mason

DRAFT

Temperature tolerances can differ widely between species.

Some species can withstand a wide range of temperatures and these are called eurythermic.

These eurytherms are mostly found in the shallower waters that have a greater temperature range.

An example is the green crab.

Green crab

By Lmbuga (Luis Miguel Bugallo Sánchez) (Own work) [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0/)], via Wikimedia Commons

DRAFT

Perhaps the greatest impact of temperature is on corals. If the sea temperature rises coral bleaching occurs when coral polyps expel algae that live inside their tissues.

Bleached branching coral (Acropora sp.) at Heron Island, Great Barrier Reef.

By: J. Roff Acropora at English Wikipedia [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves and wind
6. Currents
7. Tides
8. Sediment type
9. Nutrient availability

Waves Kiama
Photo Bob Moffatt

DRAFT

If we fly up the Queensland coast you can see many areas where estuaries are protected from the sea by either reefs, offshore islands or coastal dune systems.

This creates area if high and low energy.

Can you see them in the photograph?

Coastline and estuary
Photo Bob Moffatt

DRAFT

The net affect of waves to move sand along the coastline and create sand dunes whereas in areas where there are no wavers, mud forms making mangrove habitats.

So if you built a model to distinguish between waves as an abiotic features

You would say the abiotic feature is waves, and where they have lots of energy, sand dunes form and where they have low energy, mud forms.

Sand mud wave energy zones

Photo and model Bob Moffatt

DRAFT

Other affects of waves shaping habitats as an abiotic characteristic can be seen on the rocky shore.

Waves can shape the coastline as in a wave cut platform

Wave cut platform at Noosa
Photo Bob Moffatt

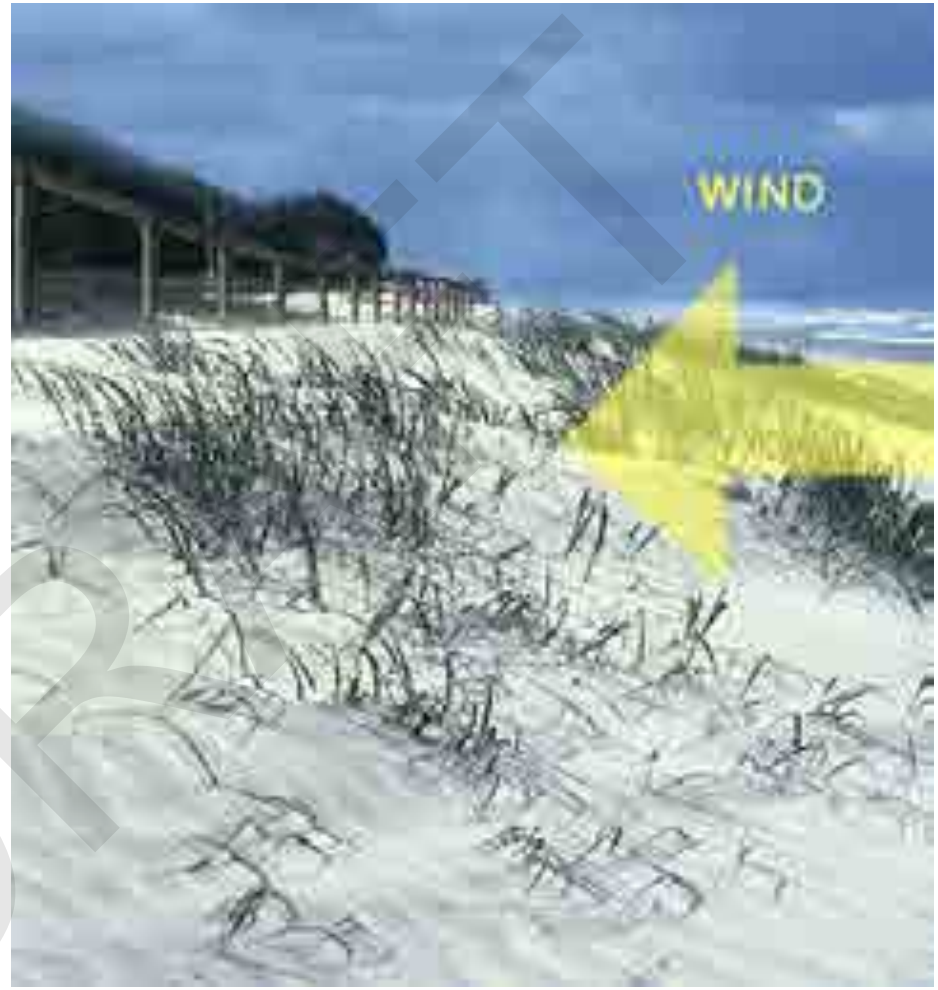
The impact of waves is that they determine where animals and plants are found on exposed shore.

Waves breaking on an exposed shore
Photo Bob Moffatt

DRAFT

Wind impacts include

- Moving sand
- Shaping plant life
- Changing habitats



Wind moves sand up beach

Photo Bob Moffatt

DRAFT

Wind sheer Queensland beach

Photo Bob Moffatt

DRAFT

Coastal plants are shorter where prevailing winds are onshore.

Here the Banksia sp are less than 1 m tall.

Banksia trees onshore prevailing winds
Photo Bob Moffatt

DRAFT

Where the prevailing winds are offshore, the Banksia sp here are 3m tall.

Banksia prevailing winds off shore
Photo Bob Moffatt

DRAFT

The impact of wind can be see if you go to North West Island on the Great Barrier Reef and walk around the island.

On the leeward side the Casurinas trees are at least 4m tall whereas on the windward side that are sheared back to half the size.

North West Island windward and leeward

Photos Bob Moffatt

DRAFT

Whereas inside the island, where there is little wind, the Pisonia trees can grow to at least five metres.

Slide taller inside

Trade currents

Affect distribution of animals

Peruvian anchoviers

Herring migrtstion

North West Island Pisonia forest
Photo Bob Moffatt

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves and wind
6. Currents
7. Tides
8. Sediment type
9. Nutrient availability

Students & current drogue
Photo Bob Moffatt

DRAFT

Currents can

- carry reproductive materials
- bring nutrients
- carry freshwater
- EAC Pengins and seals at galapagos
- Currents
- Upwellings are currents
- Longshore drift
- Distingusih the currents

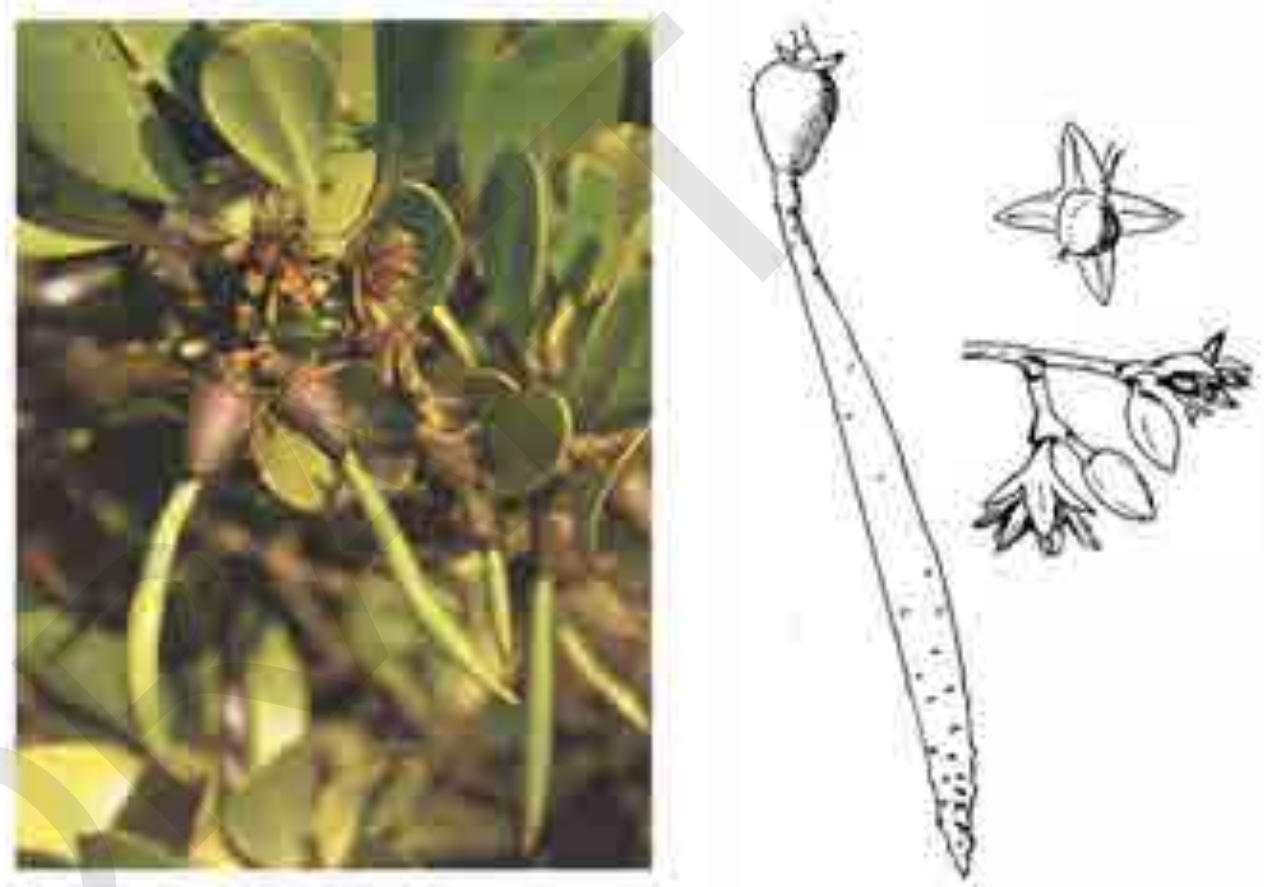


Figure Mangrove seed and fruit illustration
Photo and illustration Bob Moffatt

DRAFT

Currents carry reproductive materials

Mangrove seed and fruit illustration

Photo and illustration Bob Moffatt

DRAFT

Currents can cause erosion in estuaries

Figure Erosion on a estuarine river bank
Photo Bob Moffatt

DRAFT

Currents can move large volumes of biomass

Biomass moved by currents on a beach
Photo Bob Moffatt

No3t in thios topiuc

Consider gyres
Gulf stream
Eddies
Upwellings

Great ocean coveyor below

Salinity driven

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Waves and wind
6. Currents
7. Tides
8. Sediment type
9. Nutrient availability

Big tide at Broome
Photo Broome Historical Society

DRAFT

Tides

- expose organisms to predators
- expose habitat to sun and increased temperature
- flood habitat with seawater

High tide low tide comparison

Photos Bob Moffatt

DRAFT

In mangrove habitats, tides play a big role in stratification from the waters edge.

They expose large areas of habitat to predators and force many animals into the mud.

Mangroves waters edge
Photo Bob Moffatt

DRAFT

Further inland, low tide exposes coastal grasses which must be salt tolerant when the tide comes in.

Mangroves inland
Photo Dave Claridge

Low tides however provide feeding ground for a wide variety of wading birds.

Spoonbills feed at low tide
Photo Bob Moffatt

DRAFT

Ibis feeding at low tide

Photo Bob Moffatt

DRAFT

Fiddler crab low tide habitat

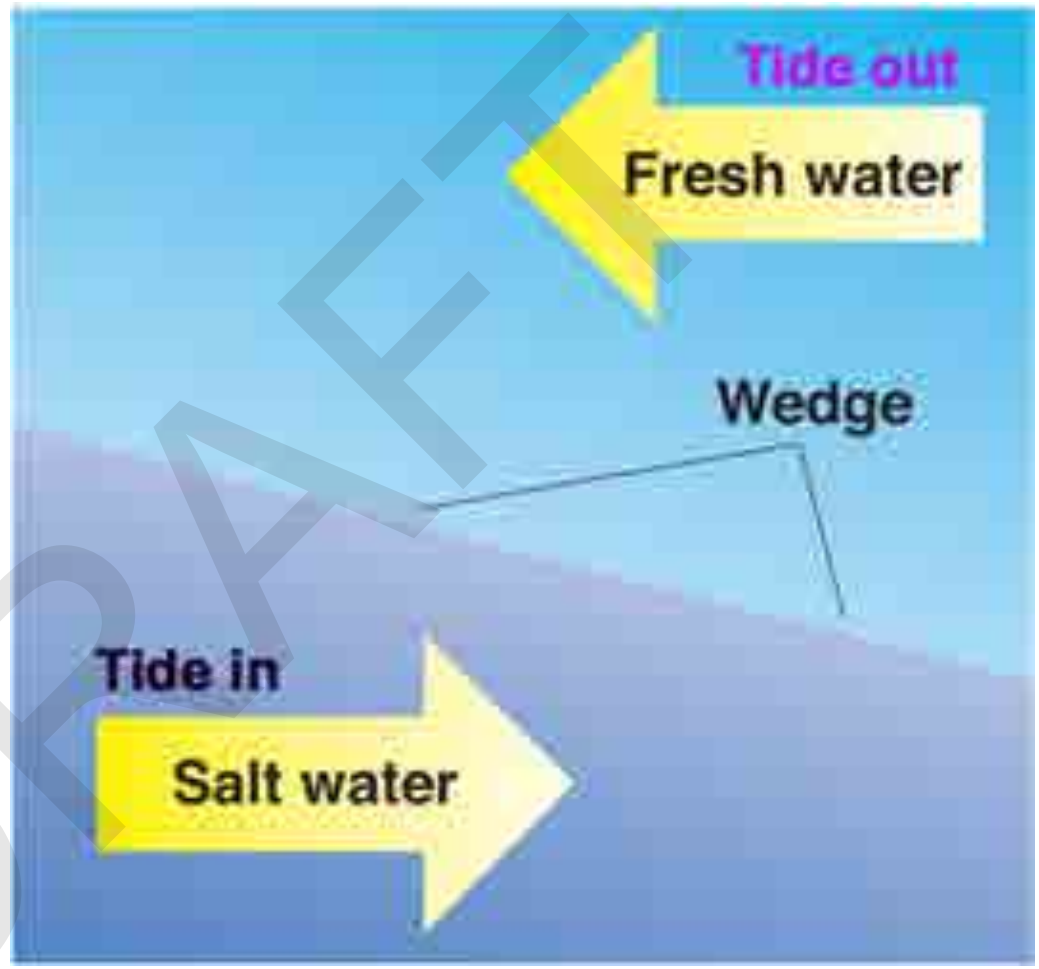
Photo Bob Moffatt

DRAFT

Salinity levels within an estuary are dependent on the tides.

During low tide, salt water influx levels are reduced.

Figure Salt water wedge
Illustration Bob Moffatt



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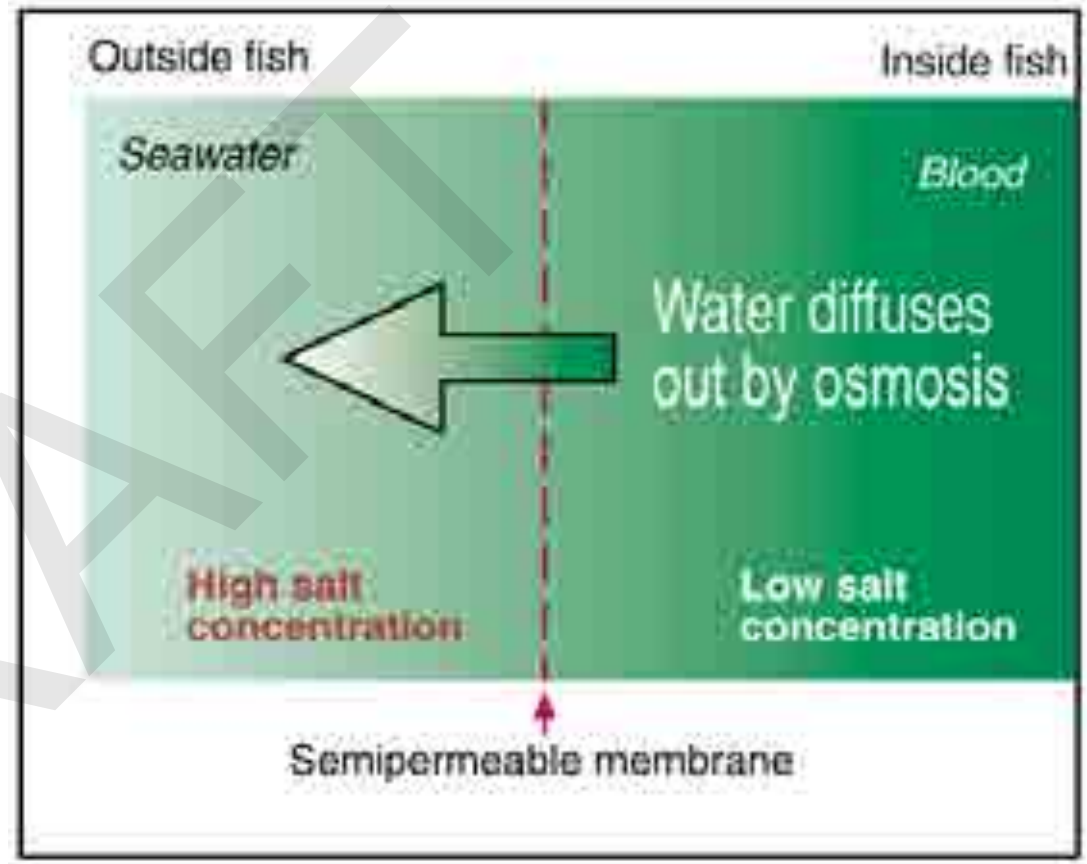
As tides come and go fish need to account for this change in salt concentration.

In order for water to enter cells, it has to pass through a cell membrane and the mechanism which regulates this is called osmosis.

The membrane through which the water moves is semipermeable and allows some substances through while inhibiting others, eg water can pass through easily but not salt.

The diffusion of water will depend on there being a difference in concentrations on either side of the semipermeable membrane.

Applying the laws of diffusion, water will diffuse from an area of low salt concentration to an area of high salt concentration presumably in an effort to dilute the salt.



Osmosis
Illustration Bob Moffatt

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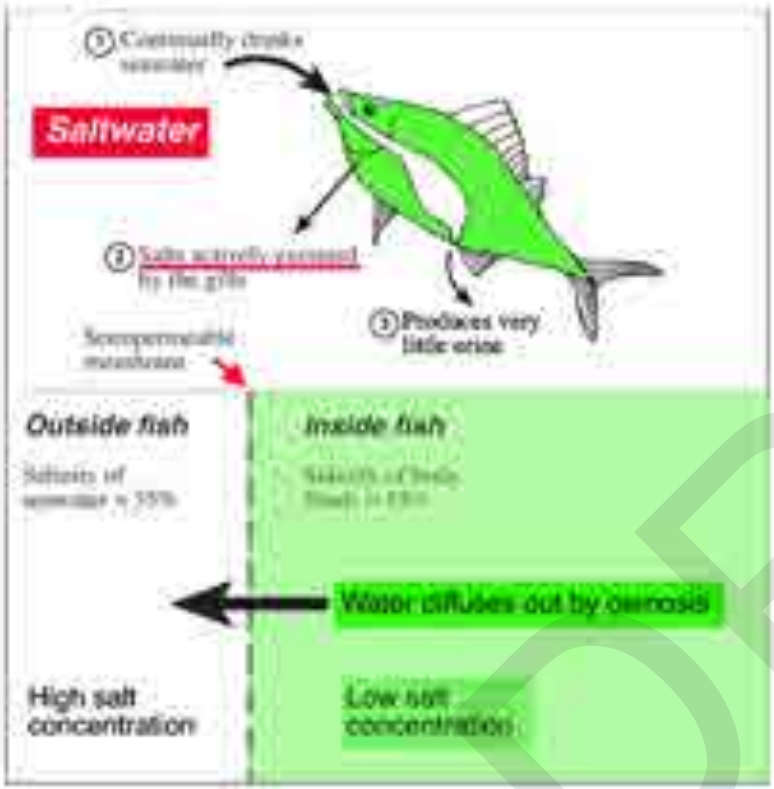

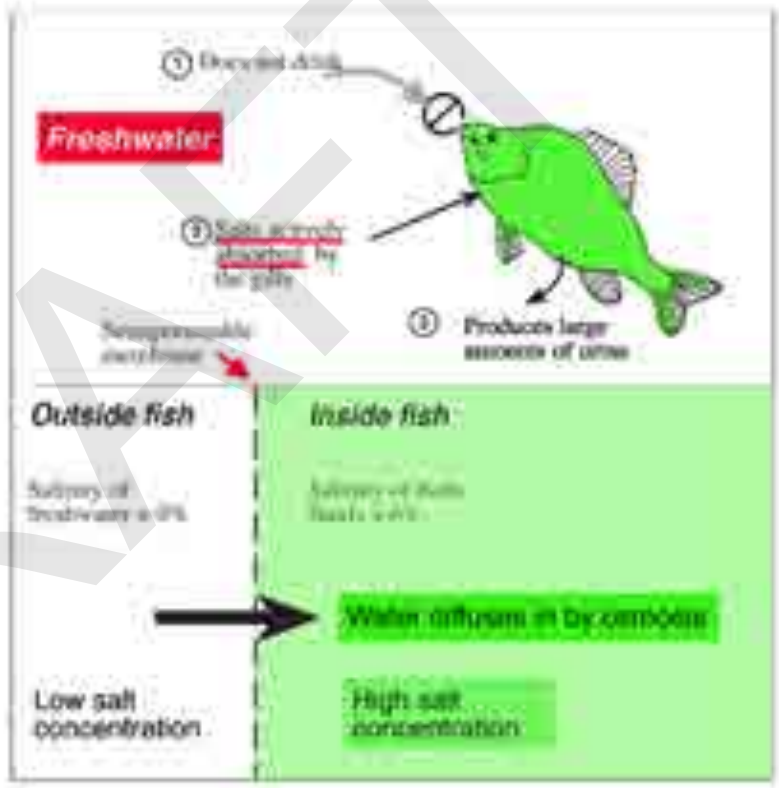

Osmosis saltwater to freshwater

Figure Bob Moffatt

DRAFT

Many estuarine plant species are halophytes: plants that can tolerate salty water on their roots or sea spray. In these plants filters in the roots remove the salt from the water that the plant absorbs.

Seagrass at low tide
Photo Bob Moffatt

DRAFT

The specialized aerial roots of mangroves enable plants to breathe air in habitats that have waterlogged mud.

The roots may grow down from the stem, or up from typical roots. Some botanists classify these as aerating roots rather than aerial roots, if they come up from soil.

The surface of these roots are covered with lenticel(small pores) which take up air into spongy tissue which in turn uses osmotic pathways to spread oxygen throughout the plant as needed.

Pneumatophores can differentiate the Black mangrove and Grey mangrove from other mangrove species.

Pneumatophores and illustration
Photo Bob Moffatt Illustration Rose Bedford

DRAFT

Animals, such as mussels and clams, have developed behavioural adaptations that expend a lot of energy to function in this rapidly-changing environment.

When these animals are exposed to low salinity, they stop feeding, close their shells, and switch from aerobic respiration (in which they use gills) to anaerobic respiration (a process that does not require oxygen).

When high tide returns to the estuary, the salinity and oxygen content of the water increases, causing these animals to open their shells, begin feeding, and to return to aerobic respiration.

Figure Mussels in an estuary
Photo Ruth Fairley

DR

1. Light availability
2. Depth
3. Stratification
4. Temperature
5. Wind and waves
6. Currents
7. Tides
8. Sediment type
9. Nutrient availability

Sand sediments
Photo Bob Moffatt

DRAFT

Water from the land carries huge amounts of sediments which can greatly affect local marine habitats. The figure below shows a sediment plume flowing out of a coastal river.

Sediment plume to coral sea

Photo Beach protection authority

DRAFT

This has great consequences for filter feeding animals. As the silt moves over the continental shelf, it will gradually flow down the continental slope till it reaches the deep sea.

Animals and plants that live here will need to cope with these layers of deep sea ooze.

Sediments from coastal towns and cities can also have devising effect one habitats.

Figure Stormwater & sediment
Photo Bob Moffatt

Gladstone port aerial photo chase up

DRAFT

The figure shows two types of sediment - course sand and fine mud.

Mangroves can grow in mud, but coastal spinifex cannot leafing to two different types of habitat.

Sand dune and mangrove.

Two sediment types

Photos Bob Moffatt Queensland Fisheries

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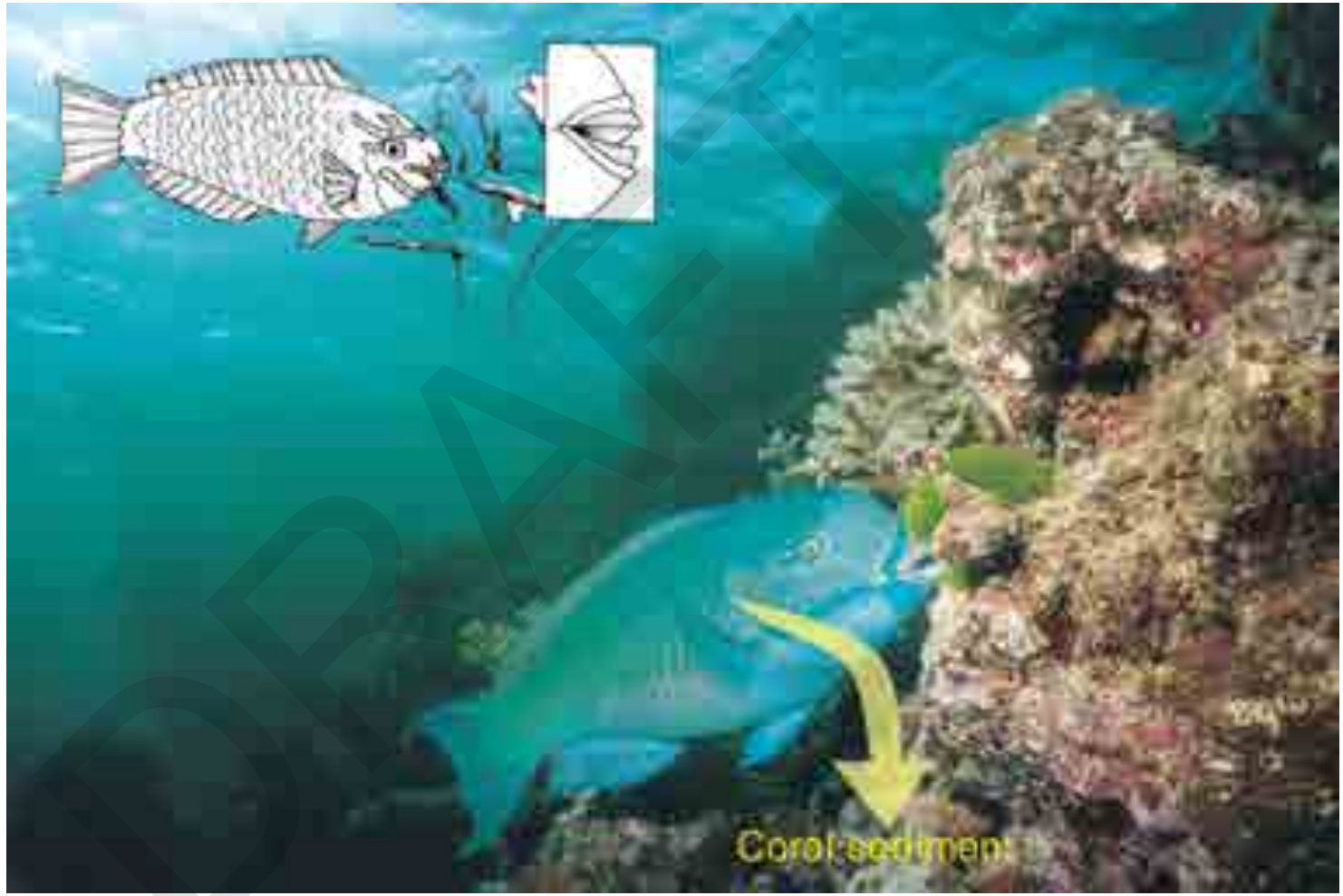
Sediments are also made in reefs by fish that graze on corals

Story of sand grains

Some from land

Some from sea

Carbonate and non carbonate sands



Parrot fish and coral sediment

Photo Bob Moffatt Illustration Steven Byers

DRAFT

1. Light availability
2. Depth
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5. Wind and waves
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8. Sediment type
9. Nutrient availability

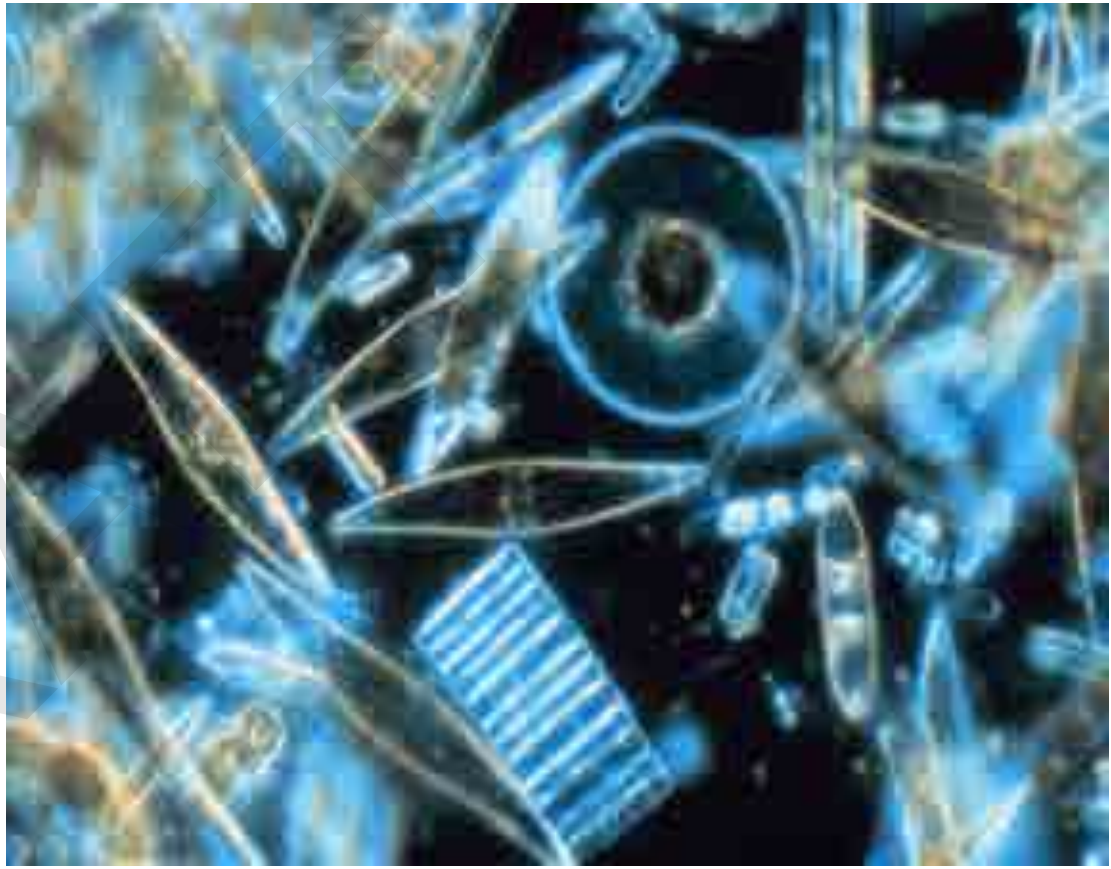
Sea gulls with seaweed
Photo Bob Moffatt

DRAFT

The most important nutrients for phytoplankton growth in the ocean are nitrate and phosphate.

Some types of phytoplankton, called diatoms, also require the nutrient silicate, which they use to build their cell walls.

Plants in the surface waters of the ocean take up these dissolved nutrients during photosynthesis.



Diatoms through the microscope

By Prof. Gordon T. Taylor, Stony Brook University (corp2365, NOAA Corps Collection) [Public domain], via Wikimedia Commons

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Phosphorus is an important element for spinifex which has an active root system to seek out this element.

When quartz and feldspar are formed, they contain a fine coating of phosphorus which sticks to the sand grain as it moves along the coast.

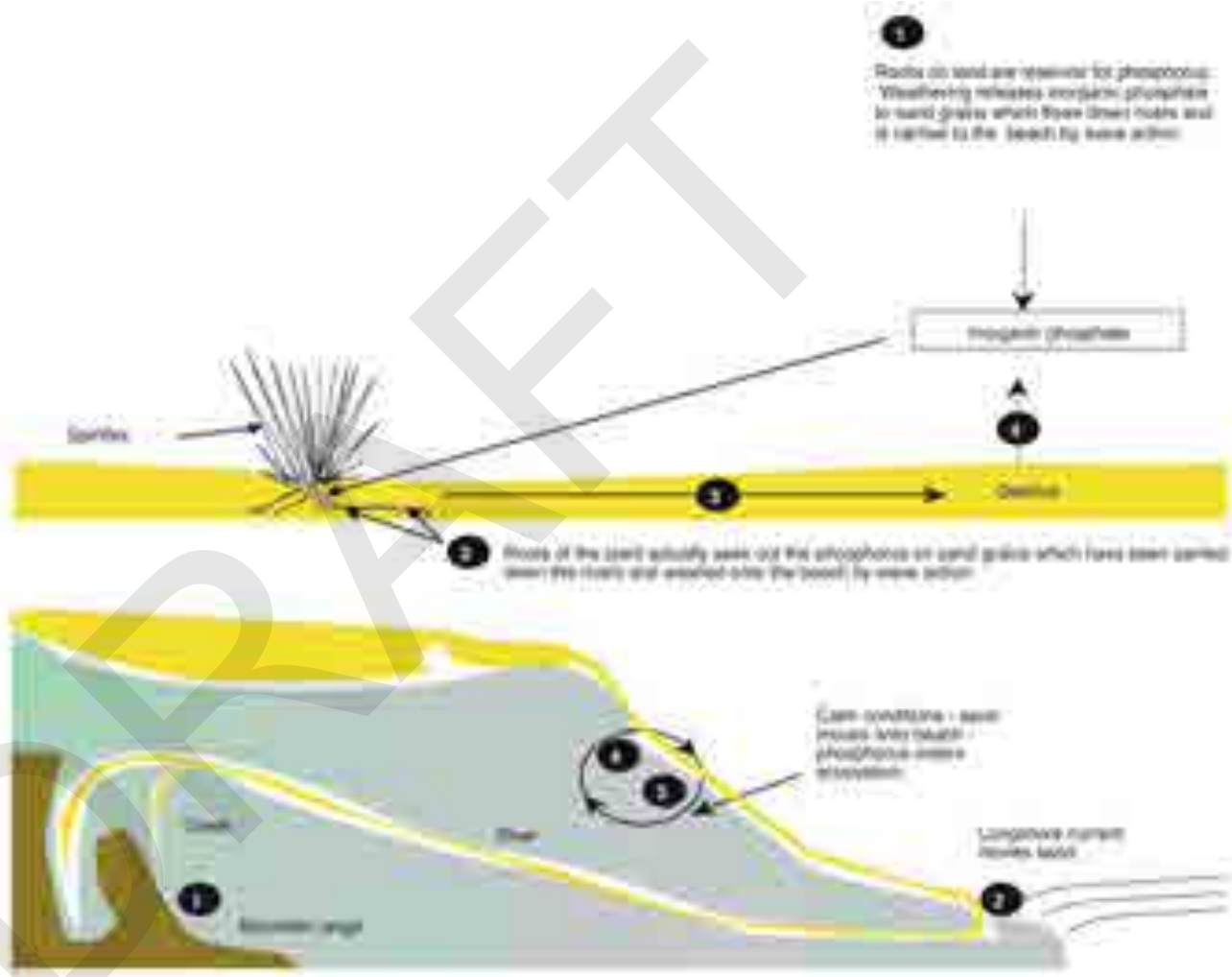
When the sand grains are washed up on the beach, they dry and are blown towards the spinifex.

Coastal spinnifex
Photo Bob Moffatt

DRAFT

The broad leaf of the plant catches the grain by reducing the wind velocity and the grains falls to the base of the plant.

Fine root hairs that grow from the main plant then absorb the phosphorus coating from the sand grain.



Spinifex and the phosphorus cycle

Illustration Bob Moffatt

DRAFT

Casuarina trees are able to convert the nitrogen in the atmosphere to a solid form inside the tree.

This is done by micro-organisms, called nitrogen fixing bacteria, that live in root nodules at the base of the tree.

Casuarina

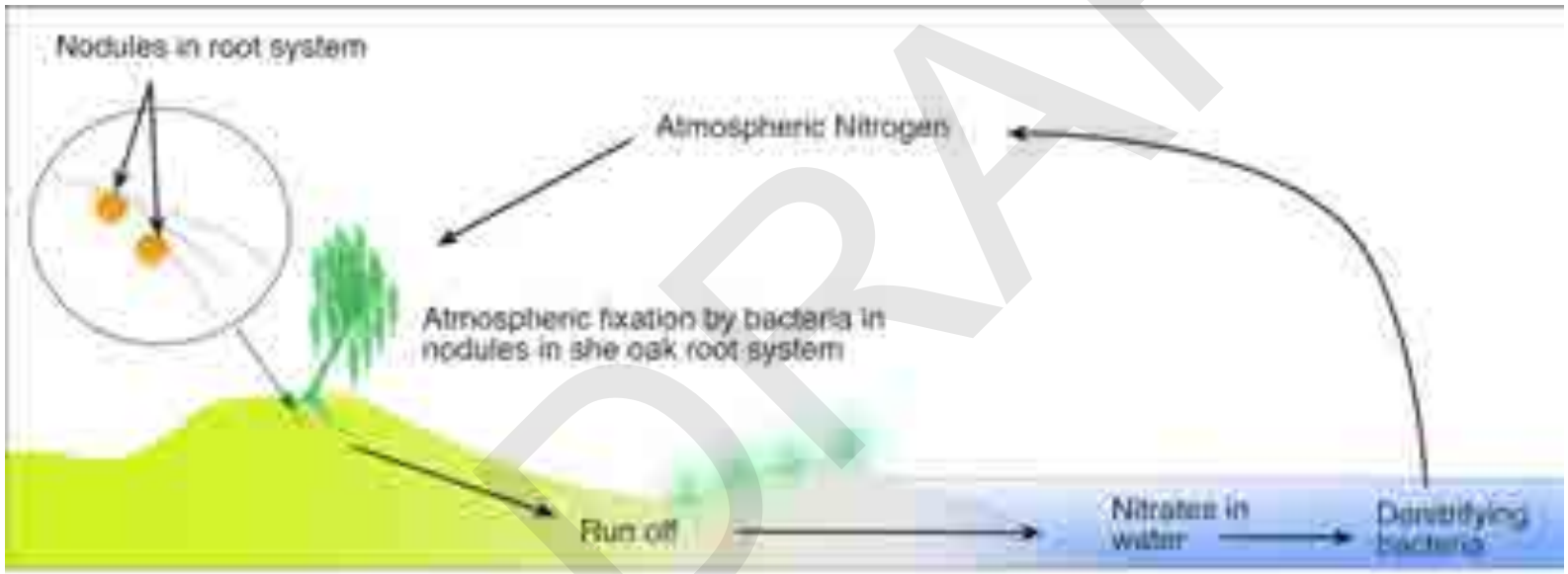
Photo Beach protection authority

DRAFT

The bacteria absorb the atmospheric nitrogen and convert it to a bound or “fixed” chemical form that can be released as a fertiliser to help the tree to grow.

This may be one reason why the tree grows so quickly.

This process is called nitrogen fixation and is part of the nitrogen cycle that is so important to the survival of the sand dunes.



Nitrogen cycle in Casurina
Illustration Bob Moffatt

DRAFT

On coral cays live Pisonia trees.

Coral cays are made from sand with few nutrients, so large trees called Pisonia's attract birds

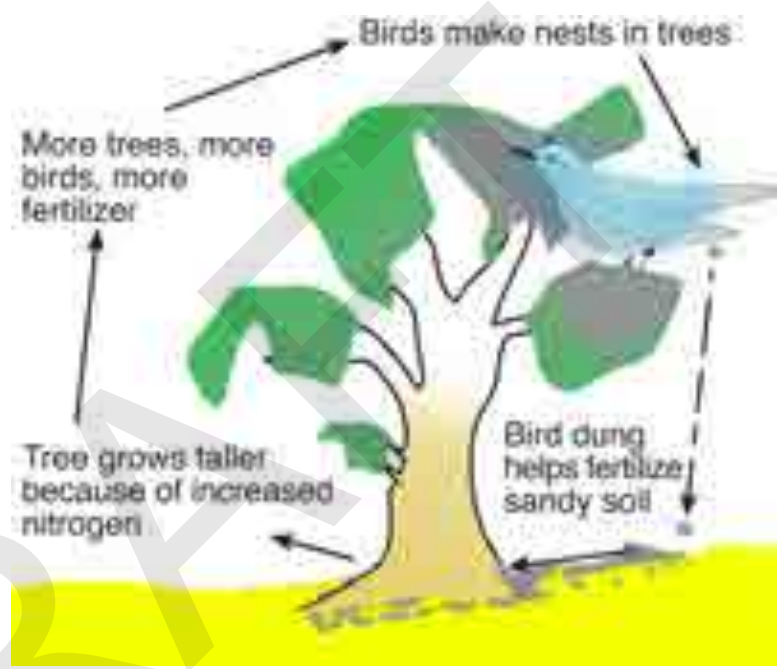
Figure Pisonia tree and students
Photo Bob Moffatt

DRAFT

Large number of bird dung fertilises the soil making available nutrients for the plant.

A cruel fate though as the leaves and flowers of the tree trap birds in summer causing death but ensuring the tree more nutrients.

Tree catch and kill



Pisonia tree bird nitrogen

Illustration Bob Moffatt

DRAFT

Salinity

MOVE

Salinity is an important nutrient for plant growth.

Estuarine grasses such as salt water couch and samphires require this salt for growth.

These grasses are important for dune development and stabilising wind eroded areas.

Salt water couch – note the colour change in the couch

Photos Bob Moffatt

DRAFT

So can you now?

Note points of difference between the following abiotic features in a variety of marine environments

Light availability
Depth
Stratification
Temperature
Waves
Currents (water and wind)
Tides
Sediment type
Nutrient availability

How does

End of unit

Distinguish

DRAFT

Revision questions

Under construction

Further

https://courses.lumenlearning.com/boundless-biology/chapter/aquatic-biomes/

DRAFT

Classroom activities

Under construction

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Marine Biology power point series

T053 Important limiting factors

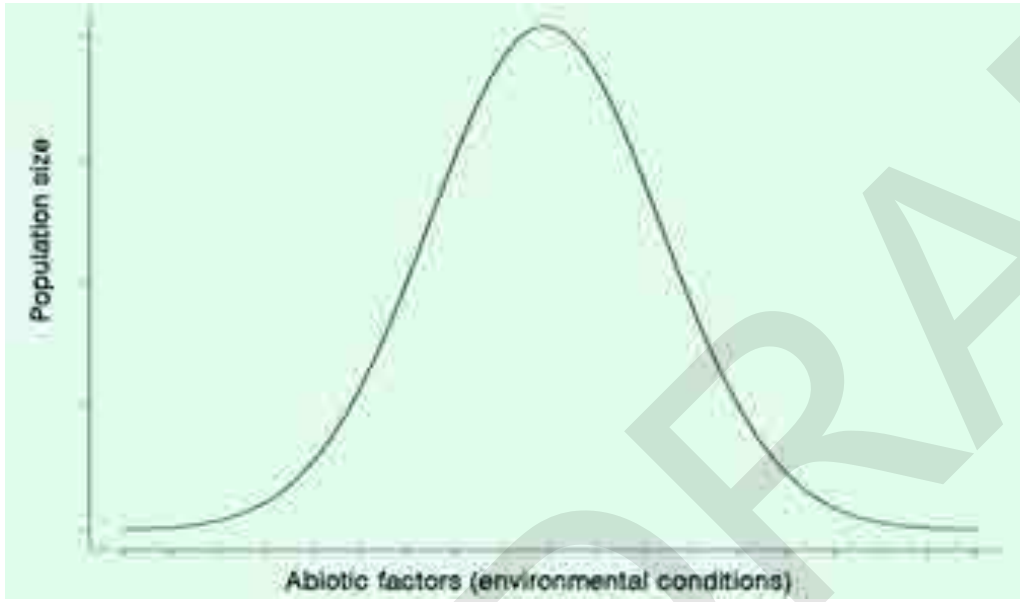

Illustration Bob Moffatt

DRAFT

Please, if you find better web references and videos, we would love to put them in future versions

The syllabus askes you to:

Understand - the importance of limiting factors and tolerance limits in population distributions

The given definition is

Understand – to recall - remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind

Understand
perceive what is meant by something; grasp; be familiar with (e.g. an idea); construct meaning from messages, including oral, written and graphic communication

This powerpoint has taken the verb part "understand" to mean
recall.

DRAFT

What you need to know

You have to recall

- What a limiting factor is, and give an example of its importance
- What a tolerance limit is and give an example of its importance
- Shelford's law when discussing tolerance limits
- Leibig's law when discussing limiting factors.

DRAFT

Definitions

Tolerance limits

A tolerance limit is the upper and lower limits to the range of particular environmental factors (e.g. light, temperature, availability of oxygen, water) within which an organism can survive.

Organisms with a wide range of tolerance are usually distributed widely, while those with a narrow range have a more restricted distribution

Limiting factors

A limiting factor is a component of an ecosystem which limits the distribution or numbers of a population

A limiting factor defines optimal survival conditions according to its effect on a species when in deficiency or excess

Limiting factors can be either biotic (living) or abiotic (non-living)

DRAFT

Tolerance limits

Just as species have geographic ranges, they also have tolerance ranges for the abiotic environmental conditions. In other words, they can tolerate (or survive within) a certain range of a particular factor, but cannot survive if there is too much or too little of the factor.

Take temperature, for example.

King penguins survive very well in low temperatures, but would die from overheating in the tropics.

King penguin colony

Photo ANARE reproduced with permission

DRAFT

On the other hand, a saltwater crocodile does very well in the heat of the tropics, but would quickly freeze to death in the Antarctic.

Saltwater crocodile
Photo Ian Morris

DRAFT

These examples point out that different types of organisms have different tolerance ranges for the same factor.

Temperature.

Exceptions are when bears hibernate or life cycles go into dormancy.

DRAFT

The tolerance range of a single individual may also change over time.

For example - Salmon

Adult Salmon

Photo Ruth Fairley reproduced with permission

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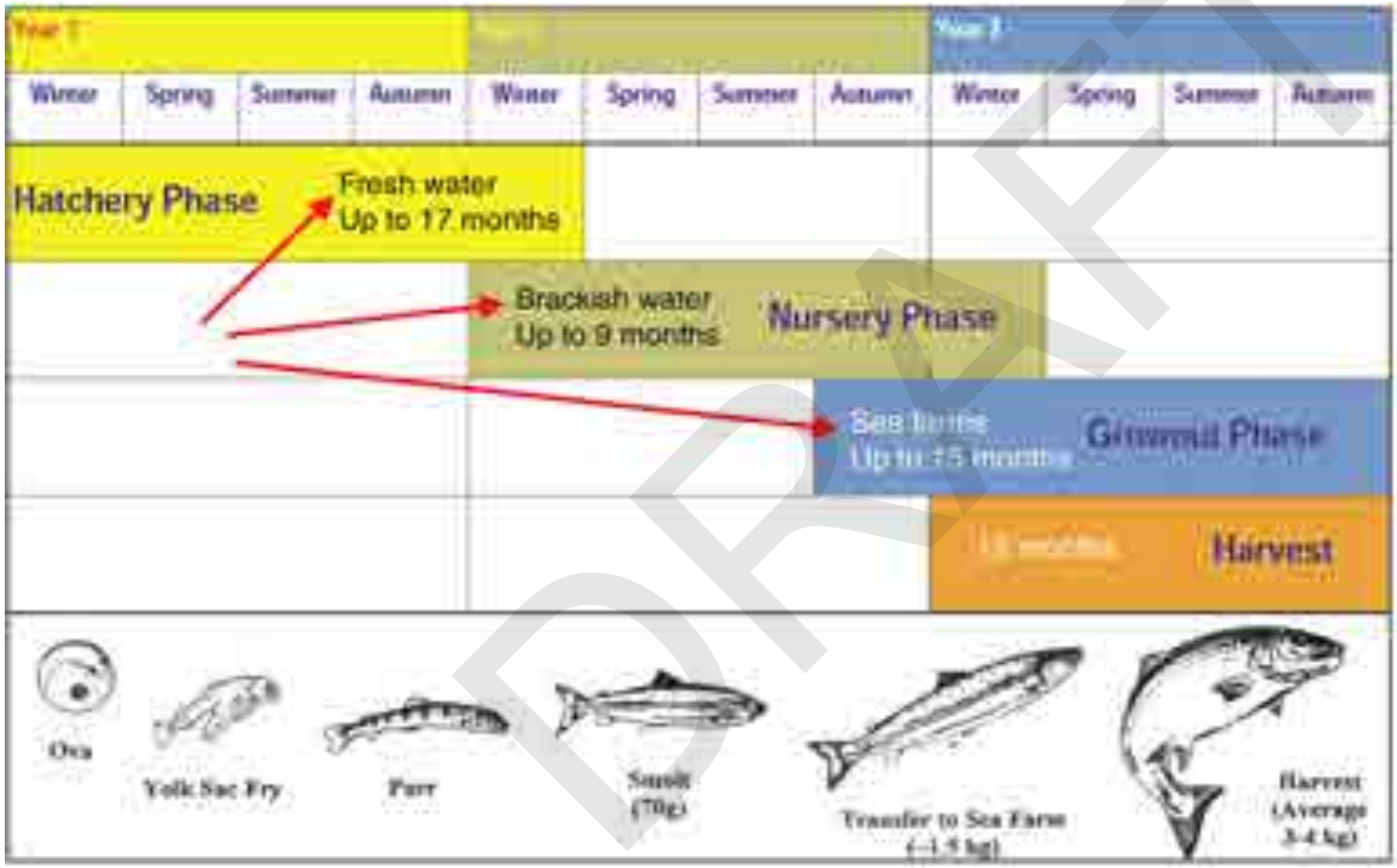
They start life in a freshwater stream, migrate out to the open ocean, and then come back to their home stream to reproduce.



So they can tolerate huge changes in the salinity and temperature during their life cycle.

Salmon life cycle

Illustration After Tassal

DRAFT

Other organisms, such as some species of fish, have low tolerances to temperature and salinity and die.

Dead fish
Photo Tim Ryan

DRAFT

Fish kills are often the first visible signs of environmental stress.

If it is a cold-related stress, juvenile fish or species that are not cold-tolerant may be selectively affected.

If toxicity is the cause, species are more generally affected and the event may include amphibians and shellfish as well.

If it dissolved oxygen it may affect larger fish more than smaller fish.

So lets have a look at how oxygen impacts on tolerance limits.

Fish kill

By United States Fish and Wildlife Service. [Public domain], via Wikimedia Commons

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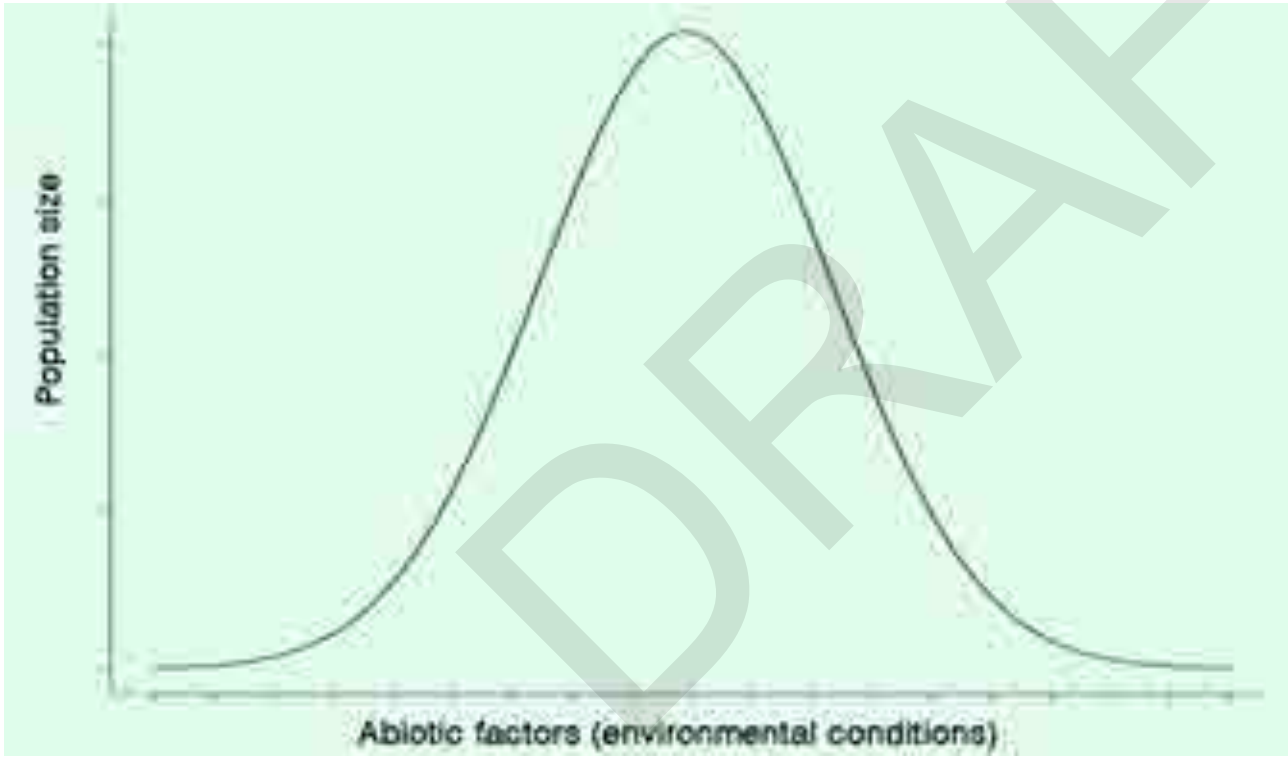
If we draw a graph of how many individuals in a population live under which part of the range of any given factor, you almost always get a bell-shaped curve.

The horizontal axis could be any of the abiotic factors (environmental conditions) and the vertical axis for population size.



Bell curve with abiotic factors

Illustration Bob Moffatt

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If we take oxygen levels as the limiting factor and compare two fish populations.

A Silver perch and a Rainbow Trout and look at their tolerance limits.

Figure Silver perch and Rainbow Trout

© State of New South Wales through NSW Department of Industry

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You would go out and measure the oxygen level of every place where you find the Silver perch and also count how many Silver perch are in each habitat.

When you make a graph of your data, it might look like Graph 1.

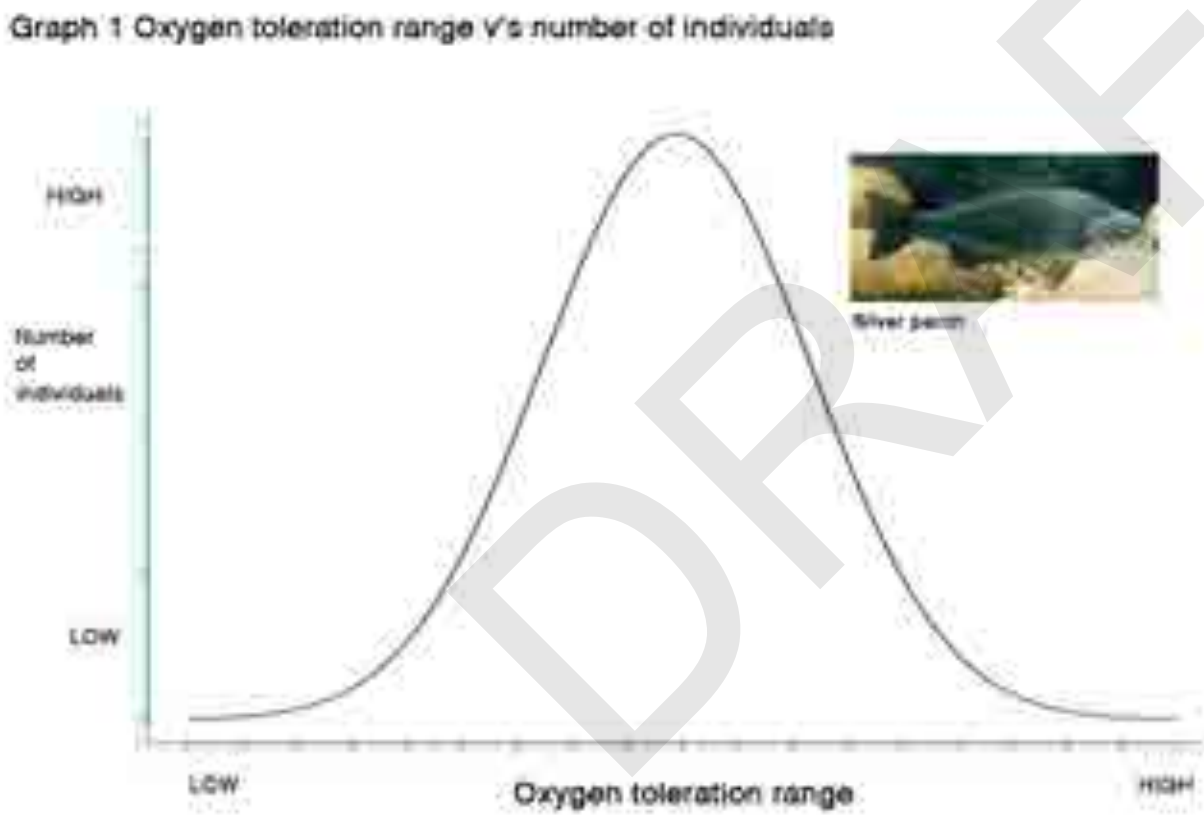

Illustration Bob Moffatt

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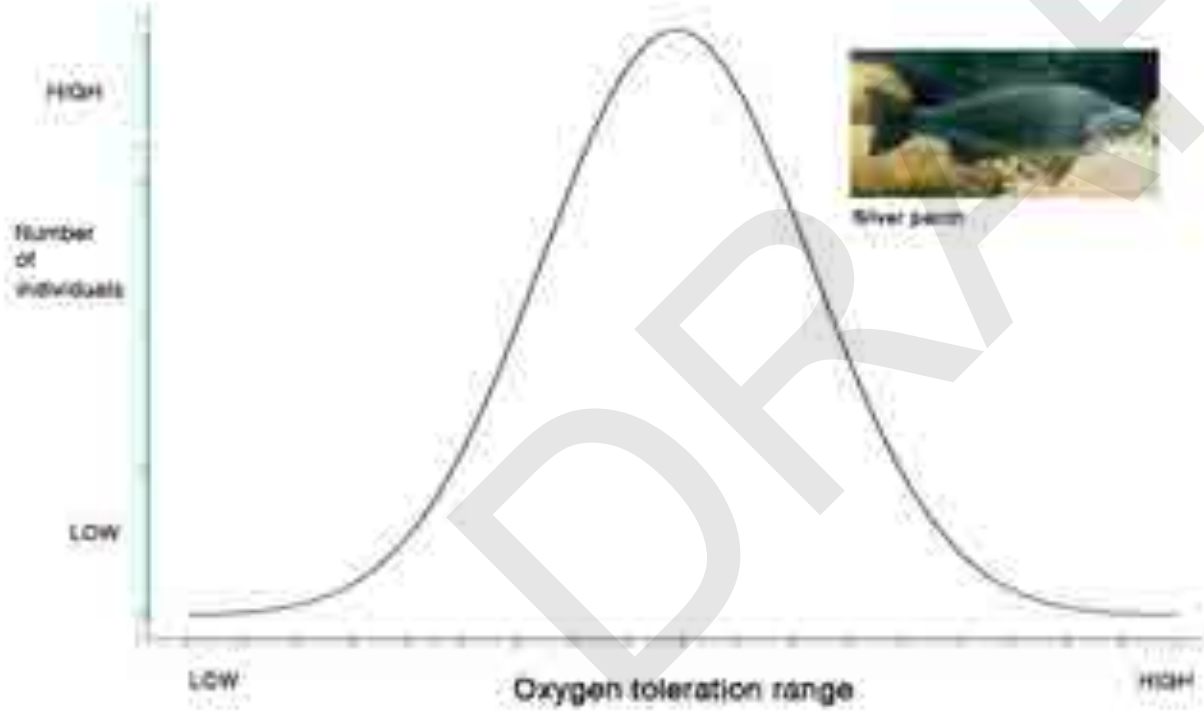
That graph is telling you that the majority of the Silver perch live in the middle part of the oxygen range; that's where the curve is highest.
As you move from the middle part to lower oxygen levels (to the left) or to higher oxygen levels (to the right), the curve is not as high – there are fewer individuals that live in habitats that have the lower or higher amounts of oxygen.



If the oxygen level is extremely low or high, it is beyond the tolerance range of the species and no Silver perch live in those habitats.

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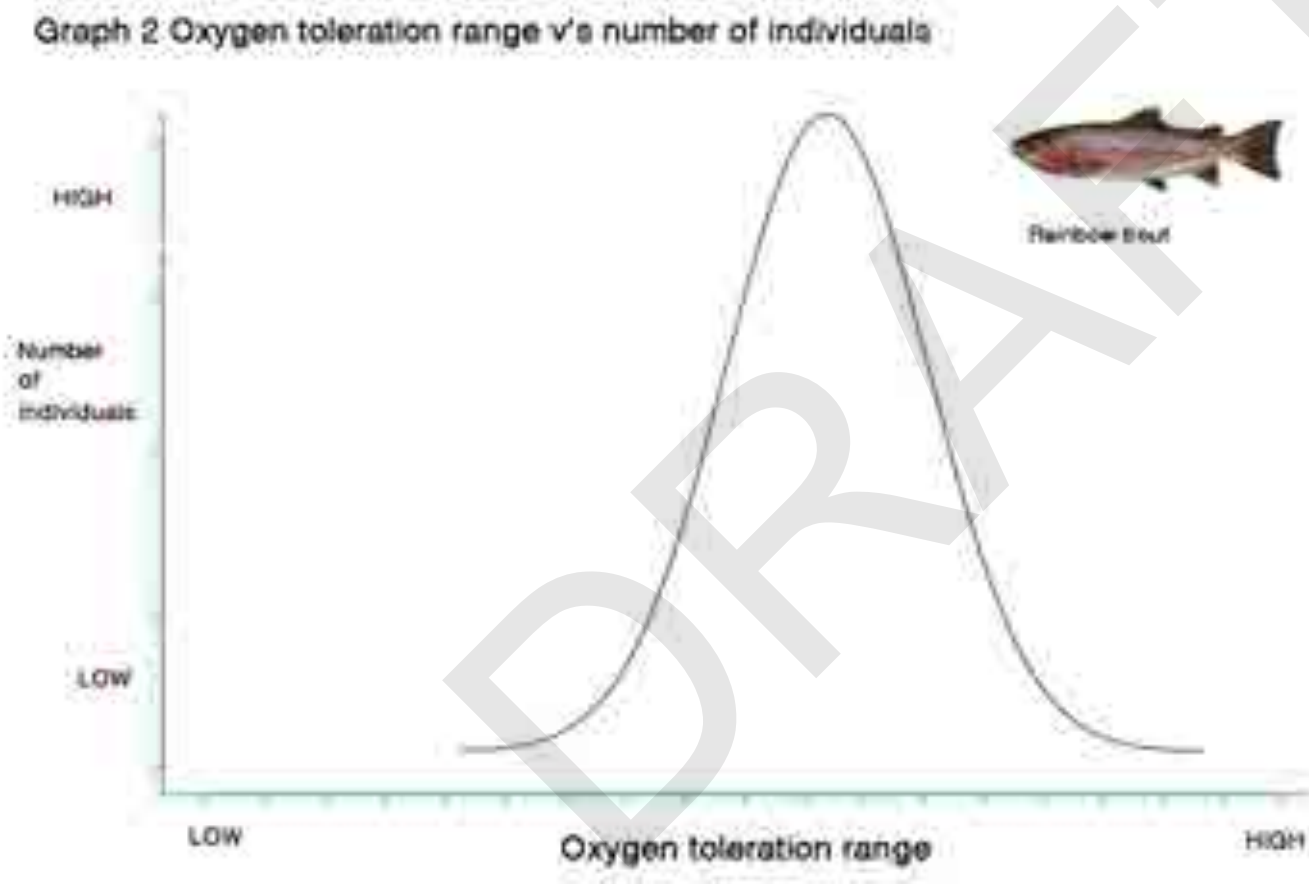
Now take a look at Graph 2, which represents the oxygen tolerance range curve for the Rainbow trout.



This is telling us that Rainbow trout have a much narrower tolerance range for oxygen than Silver Perch.

Illustration Bob Moffatt

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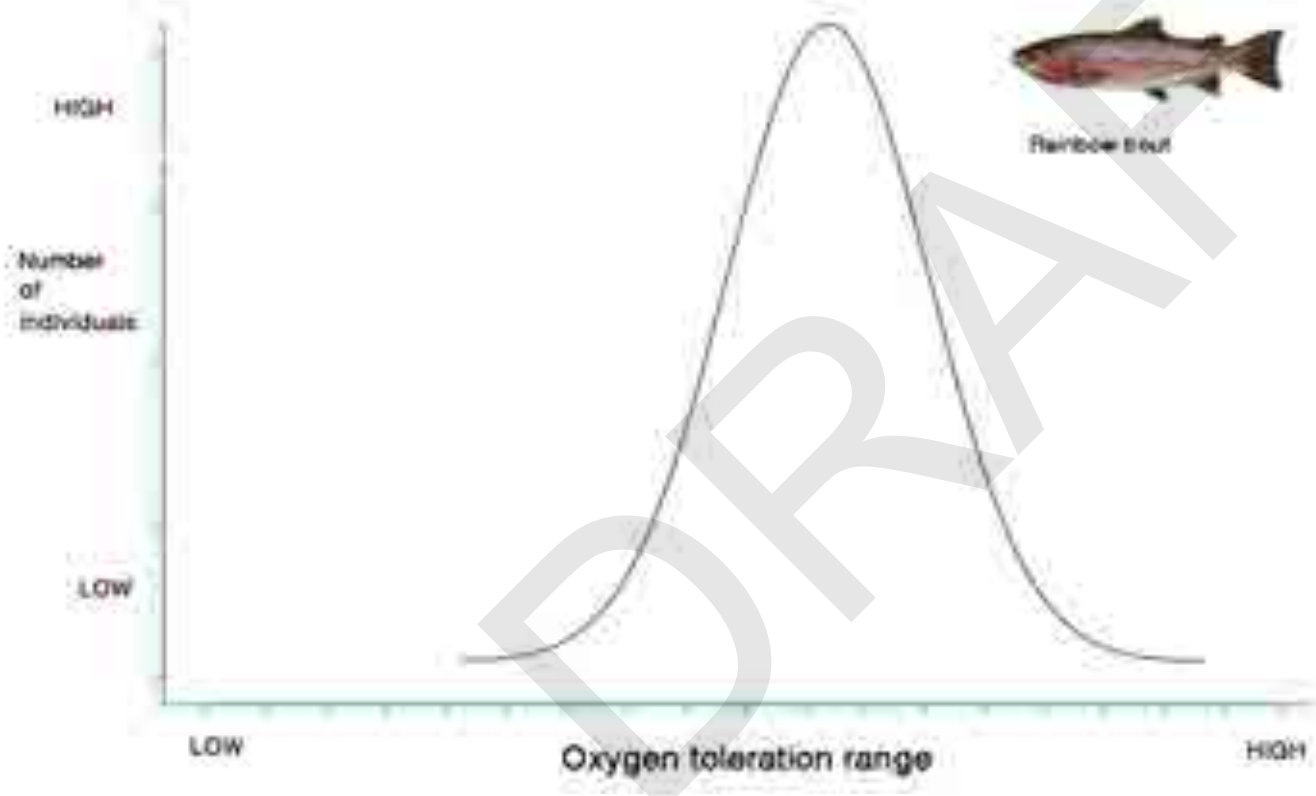
Rainbow Trout can only survive and thrive in a narrow band of oxygen levels, so you would expect that its geographical range would be more restricted.



Rainbow Trout would not be distributed as widely as the Silver Perch since it wouldn't do well in stagnant areas with lower oxygen levels.

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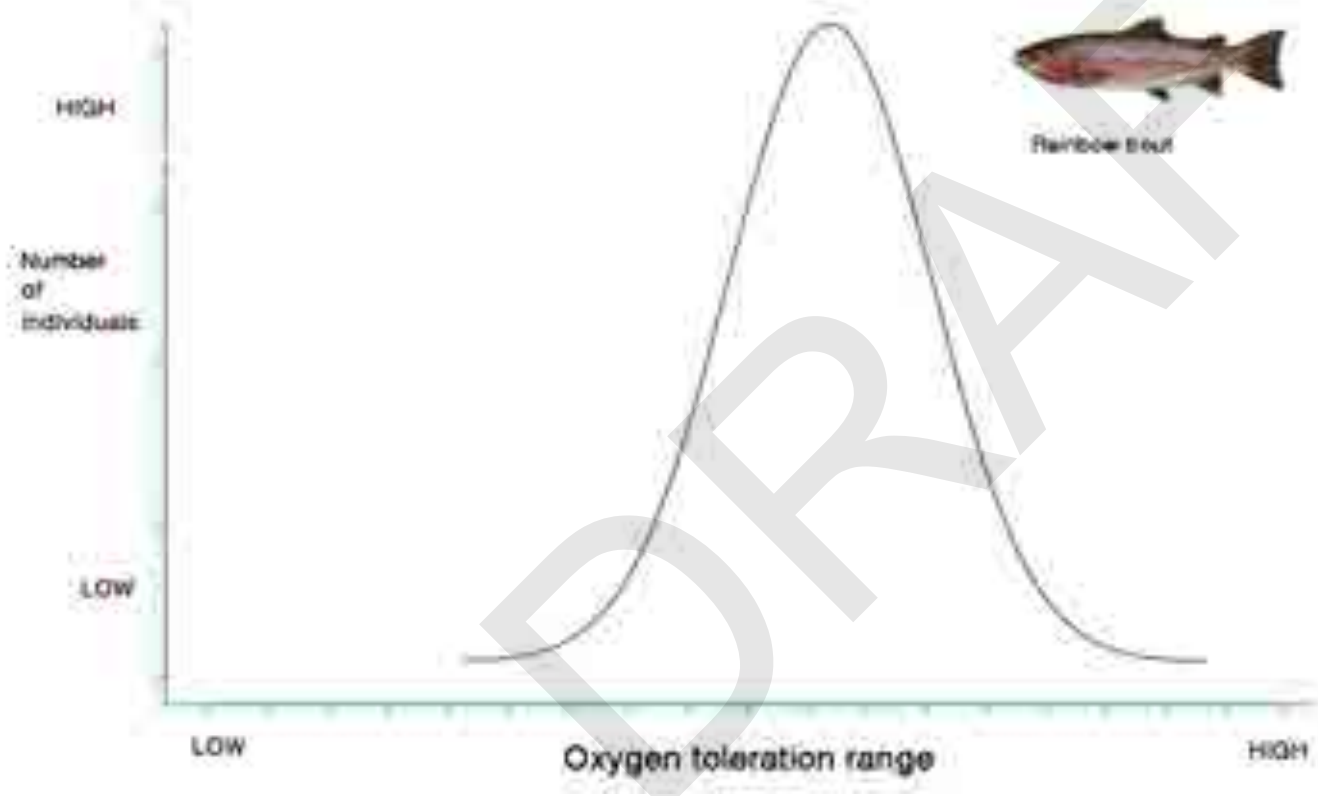
If you look closely, you'll also notice that the peak of the curve for the Rainbow trout is a little bit to the right of the peak of the curve for the Silver perch.



This tells us that compared to Silver perch, Rainbow Trout do best in water that is slightly more oxygenated.

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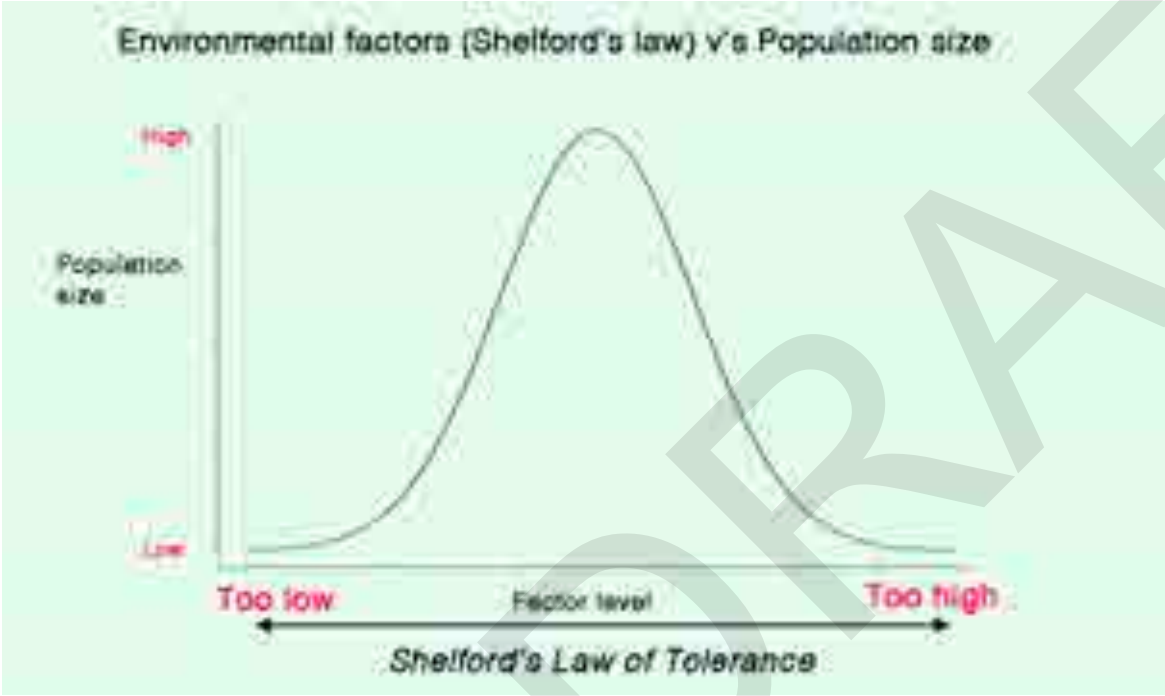
These bell shaped curves can be introduced to explain Shelford's Law of Tolerance

This states that <u>for every organism there is an optimum in regard to environmental factors</u>.



When environmental factors are not favourable

eg too low or too high

- the number of individuals will decrease.

Environmental factors (Shelford's law) v's Population size Illustration
Bob Moffatt

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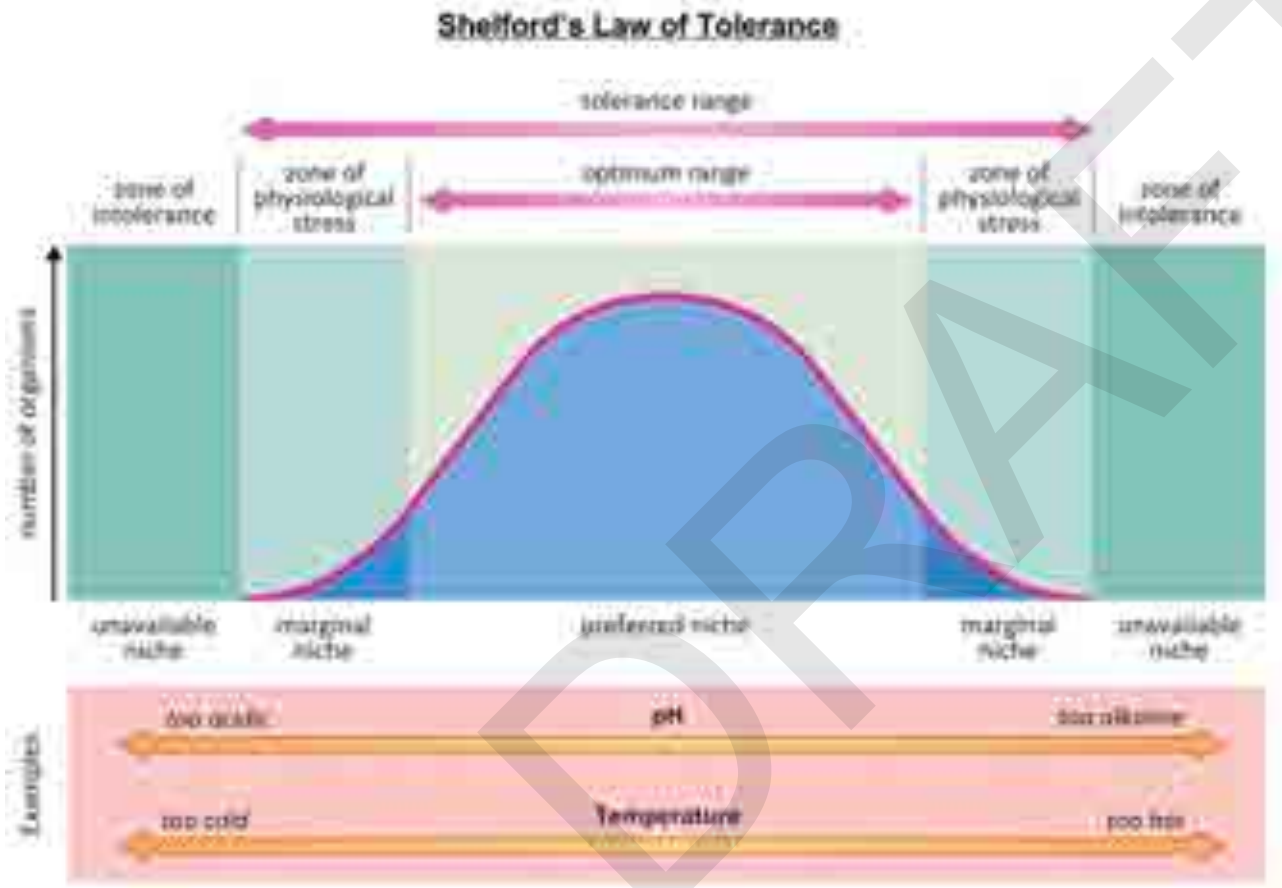
Marine scientists have taken the graph further to include the bell-shaped curve with 3 distinct regions.



Shelfords law with three zones of tolerance

From: http-//ib.bioninja.com.au/options/option-c-ecology-and-conser/c1-species-and-communities/survival-factors.html.jpg

Optimal zone – Central portion of curve which has conditions that favour maximal reproductive success and survivability

Zones of stress – Regions flanking the optimal zone, where organisms can survive but with reduced reproductive success

Zones of intolerance – Outermost regions in which organisms cannot survive (represents extremes of the limiting factor)

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Next year you will study corals which live in specific temperature ranges.

Global distribution of coral reefs

Credit: http-//ib.bioninja.com.au/options/option-c-ecology-and-conser/c1-species-and-communities/survival-factors

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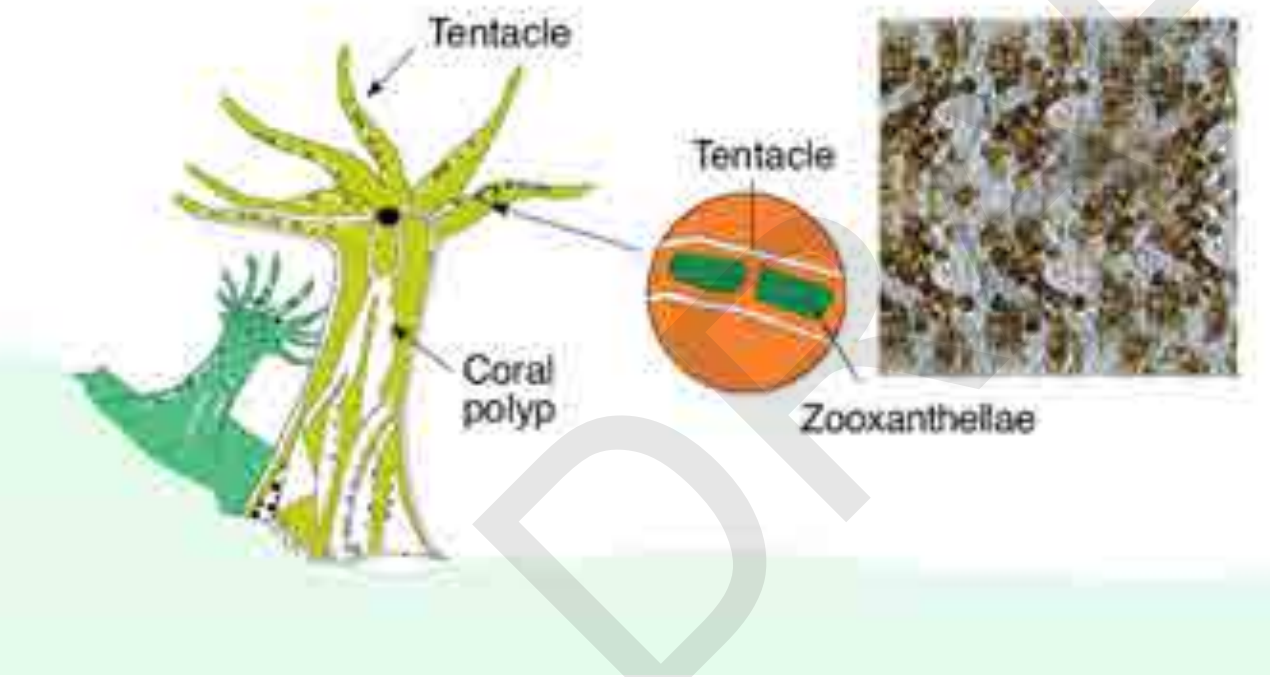
Coral polyps receive nutrition from photosynthetic zooxanthellae (an algae) that lives within the polyp's endodermis

The zooxanthellae cannot survive in lower ocean temperatures (i.e. < 18ºC)



Zooxanthellae and coral

Illustration Bob Moffatt Photo CSIRO reproduced with permission

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Increases in ocean temperature cause zooxanthellae to leave the coral tissue, leading to coral bleaching (i.e. > 35ºC)

Reef-building coral species therefore have a typical optimal growth range in temperate waters between 20 – 30ºC

Coral bleaching

Photo Craig Reid, reproduced with permission

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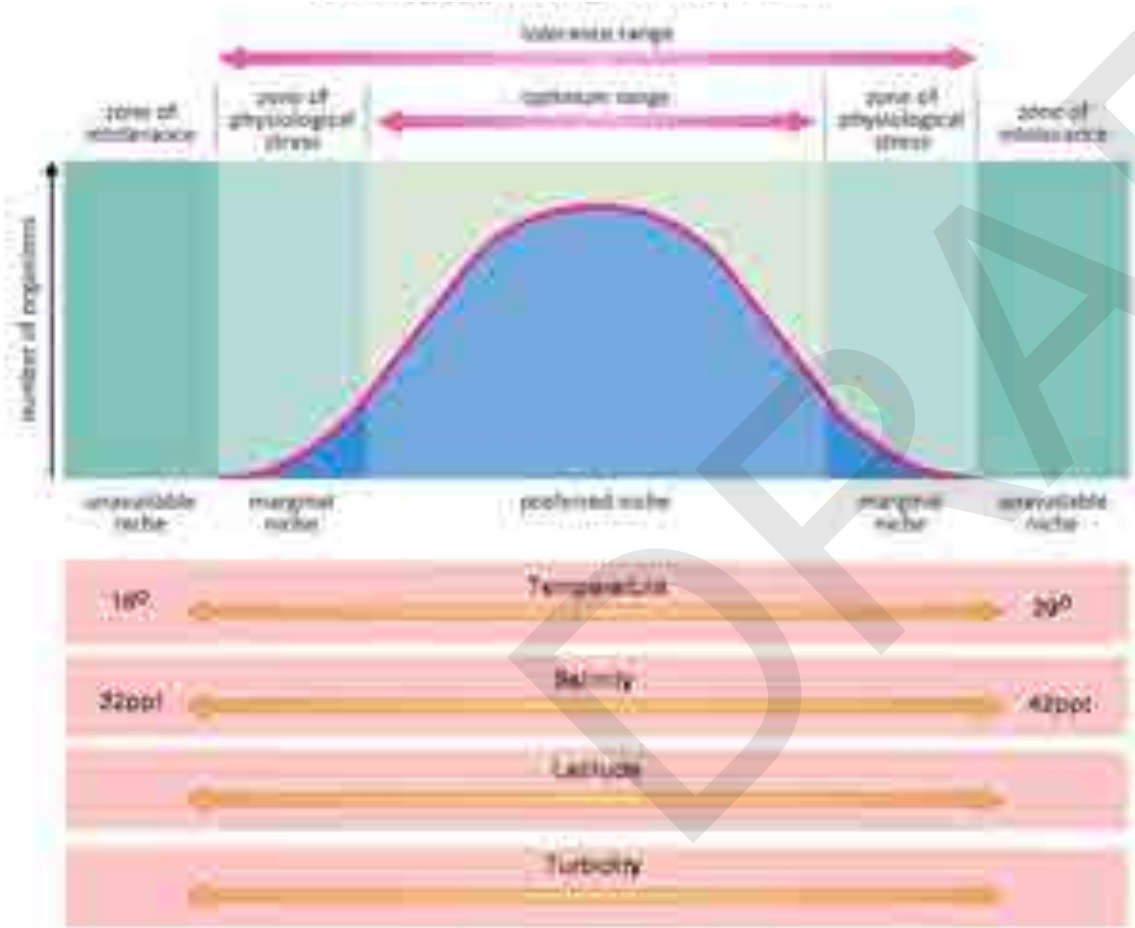
We can use the bell curve to explain the concept of coral bleaching in terms of Shelford's law of tolerance



Shelford's law graph and coral bleaching

Illustration Bob Moffatt and From: http-//ib.bioninja.com.au/options/option-c-ecology-and-conser/c1-species-and-communities/survival-factors.html.jpg

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B. Limiting factors

In ecology, a limiting factor is a component of an ecosystem which limits the distribution or numbers of a population

A limiting factor defines optimal survival conditions according to its effect on a species when in deficiency or excess

Limiting factors can be either biotic (living) or abiotic (non-living)

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Biotic factors include interactions between organisms – either within species (for example competition) or between species (for example predator prey, parasitism).

Figure Birds steeling food
Illustration Kerry Kitzelman

Figure Food chain Illustration Sharyn Madder

DRAFT

Abiotic factors include environmental conditions – such as

light, temperature, salinity, rainfall, wind velocity, pH, oxygen, cyclone waves, flood sediments

Sediment runoff from Tweed River
Photo Paula Moffatt

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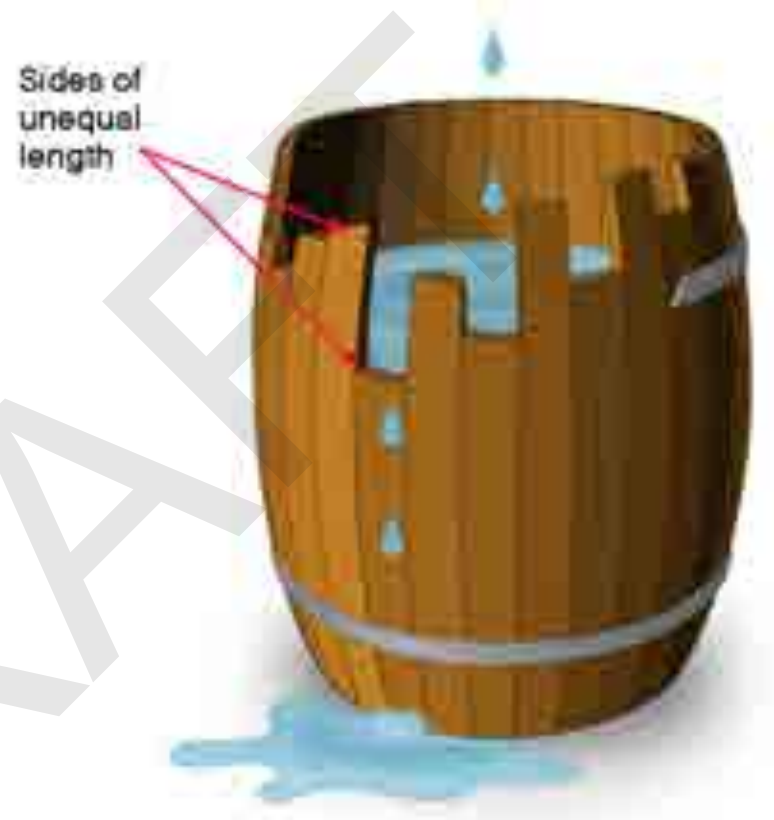
Liebig's Law of the Minimum seeks to explain how these limiting factors impact on population numbers.

This states that growth of a population is controlled not by the total amount of resources available, but by the scarcest resource.

If you go to the internet, most explanations of the law use a barrel with unequal sides, filled with water.



Leibigs barrel showing unequal sides

By DooFi (Own work) [Public domain], via Wikimedia Commons

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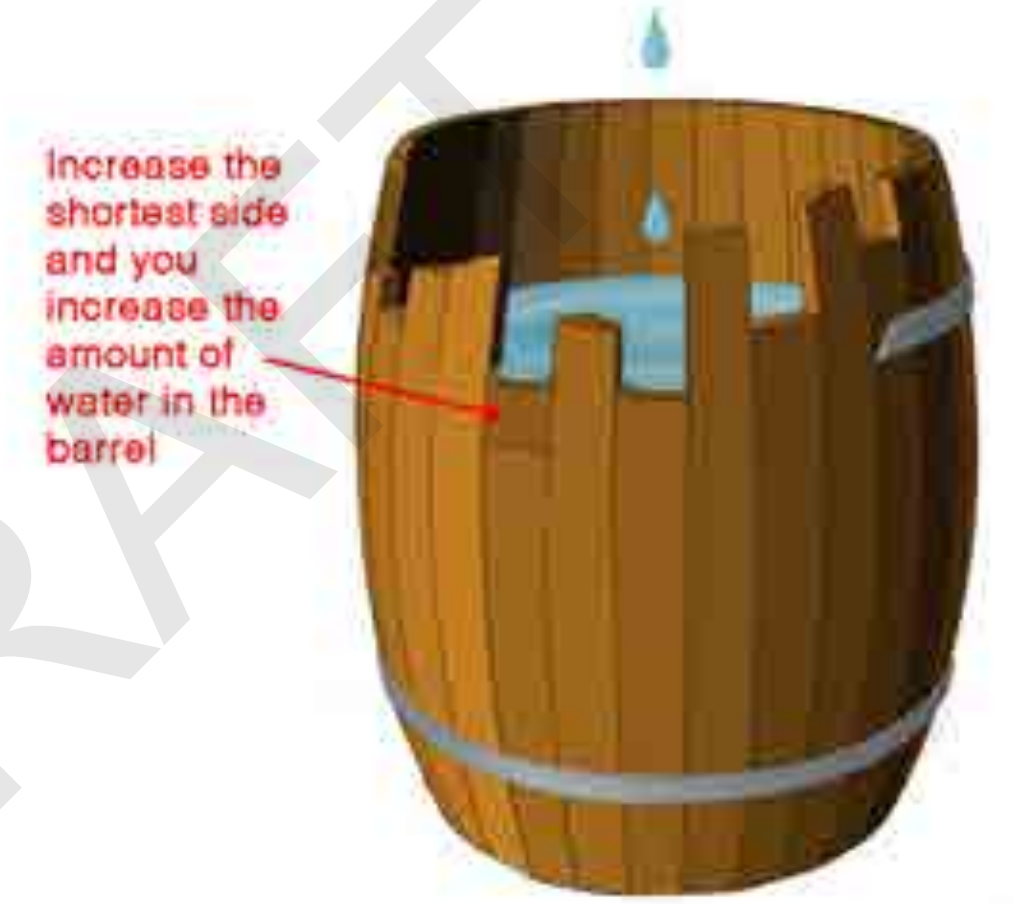
The limiting factors for the amount of water the barrel can hold is the shortest side.

Increase the shortest side and the barrel holds more water.



Leibig's barrel shortest sid

By DooFi (Own work) [Public domain], via Wikin

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Liebig's argued that a plant's growth is limited by the nutrient in shortest supply.

If we call the sides nitrogen, phosphorus, iron and magnesium, we could get more plants by adding more nitrogen.

So the limiting factor was nitrogen.

Leibigs barrel with increased nitrogen

By DooFi (Own work) [Public domain], via Wikimedia Commons and Bob Moffatt

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So can this be taken further?

We stated that limiting factors can be either biotic (living) or abiotic (non-living) so can we find examples of their potential to control population growth?

Leibigs barrel with abiotic and biotic factors

Illustration By DooFi (Own work) [Public domain], via Wikimedia Commons and Bob Moffatt

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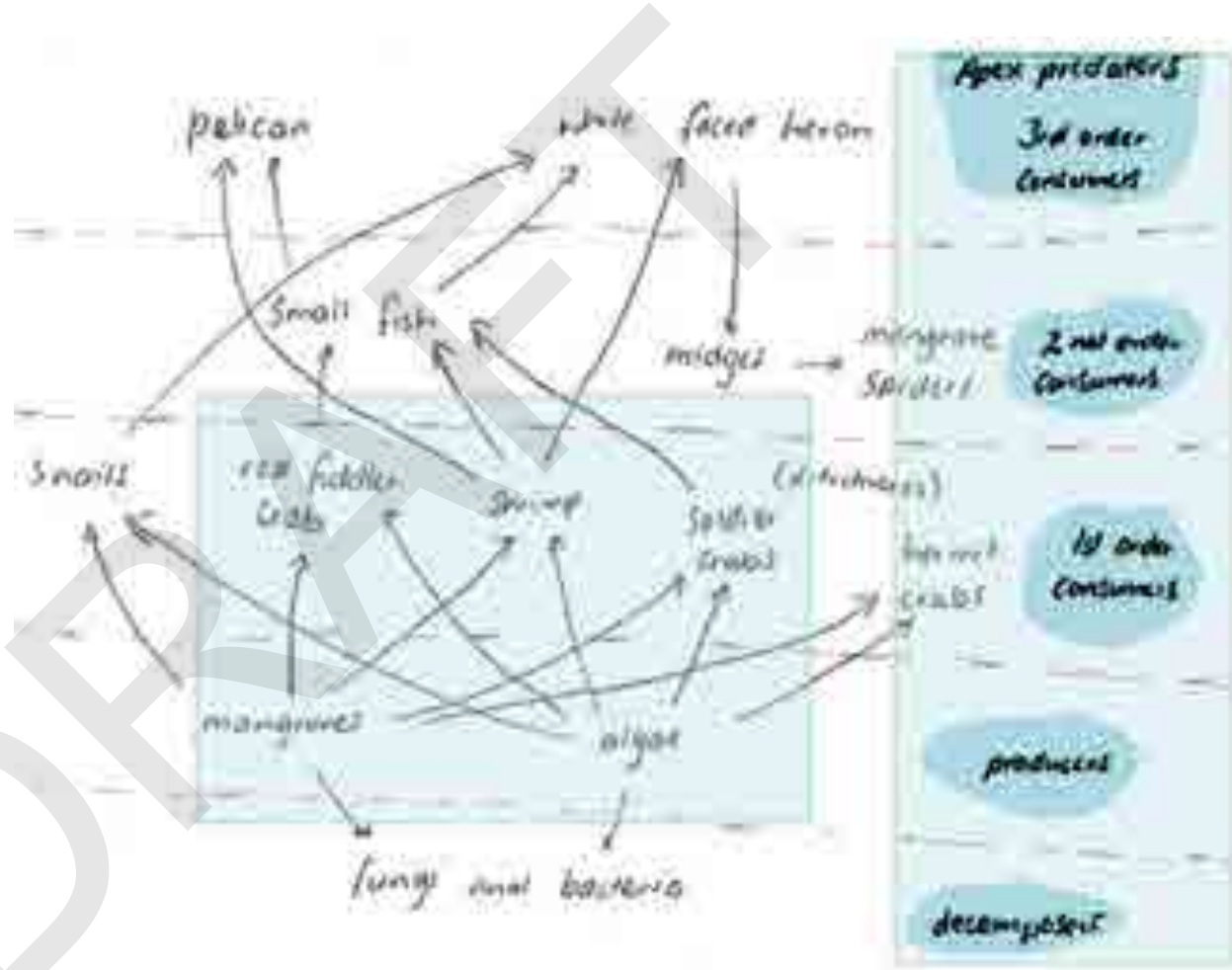
Can we apply this using a food web?

Although a given population may interact with many different species in a food web, and

also interact with many different abiotic factors outside the food web,

not all of these interactions are of equal importance in controlling that population's growth.



Mangrove food web

From QCAA Author unknown Queensland student circa 2012

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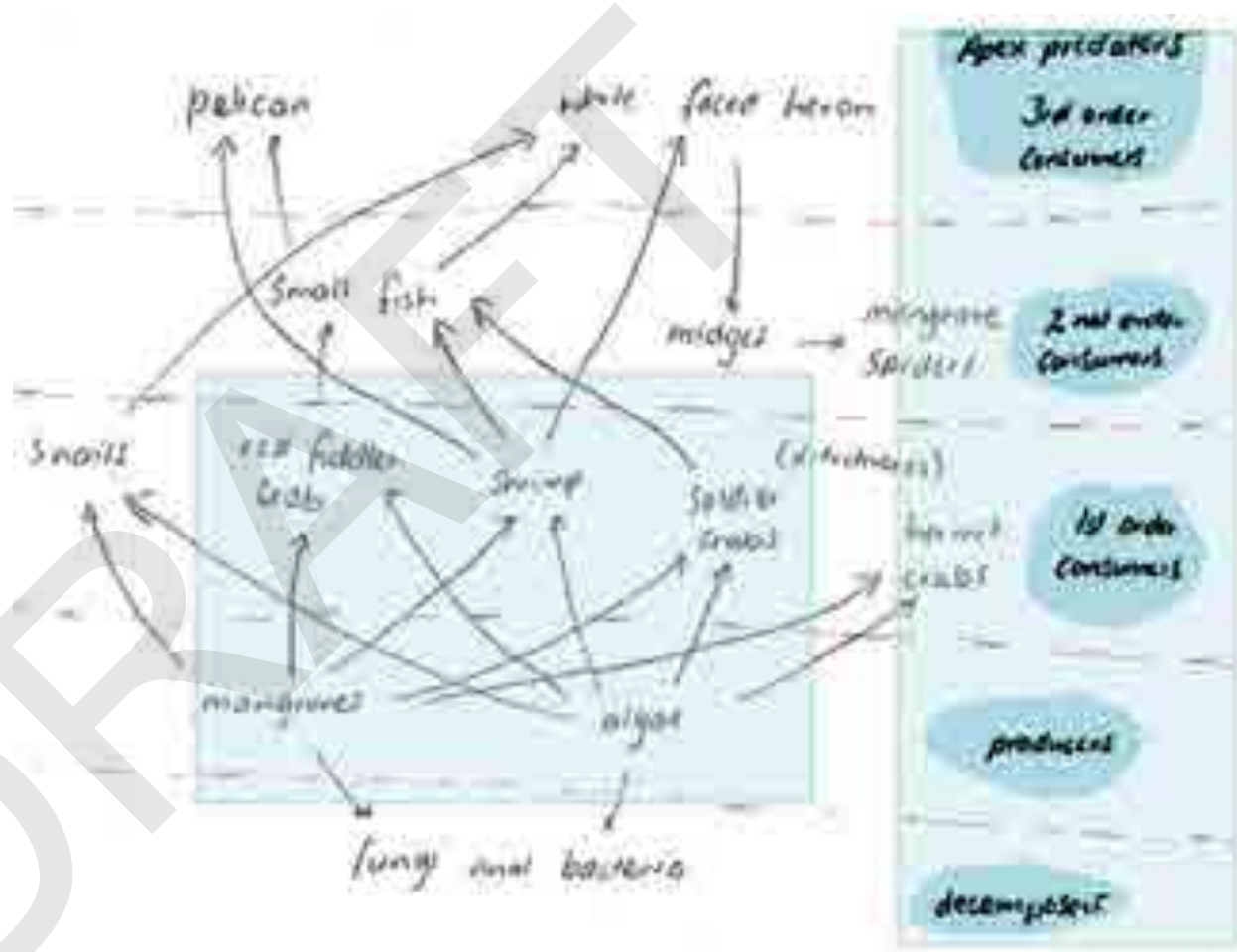
A noted scientist Berryman in 1993 stated that

"only one or two other species dominate the feedback structure of a population at any one time and place."

The identity of these dominating species may change with time and location, but the number of species that limits a given population (i.e. actively controls its dynamics) is usually only one or two."

So which two species in the food web will control the food web?



Mangrove food web

From QCAA Author unknown Queensland student circa 2012

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He argued that Liebig's Law, in its modern form, expresses this idea.

It says that of all the biotic or abiotic factors that control a given population, one has to be limiting (i.e. active, controlling the dynamics).

Time delays produced by this limiting factor are usually one or two generations long.

Leibigs law applied to coral reefs

After Coral Reefs at the Crossroads edited by Dennis K. Hubbard, Caroline S. Rogers, Jere H. Lipps, George D. Stanley, Jr.

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The classic paper on Liebig's Law of the minimum and plankton ecology has lead scientists to treat Leibig's law as a paradox

- known to be invalid argument but are still valuable in promoting critical thinking.

Pergamon

0079-6611(94)00007-7

von Liebig's Law of the Minimum and Plankton Ecology (1899-1991)

H.J.W. de Baar

Department of Marine Biology, University of Groningen, P.O. Box 14, 9750AA Haren, The Netherlands

Abstract – The Law of the Minimum was originally formulated by Justus von Liebig, as one of the 50 interlinked laws concerned with agriculture. The original writings of J. von Liebig often were misinterpreted by his successors. Brandt (1899) took the one law out of its context and proposed that limitation by nitrogen is a dominant factor in plankton ecology, far beyond its original application in agriculture. This was opposed by Nathansohn (1898) who suggested instead a dynamic balance of growth and loss terms. Towards validating, or eventually falsifying, Brandt's hypothesis, Atkins, Harvey, Cooper and others developed the chemical methods necessary for re-defining ocean nutrient cycling and growth limitation. The major exception to these modern perspectives was the Antarctic Paradox of high nutrients and low chlorophyll which inspired Gran, Atkins, Harvey and Cooper to pioneer the concept of iron limitation. An exhaustive overview is given of efforts to define Fe as seawater and its controlling effect on in situ plankton growth, for the 1929-1984 period. Somewhat parallel work in the laboratory on single species of algae in chelator-controlled media has provided much insight, but is sketched only briefly. Martin and contemporaries developed the chemical methods necessary for defining the ocean chemistry of Fe and its role for in situ growth. These developments are sketched for the 1982-1991 period. Data again the Law of the Minimum and associated field hypotheses served, albeit briefly, to bring a nutrient element to the forefront of research. This, and the recent awareness of CO_2 as rate limiting factor, underline the conclusion that advances in sciences often hinge on advances in technology (confirming Kuhn 1962). In this case the new analytical techniques developed by Atkins, Harvey, Cooper, Martin and their associates have proven extraordinary for plankton ecology. Some observations in plankton ecology may be reminiscent of the agricultural Law of the Minimum, but this would not warrant its direct application, beyond its original context of agriculture, to plankton ecology. Rather the tenets of increase of phytoplankton in the dynamic balance of multiple growth and loss terms, together also determining the increase in grow rate and space.

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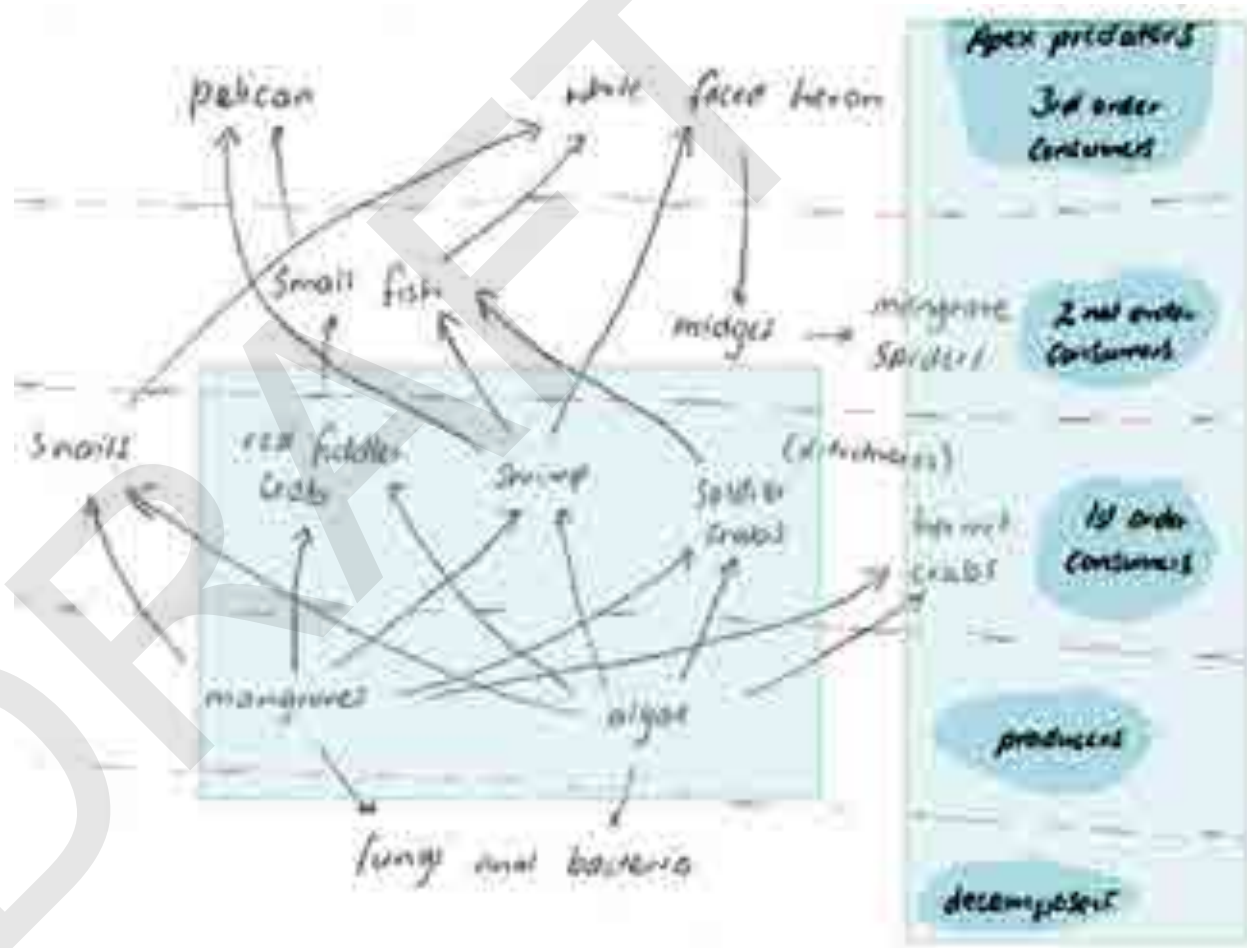
De Baars original paper page 1

https://www.rug.nl/research/portal/files/14561526/1994ProgOceanogrdeBaar.pdf

So when you come to make a study during this semester consider Leibig's law as a starting point for a quantitative study on what you think the limiting factors are.



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At the end of the day you are going to study a mangrove, reef or rocky shore ecosystem.
The question is - Is there a limiting factor that has to be present in sufficient qualities, that allows the biodiversity in an ecosystem to be maintained

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So can you now?

recall

- What a limiting factor is, and give an example of its importance
- What a tolerance limit is and give an example of its importance
- Shelford's law by drawing a diagram and writing an explanation
- Leibig's law by drawing a diagram and writing an explanation

recall

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Revision questions

Under construction

DRAFT

Classroom activities

Under construction

DRAFT

Introduction

DRAFT

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Marine Biology power point series

T054 Assess tolerance limit data

Acknowledgement
Mick O'Connor for his tireless efforts to develop aquaculture in schools 1985 – 2016.

Artemia hatchery
Photo Mick O'Connor

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The syllabus askes you to:

assess data to identify an organism's tolerance limit

The given definition is

Assess– to measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something

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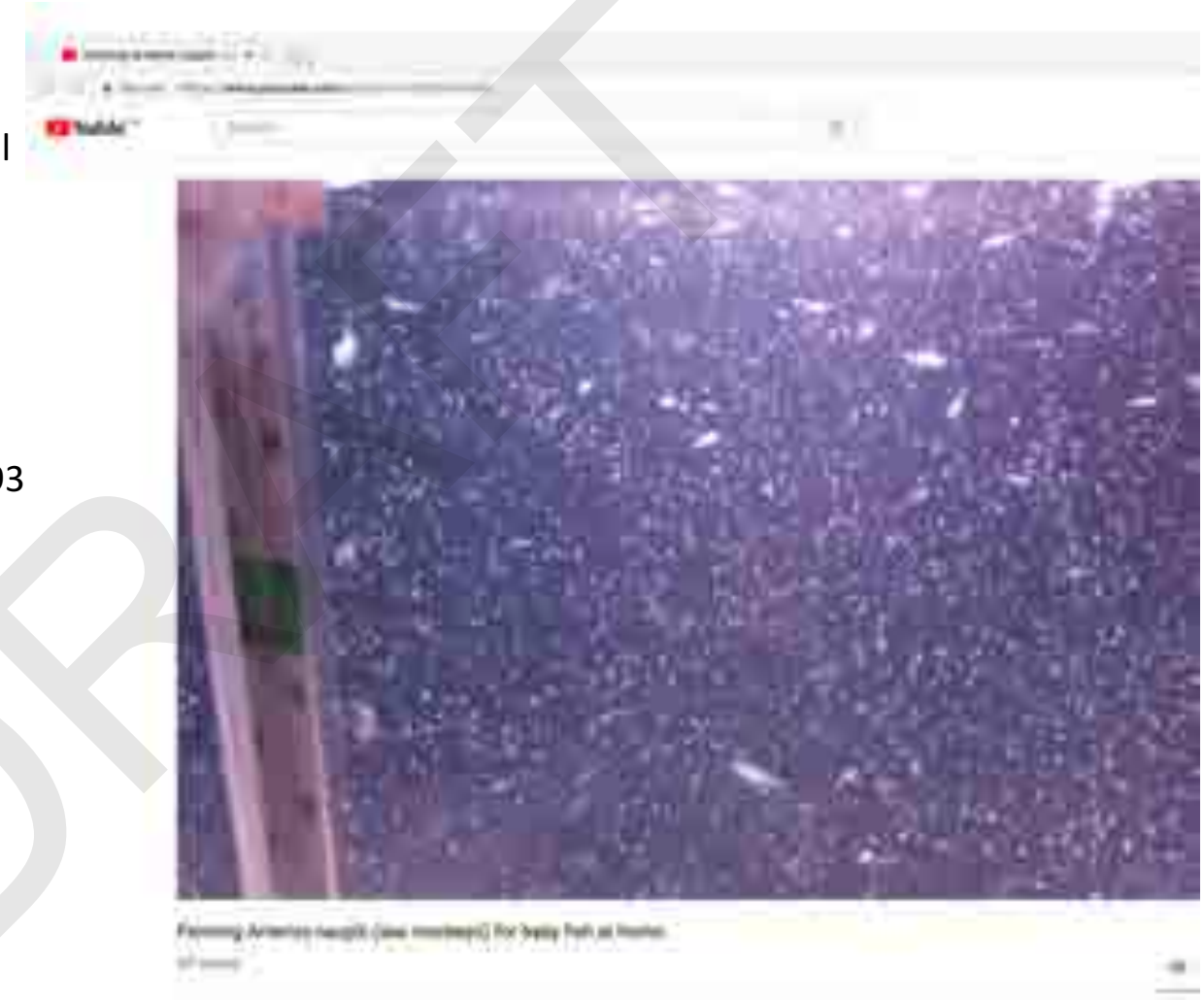
Introduction

This power point uses Artemia brine shrimp as the organism on which data will be collected and assessed.

So what do they look like?

Watch the video https://www.youtube.com/watch?v=Ih193HA7f8k



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The scientific name for brine shrimp is Artemia salina.

They live in isolated bodies of salt water and feed on microscopic organisms such as algae, yeast, and bacteria.

They are also bread as a food supply for a multitude of marine animals and aquaculture farms.

Artemia breeding ponds

By Doc Searls [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons

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Brine shrimp are aquatic crustaceans less than 1cm in length.

Their bodies have wings along their sides with eleven pairs of appendages that undulate and act as paddles.

Artemia adult

Photo © Hans Hillewaert / , via Wikimedia Commons

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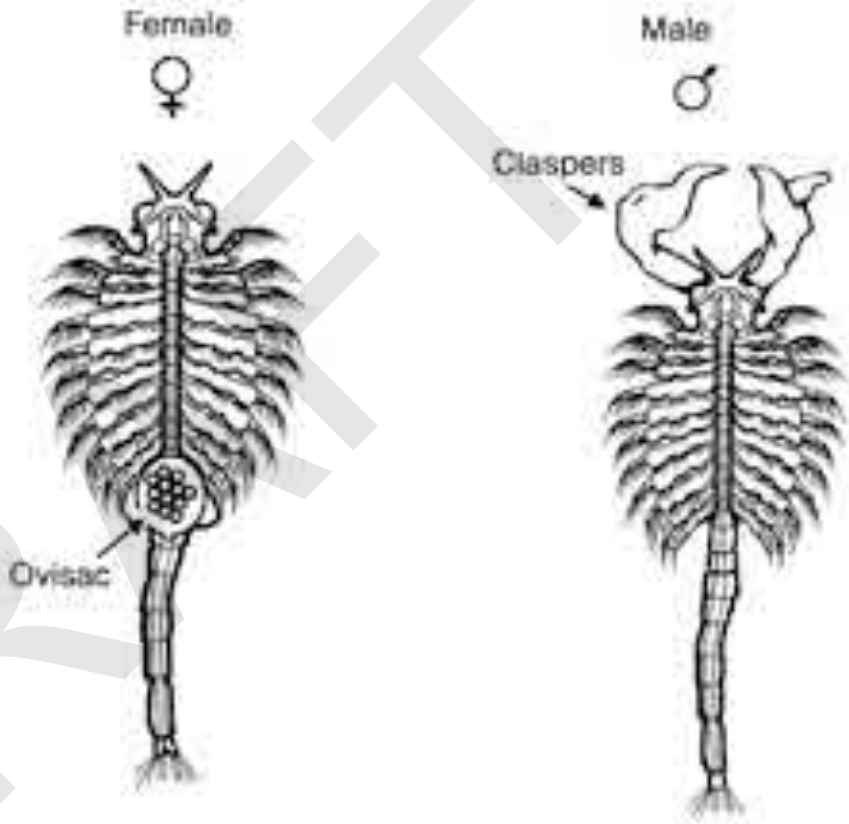
Males differ from females by having the second antennae markedly enlarged, and modified into clasping organs used in mating.

Adult female brine shrimp ovulate approximately every 140 hours.



Artemia female and male

Illustration Kerry Kitzelman

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Adult female brine shrimp ovulate approximately every 140 hours.
Eggs are less than .1mm

Artemia adult and egg
Photo Mick O'Connor

DRAFT

Once placed in briny (salt) water, the eggs hatch within a few hours.

The nauplius larvae are less than 0.4 mm in length when they first hatch. Brine shrimp have a biological life cycle of one year.

Artemia Nauplius

Photo Mick O'Connor

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In extreme conditions, such as low oxygen level or salinity above 150‰, female brine shrimp produce eggs with a chorion coating which has a brown colour.

These eggs, also known as cysts.

You can read more about cryptobiosis at
https://en.wikipedia.org/wiki/Brine_shrimp

Artemia cyst

Photo By Adrian J. Hunter (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

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Artemia cysts can stay dormant for long periods of time and can be easily hatched.

The chorion, also known as the ‘capsule, is a shell made up of lipoproteins reinforced with haematite (iron ore) which gives the cyst its brown colour.

The outer cuticular membrane is directly under the chorion and allows the movement of small molecules only such as O2, H2O and CO2.

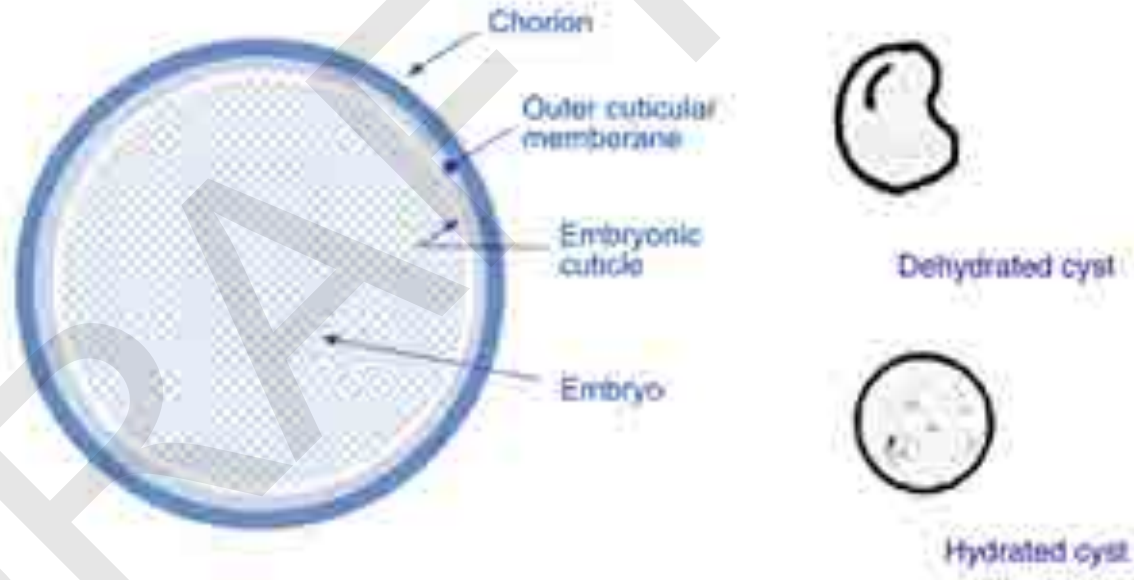

Figure Artemia cyst structure
Illustration Bob Moffatt

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It is this indigestible shell that causes gut problems when eaten by many fish larvae.

This must be removed before the ‘egg’ will hatch.

It can be removed by oxidising it with a 2.6% sodium hypochlorite solution without affecting the embryo in a process known as decapsulation.

An excellent brine shrimp decapsulating video is at:

https://www.youtube.com/watch?v=njmiRcJ7G3s

DR

In their first larval stage as nauplii and hatch within a few hours

They are a brownish orange colour and do not eat because their mouths and anus are not fully developed.

You can watch them hatch at

https://www.youtube.com/watch?v=7ZppkGdO-kU

(Turn the music down)

Artemia Nauplii 1

Photo By Adrian J. Hunter (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

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They grow well in favourable conditions with good food, oxygen levels, and the right salt concentration.

By the second larval stage, after 12 hours, they moult and filter feed on particles of different microalgae, bacteria, and detritus.

Artemia Nauplii 2

Photo By Adrian J. Hunter (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

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They moult through 15 moulting cycles and they can reach full adulthood in three to six weeks.

Figure Artemia adult
Photos Mick O'Connor

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In summary the life cycle of an Artemia begins with the hatching of cysts which are encased embryos that can stay in their dormant state for years if kept dry.

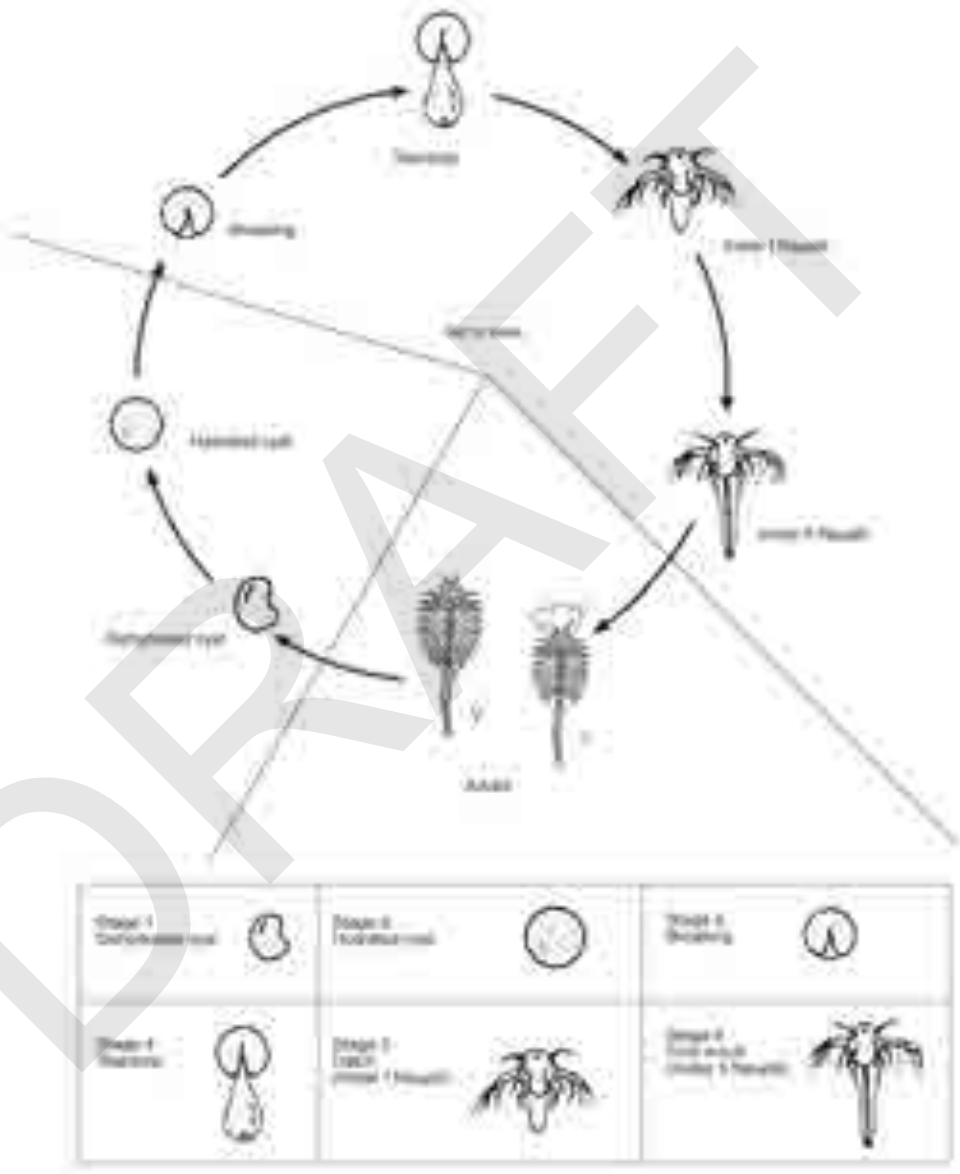


Figure Artemia life cycle
Illustration Bob Moffatt

DRAFT

Artemia’s tolerance limits include the following limiting factors

Abiotic
Temperature
pH
Light availability
Dissolved oxygen
Salinity

Biotic
Population density
Food availability

DRAFT

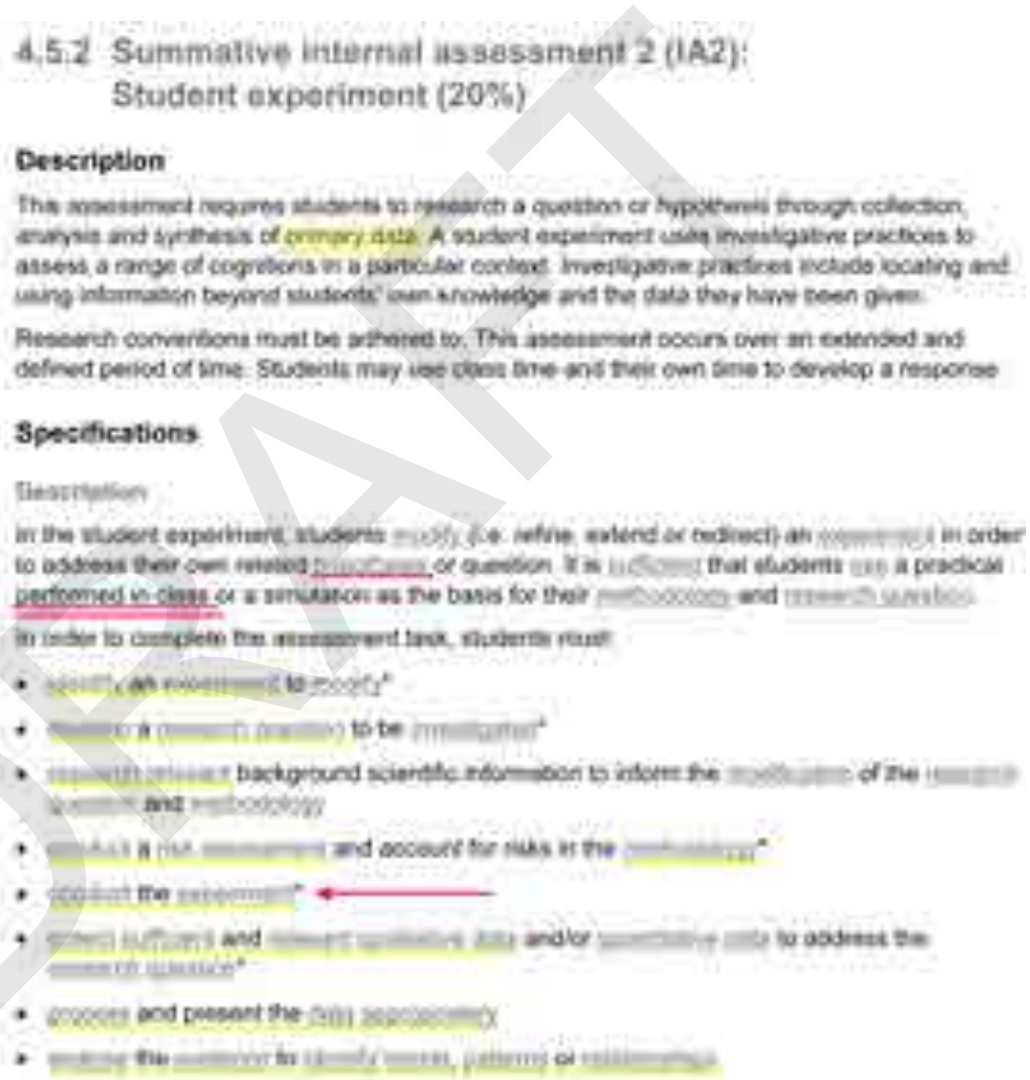
Your experiment is to

- assess data to identify an organism's tolerance limit

Assess - measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something

QCAA Assessment IA2

Credit QCAA syllabus



4.5.2 Summative internal assessment 2 (IA2): Student experiment (20%)

Description

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Specifications

Description

In the student experiment, students modify (i.e. refine, extend or redirect) an experiment in order to address their own related hypothesis or question. It is sufficient that students use a practical performed in class or a simulation as the basis for their methodology and research question.

In order to complete the assessment task, students must:

- select an investigation to modify*
- develop a research question to be investigated*
- research relevant background scientific information to inform the modification of the research question and methodology
- conduct a risk assessment and account for risks in the methodology*
- conduct the experiment*
- select sufficient and relevant qualitative data and/or quantitative data to address the research question*
- process and present the data appropriately
- analyse the evidence to identify trends, patterns or relationships

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Research claims have shown that

Adults growing and cyst hatching should be done at optimal temperatures of 25-30°C.

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The preferable salinity is 30-35 ppt but they can live in fresh water for about five hours before dying.

Research claim

DRAFT

A pH of more than five and less than ten is also suitable for the Artemia to ensure no fatalities preferably 8

Research claim

DRAFT

Density cyst density should be less than 5 grams (one and a half level teaspoons) of decapsulated hydrated cysts per litre.

Research claim

DRAFT

Fixed amounts of light are needed for hatching

Research claim

Artemia hatchery with light
Photo Bob Moffatt To come

DRAFT

Oxygen levels in the water dictate what the brine shrimp will eat if they are heavily feeding on microalgae they will look green in color.

Oxygen levels should be above above 2 mg/L have been stated.

Research claim

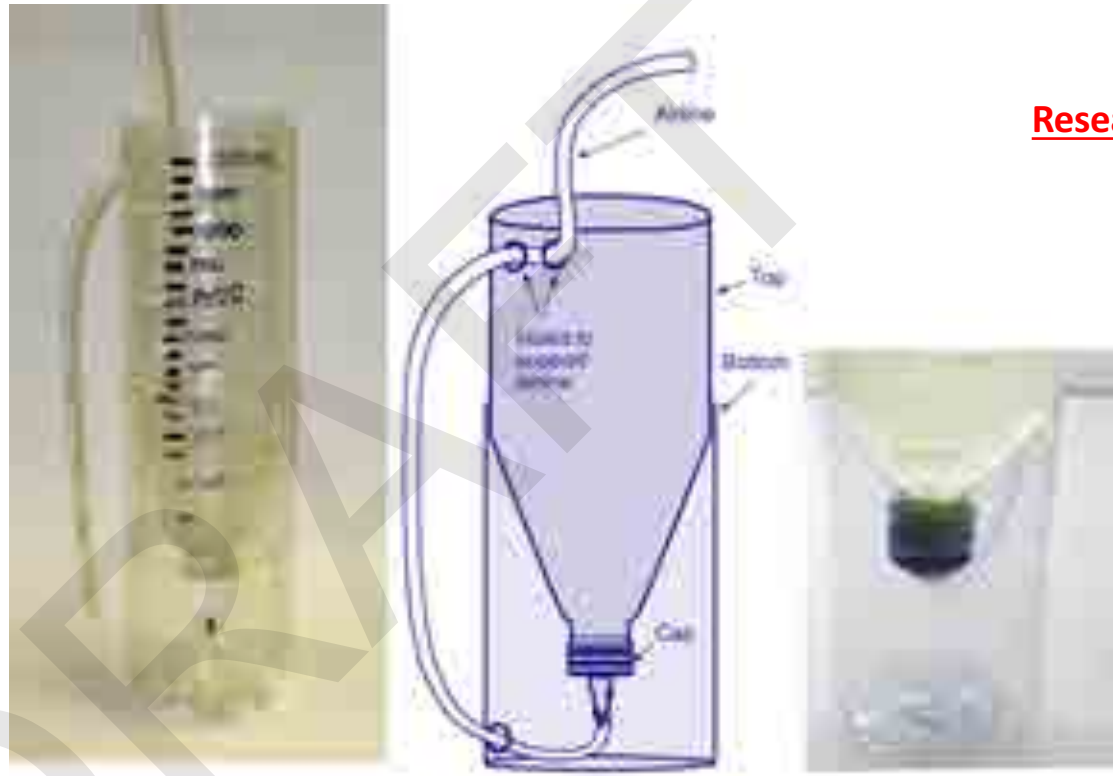

Figure Hatchery aeration.jpg
Photos Bob Moffatt

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The experiment is also an example of how Shelford's law could be applied.

These are the claims.

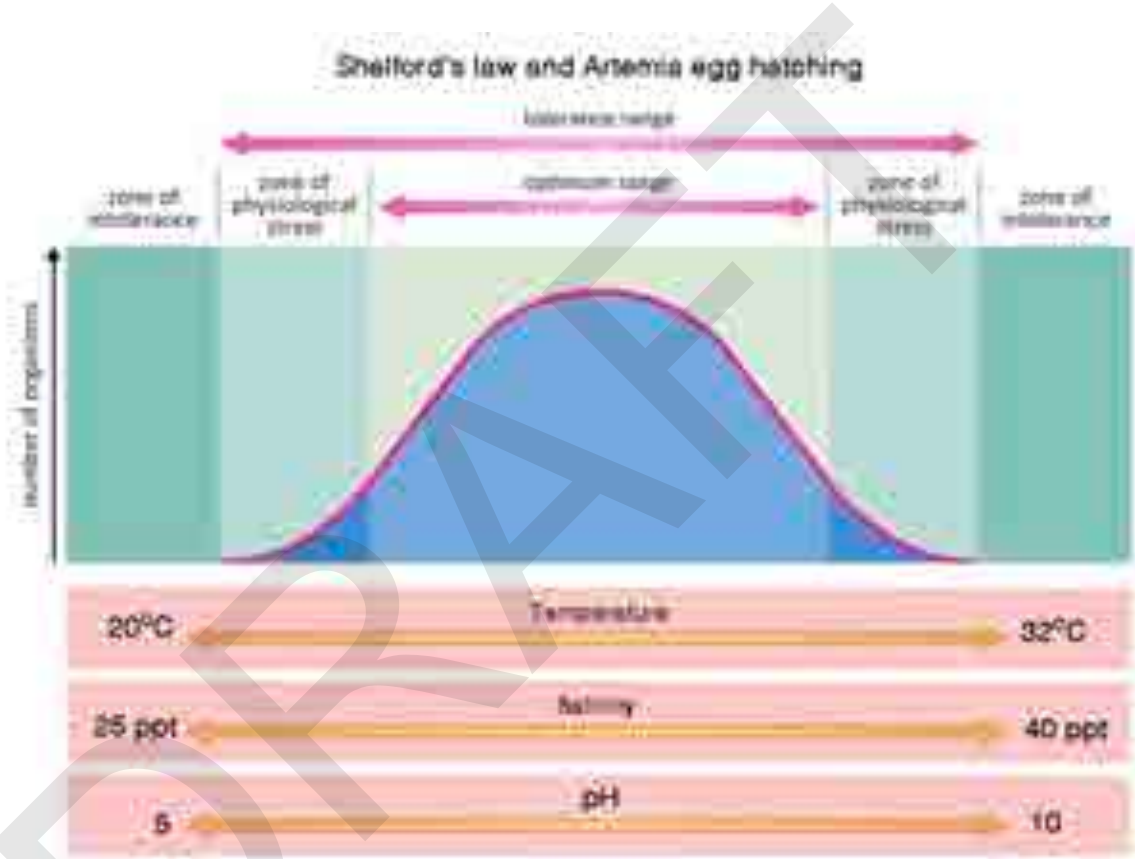

Figure - Shelfords law and Artemia

Illustration Bob Moffatt

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Student experiment

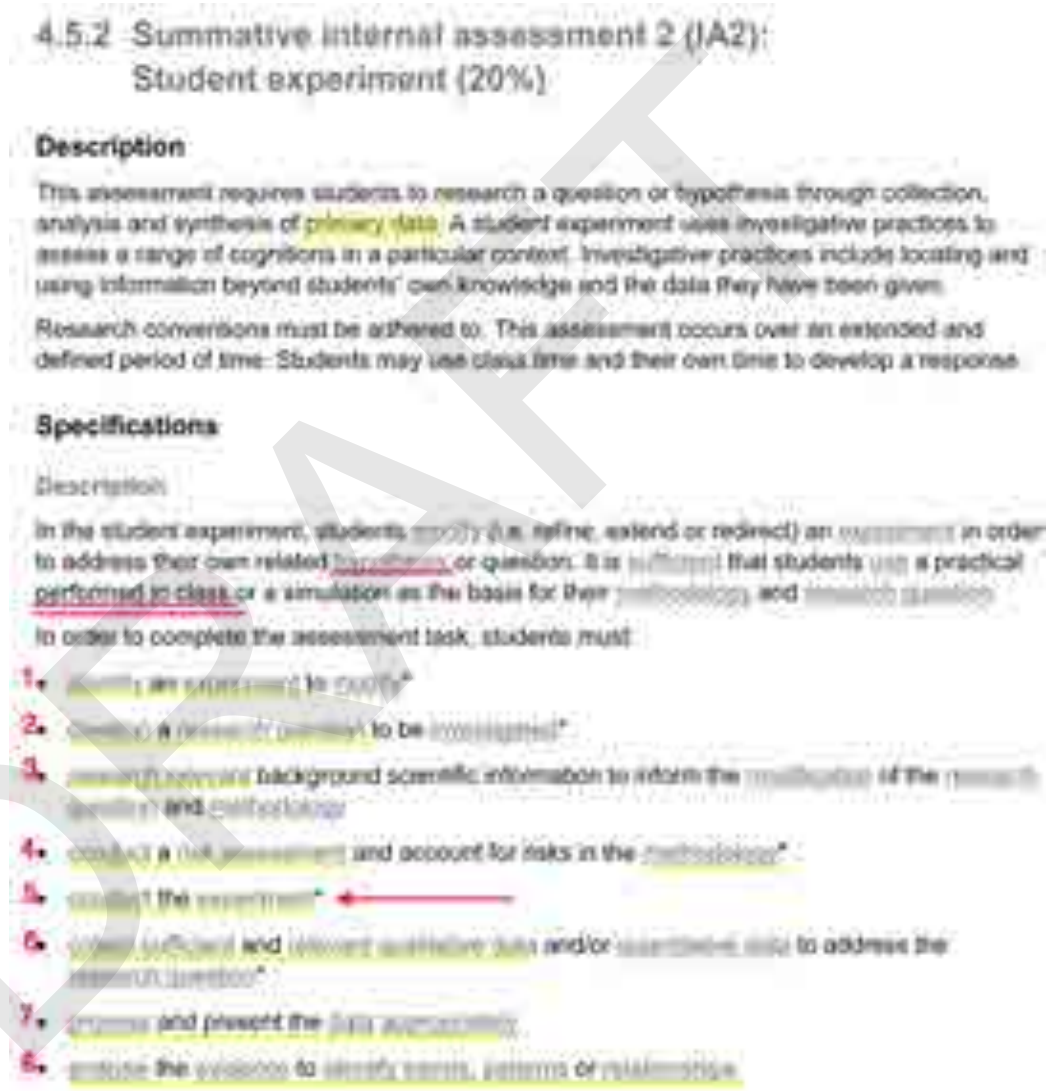
1. Identify an experiment to modify.

The assessment of temperature data to determine tolerance limits for egg hatching success in Artemia

You could also do
Carbon dioxide (pH) (Ocean acidification)

Salinity (sediment runoff from the land)

Ethyl alcohol (a pollutant)



4.5.2 Summative internal assessment 2 (IA2): Student experiment (20%)

Description

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Specifications

Description

In the student experiment, students modify (i.e. refine, extend or redirect) an experiment in order to address their own related hypothesis or question. It is sufficient that students use a practical performed in class or a simulation as the basis for their methodology and research question.

In order to complete the assessment task, students must:

1. identify are constrained to modify*
2. develop a research question to be investigated*
3. research relevant background scientific information to inform the modification of the research question and methodology
4. conduct a risk assessment and account for risks in the methodology*
5. conduct the experiment*
6. collect sufficient and relevant qualitative data and/or quantitative data to address the research question*
7. process and present the data appropriately
8. analyse the evidence to identify trends, patterns or relationships

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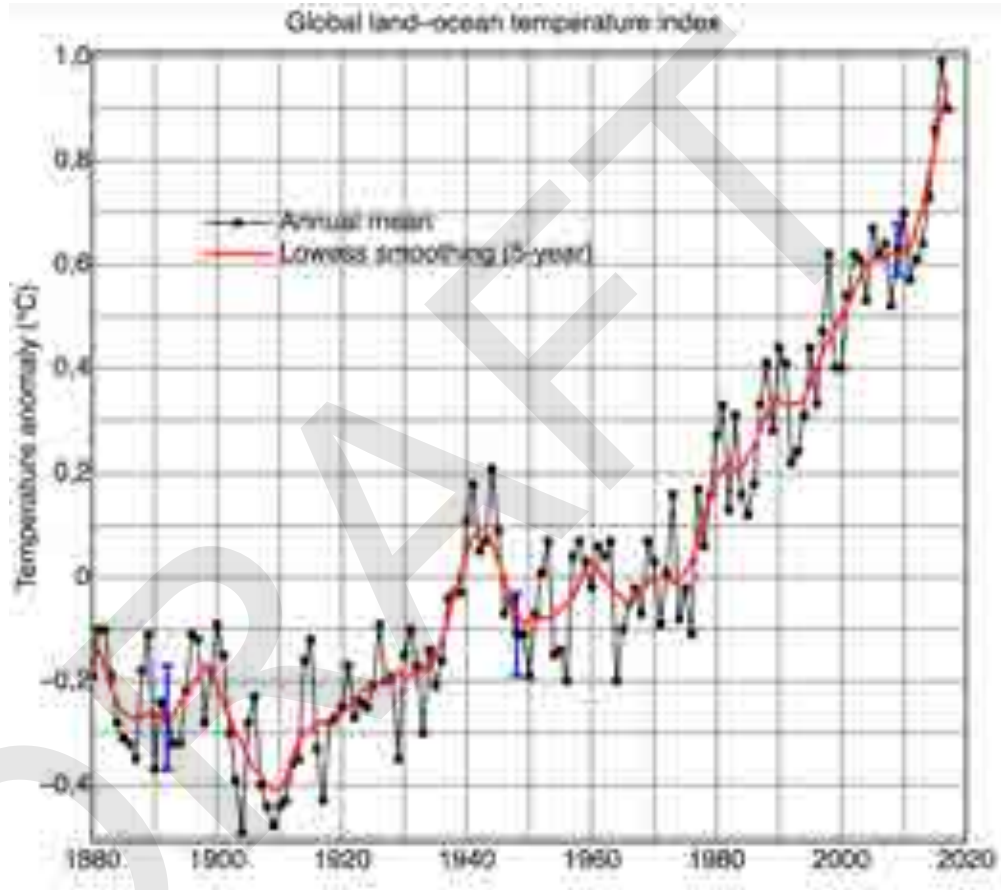
IA2
Credit QCAA Marine Science Syllabus

2. Develop a research question to be investigated

Will global warming affect the hatching success of a marine organism?



Global Temperature Anomaly

By NASA Goddard Institute for Space Studies (http://data.giss.nasa.gov/gistemp/graphs/) [Public domain], via Wikimedia Commons

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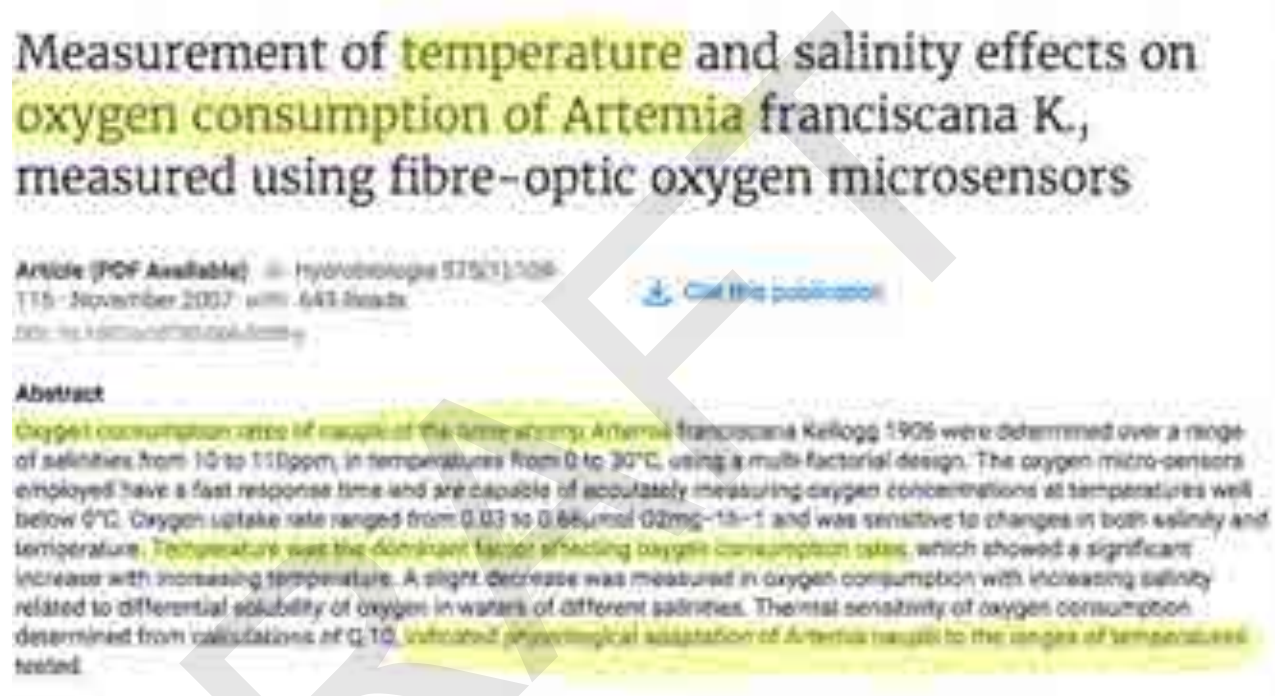
3. Research relevant background information to inform the modification of the research question and methodology

Sample article 1

Measurement of temperature and salinity effects on oxygen consumption of Artemia franciscana K., measured using fibre-optic oxygen microsensors



Measurement of temperature and salinity effects on oxygen consumption of Artemia franciscana K., measured using fibre-optic oxygen microsensors

Article [PDF Available] in Hydrobiologia 575(1):109-115 · November 2007 with 643 Reads

Cite this publication

Abstract

Oxygen consumption rates of nauplii of the brine shrimp Artemia franciscana Kellogg 1906 were determined over a range of salinities from 10 to 110ppm, in temperatures from 0 to 30°C, using a multi-factorial design. The oxygen micro-sensors employed have a fast response time and are capable of accurately measuring oxygen concentrations at temperatures well below 0°C. Oxygen uptake rate ranged from 0.03 to 0.66μmol O2mg−1h−1 and was sensitive to changes in both salinity and temperature. Temperature was the dominant factor affecting oxygen consumption rates, which showed a significant increase with increasing temperature. A slight decrease was measured in oxygen consumption with increasing salinity related to differential solubility of oxygen in waters of different salinities. Thermal sensitivity of oxygen consumption determined from calculations of Q10 indicated physiological adaptation of Artemia nauplii to the ranges of temperatures tested.

Research article 1

https://www.researchgate.net/publication/225993308_Measurement_of_temperature_and_salinity_effects_on_oxygen_consumption_of_Artemia_franciscana_K_measured_using_fibre-optic_oxygen_microsensors

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Sample article 2

Impacts of Climate Change on Marine Organisms and Ecosystems

Research article 2https://www.sciencedirect.com/science/article/pii/S0960982209011816

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The experiment you are modifying:

Raising Artemia as food source for aquaculture organisms.

Artemia eggs in a packet
Photo Bob Moffatt

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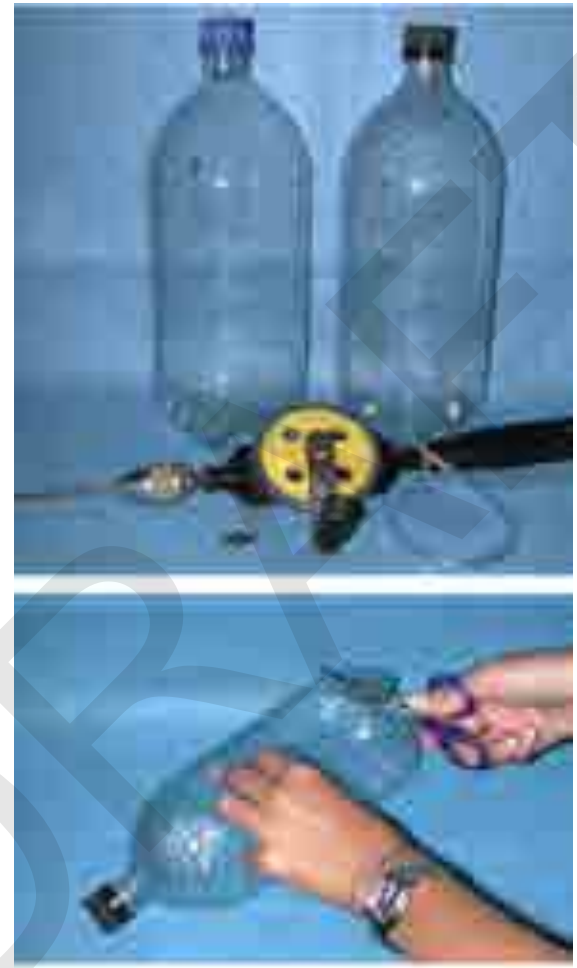
4. Risk assessment and account for risks in the methodology

Safety precaution, animal ethics and risk assessments

Lab coats, foot and skin protection.

Follow school safety precautions for glassware and salt water solutions –

Methodology - (sodium hypochlorite MSD) - modify school risk assessments for laboratory and incubators and water baths (if applicable)



Risk assessment

Photo Mick O'Connor

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5. Conduct the experiment

In this example we will use temperature

Hypothesis

As the temperature increases, the rate of hatching success of brine shrimps also increases until optimum temperature is achieved.

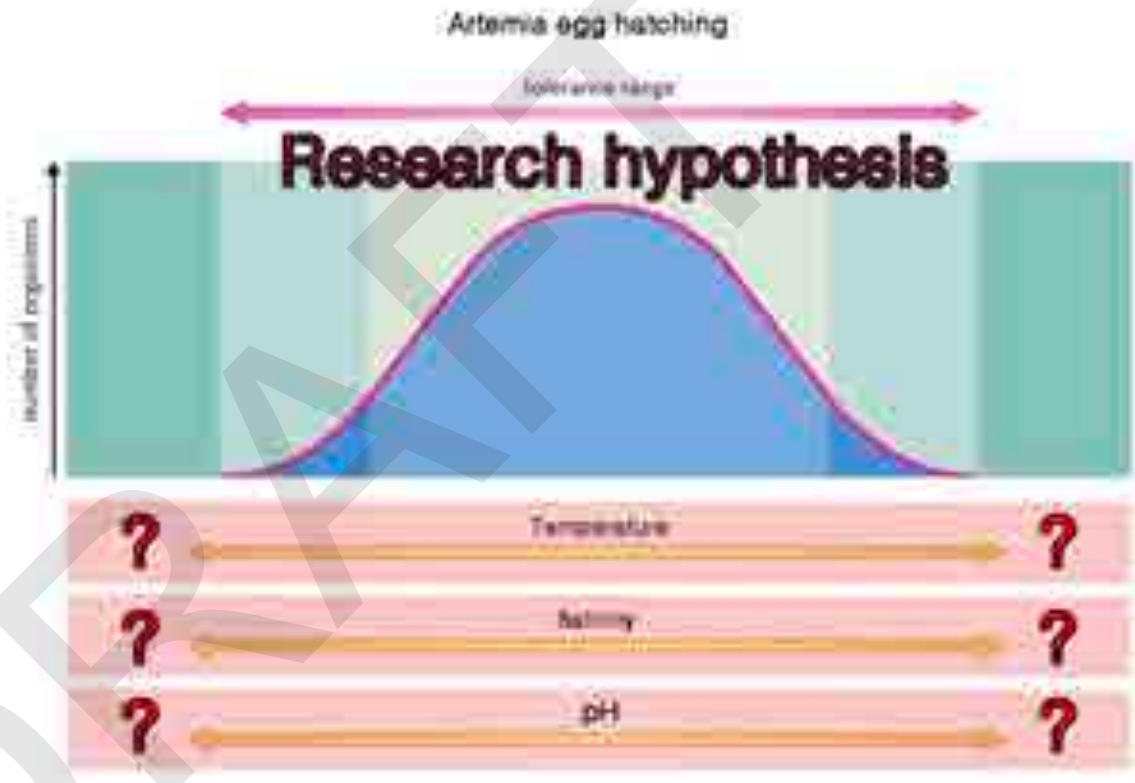

Illustration Bob Moffatt

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Types of variables
Manipulated variable is

Temperature (oC)
Responding variable is number of shrimps hatched

Fixed variables are salinity, light, pH of water and water volume

DRAFT Variable types in Artemia experiment

Illustration Bob Moffatt

Types of variables	Ways variables can be controlled
Manipulated variable Temperature (°C)	Different use of temperatures 22°C, 29°C and 32°C to incubate brine shrimp egg cysts
Responding variable Number of shrimps hatched	Calculated by catching using fine glass pipette and counting the number of larva that swim towards a light source for 2 days
Fixed variables	
Salinity	Use same weight of salt (7g) for each fixed volume of water (200 mLs)
Light	Place in same light
pH of water	Ph of water to be kept between 8 – 8.5
Water volume	Use same volume of water (petri dish – to be verified)

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Apparatus

Artemia hatchery

Photo Mick O'Connor

See also

http://www.solidgoldfish.com/2013/11/easy-diy-brine-shrimp-hatchery.html

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Materials

Buy decapsulated 10 grms eggs from local supplier

Eg: http://theaquariumshop.com.au

Cost about
$20

Light

Thermometer

More to come

Artemia eggs
Photo Bob Moffatt

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6. Collect sufficient and relevant qualitative and quantative data to address the research question

STEP 1: Decapsulate eggs

You can watch the decapsulation process at

Figure Brine shrimp decapsulating video

Credit: https://www.youtube.com/watch?v=njmiRcJ7G3s

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STEP 2:

Set up 3 hatcheries with equal numbers of eggs at three different temperatures.

Incubate for 24 hours

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OR use water baths

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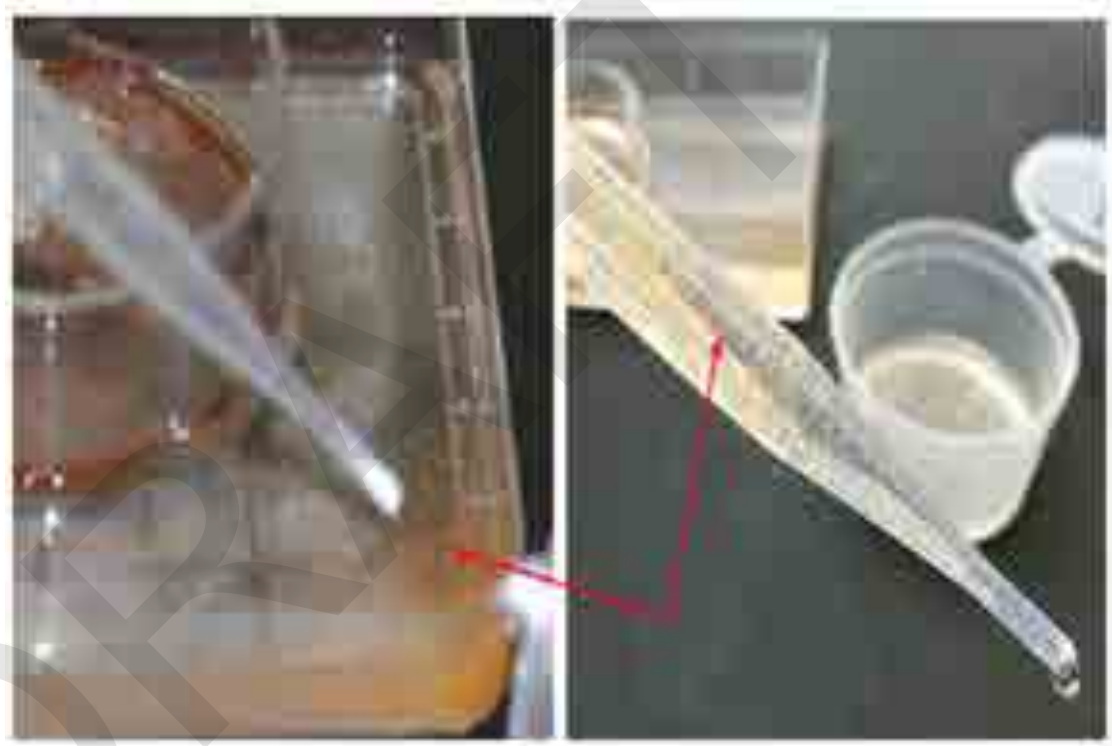
STEP 3:
COUNT HATCHED EGGS
Day 1

This is the test and I have not counted themShine light on hatchery and count numbers using a magnifying glass

Or take sample and count in pipette

STEP 4:
COUNT HATCHED EGGS
Day 2



Artemia nauplii in pipette.jpg

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STEP 5: Tabulate results

Artemia temperature experiment result table

Temperature (°C)	First Day (After 24 hours)	Second Day (After 48 hours)
22	8	10
29	9	12
32	3	5

Table 2: Number of Brine Shrimps hatched in respective temperature by day count

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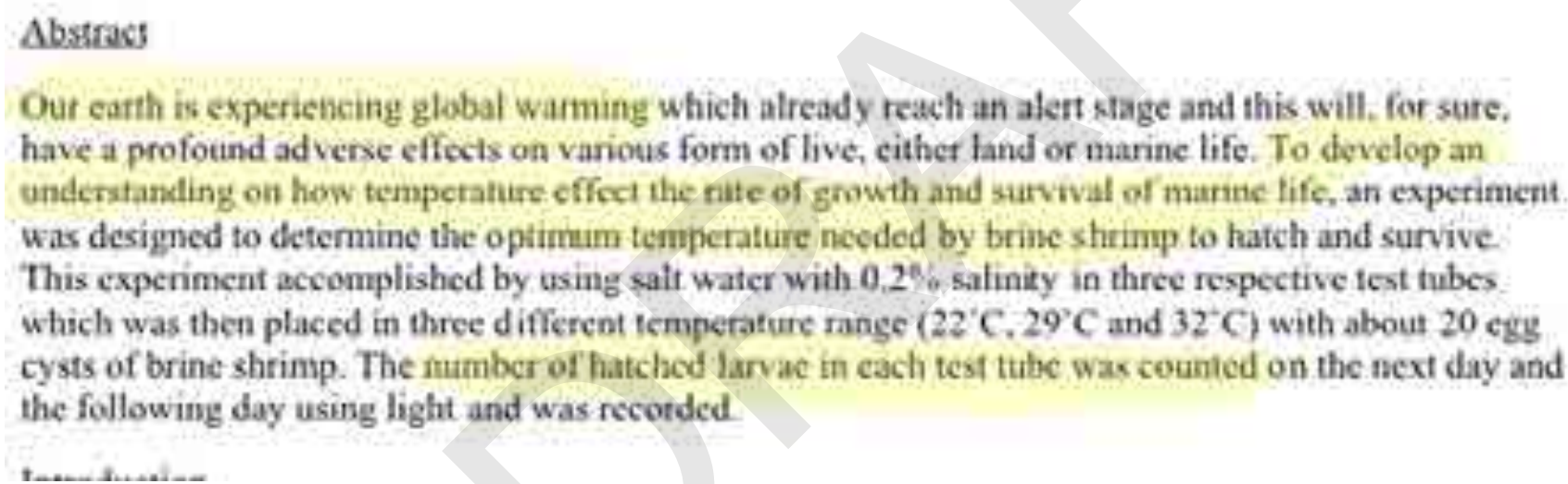
7. Process and present data appropriately

Abstract

In this case this is a brief summary of the analysis of the experiment to help the reader quickly ascertain the paper's purpose.



Abstract

Our earth is experiencing global warming which already reach an alert stage and this will, for sure, have a profound adverse effects on various form of live, either land or marine life. To develop an understanding on how temperature effect the rate of growth and survival of marine life, an experiment was designed to determine the optimum temperature needed by brine shrimp to hatch and survive. This experiment accomplished by using salt water with 0.2% salinity in three respective test tubes which was then placed in three different temperature range (22˚C, 29˚C and 32˚C) with about 20 egg cysts of brine shrimp. The number of hatched larvae in each test tube was counted on the next day and the following day using light and was recorded.

Introduction

Abstract sample

From https://www.scribd.com/doc/149338069

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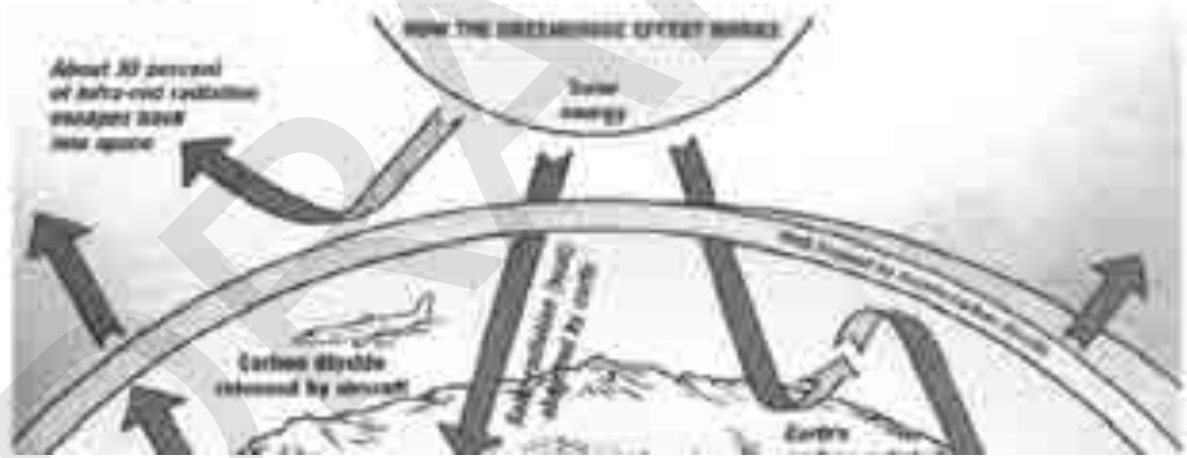
Introduction

In this case this is a discussion justifying the experiment in line with previous research.

1. Global Warming(Greenhouse Effect)

Greenhouse effect is a phenomenon in which earth's atmosphere traps the heat from the sun and prevents it from escaping. Atmosphere acts like a greenhouse glass in which sunlight enters through transparent glass but then, the heat released by plants (infrared radiation form) is not allowed to escape. Thus the temperature increases inside the greenhouse. This is an analogy for what is happening to our earth but in this case, certain gases known as greenhouse gases act as atmosphere and this contributes to global warming.



Introduction sample

From https://www.scribd.com/doc/149338069

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Methodology critique

Describe the variables and how they were controlled

Light
Population density
Water volume
Salinity
Sterilisartion
Measurements
Standards

More to come

In this experiment, what is the dependent variable? (It is the number of eggs to hatch.)

What is the independent variable? (Temperature.)

How many different salinities will you test?

What other variables will you keep constant? (Salinity, the number of eggs, etc.)

How will you keep those variables constant?

Count the eggs after 10 days

The more appropriate the salt concentration the more eggs will hatch.
Does it show Leibigs law and can you draw a graph to illustrate Shelfords law
Could Leibigs law also be applied?

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Results

Temperature (°C)	First Day (After 24 hours)	Second Day (After 48 hours)
22	8	10
29	9	12
32	3	5

Table 2: Number of Brine Shrimps hatched in respective temperature by day count

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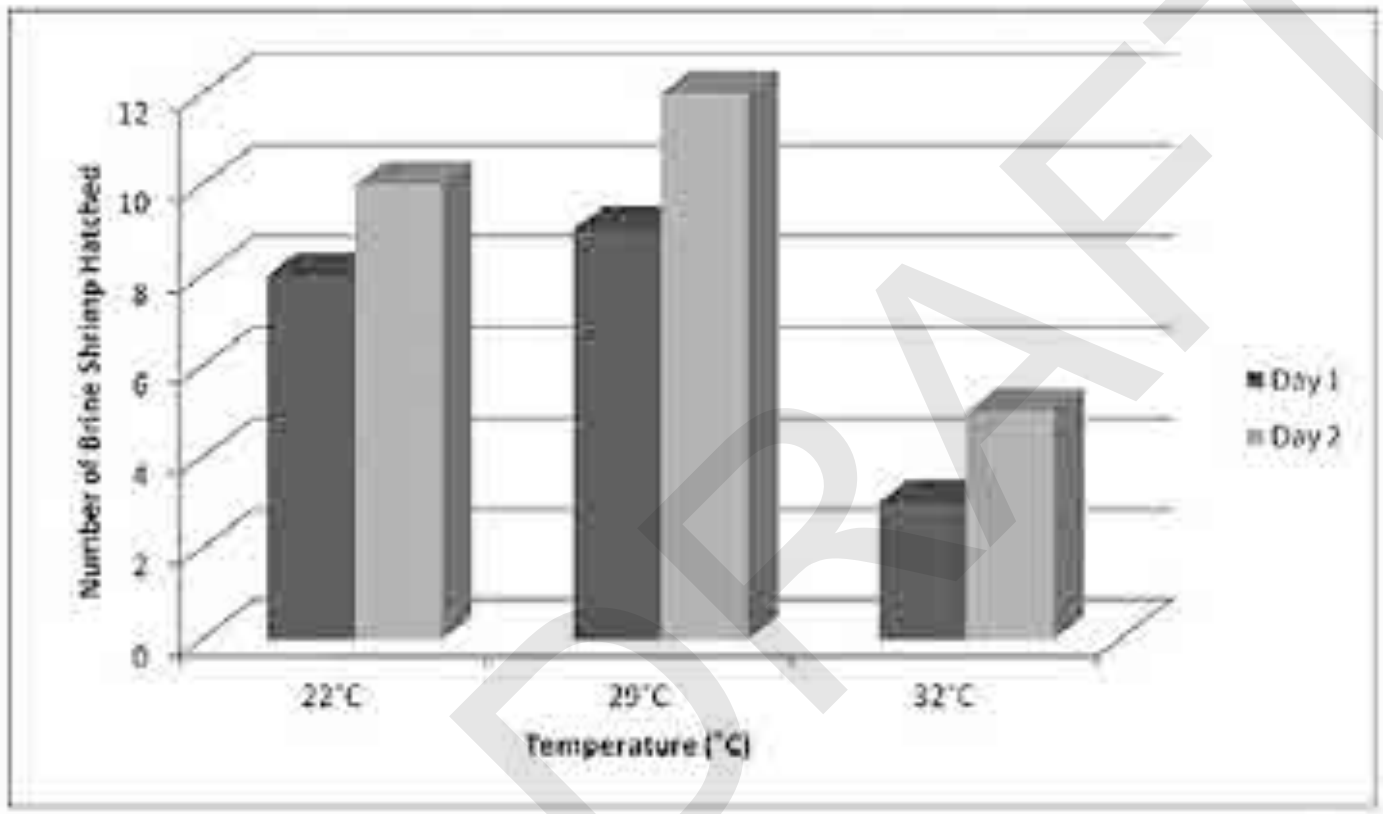
Graph results



Graph 1: Number of Brine Shrimp Hatched in respective temperature by day count

Artemia temperature experiment result graph

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8. Analyse the evidence to identify trends, patterns and relationships

Table 1 shows the number of brine shrimps with respect to temperature 22oC, 29oC and 32oC) and day count.

To analyse the data we look at the temperature at which the brine shrimps hatched.

On the first day at 22oC, 8 larvae swam towards the light source or about 40% of the total brine shrimp eggs used in the experiment.

On the second day 10 larvae swam towards the light meaning 50% had hatched.

Temperature (°C)	First Day (After 24 hours)	Second Day (After 48 hours)
22	8	10
29	9	12
32	3	5

Table 2: Number of Brine Shrimps hatched in respective temperature by day count

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On the first day at 29oC, 9 or (45%) of larvae had hatched which increased to 12 or 60% on the second day.

This was the highest percentage hatching for the experiment.

On the first day at 32oC only 3 had hatched (or 15%) and by the second day only increased to 5 or (25%) of the total amount of Artemis eggs used.

Temperature (°C)	First Day (After 24 hours)	Second Day (After 48 hours)
22	8	10
29	9	12
32	3	5

Table 2: Number of Brine Shrimps hatched in respective temperature by day count

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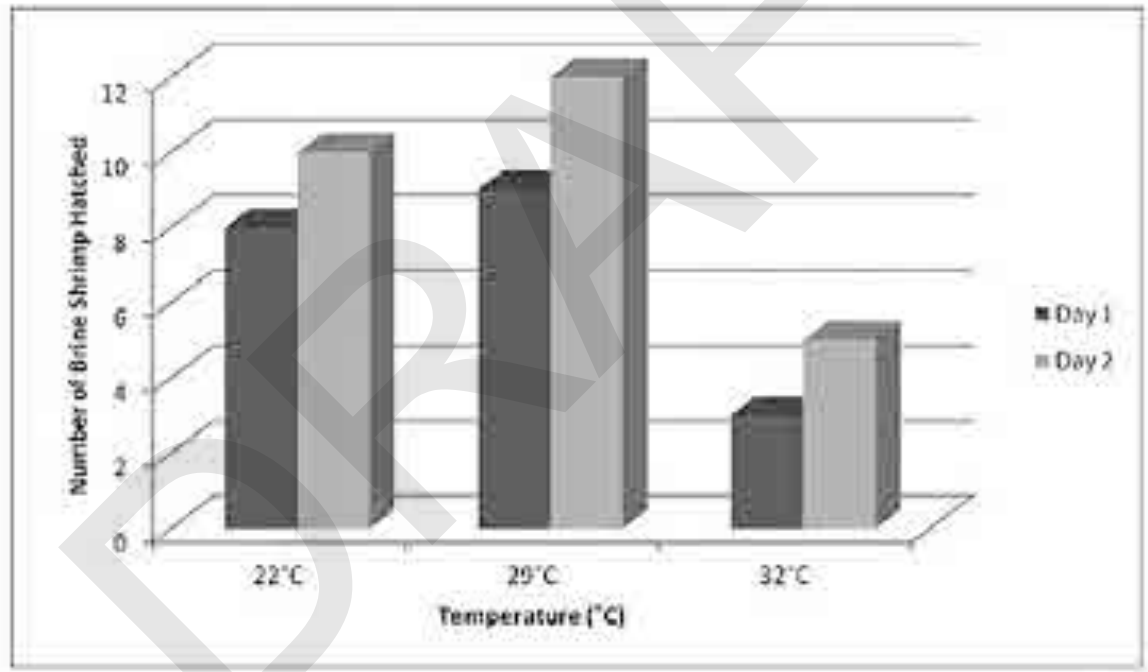
So it can be concluded that the highest number of brine shrimp hatch at 29oC and the lowest at 32oC.



Graph 1: Number of Brine Shrimp Hatched in respective temperature by day count

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Discussion

The optimum temperature for hatching is 29oC.

Beyond this temperature the enzyme reaction decreases and is predicted to completely stop at about 40oC.

Here the enzyme is completely denatured.

So it can be said that at 32oC the hatching enzyme already starts to denature causing the hatching rate to drop significantly.

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9. Make a conclusion and suggest further investigations

The rate of hatching of brine shrimp eggs increases as temperature increases unit an optimum temperature is attained.

This experiment shows the optimum temperature is between 22 and 29oC.So the hypothesis is accepted.

Further investigation

Use different salinities to determine optimum for hatching rate. Temperature and pH are controlled this time using different amounts of salt 2, 4, 6 ,8 gems in 40 mLS of water.

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Revision questions

Under construction

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