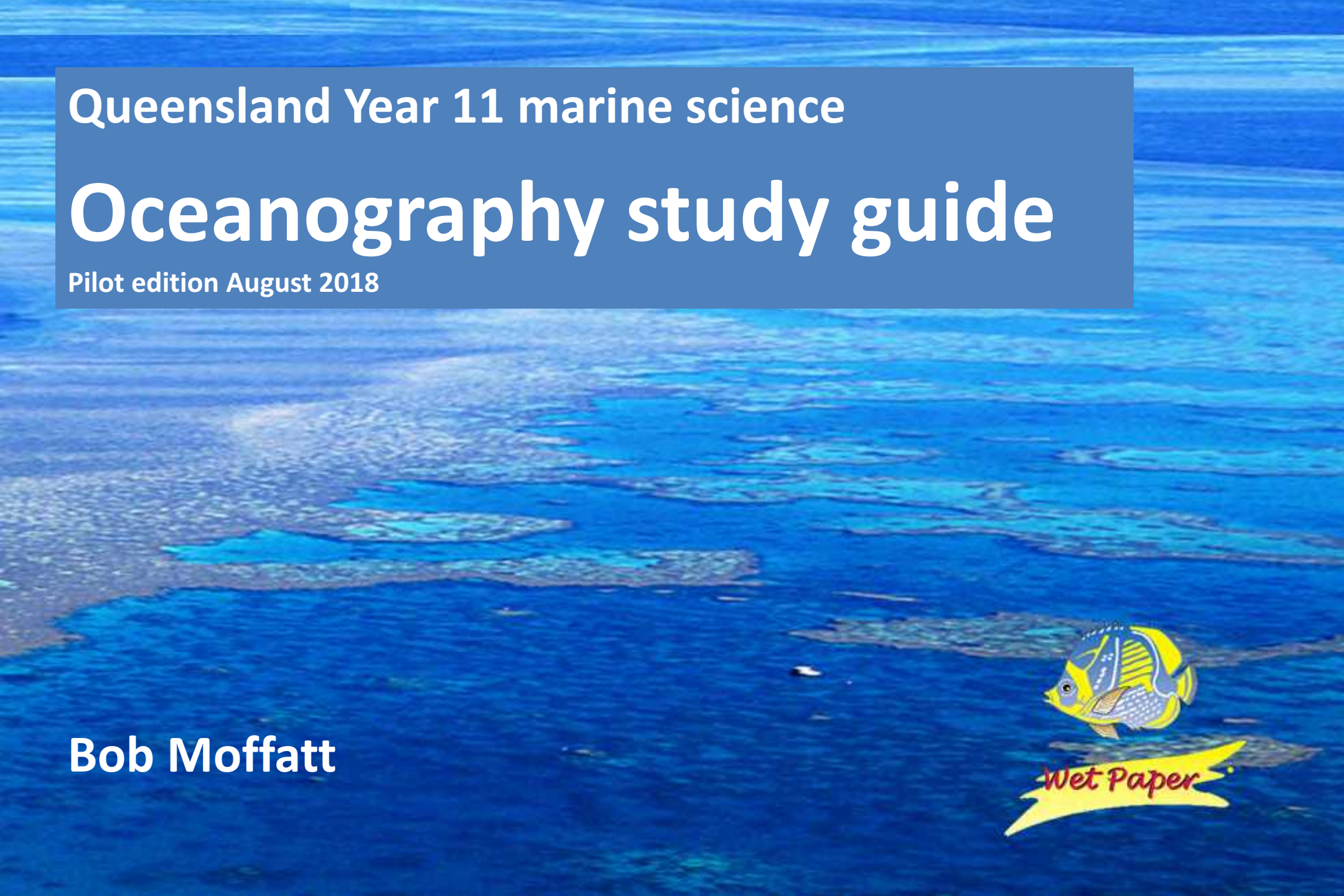
Queensland Year 11 marine science

Oceanography study guide

Pilot edition August 2018



Bob Moffatt

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Unit 1: Oceanography

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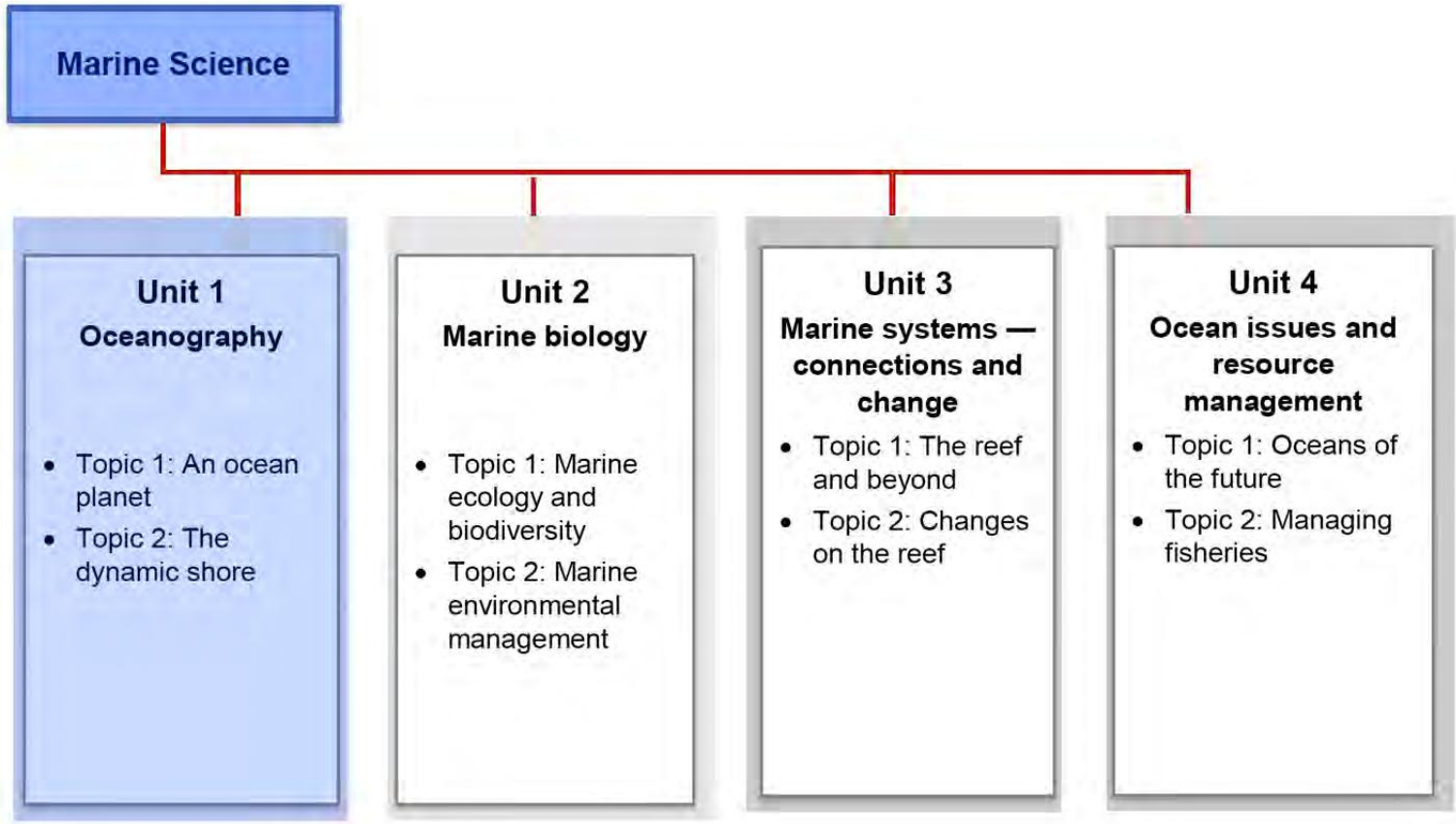
Syllabus reference



Classification of verbs – degree of difficulty.

★	★★	★★★
calculate (e.g. numerical answer; mathematical processes)	analyse	appraise
clarify	apply	appreciate
comprehend (meaning)	categorise	argue
construct (e.g. a diagram)	classify	assess
define	compare	comment (make a judgment)
demonstrate	consider	conduct (e.g. investigations)
describe	contrast	construct (e.g. an argument)
document	critique	create (e.g. a unique product/ artefact; language texts; meaning)
execute	deduce	decide/determine
explain	derive	discuss/explore
identify	determine	evaluate
implement (e.g. a plan, proposal)	discriminate	experiment/test (e.g. ideas, methods)
recall	distinguish	generate/test (e.g. hypotheses)
recognise (e.g. features)	identify	investigate/examine
select	infer/extrapolate	justify/prove (e.g. an argument, statement or conclusion)
understand	interpret (e.g. meaning)	modify
use		predict (e.g. a result)

Ch 1 Oceanography

T001 Bathymetric features

T002 Marine geology models

T003 Biogeochemical cycles

T001 Bathymetric features

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.

Question

Give an account of the shape of ocean 7 bathymetric features.

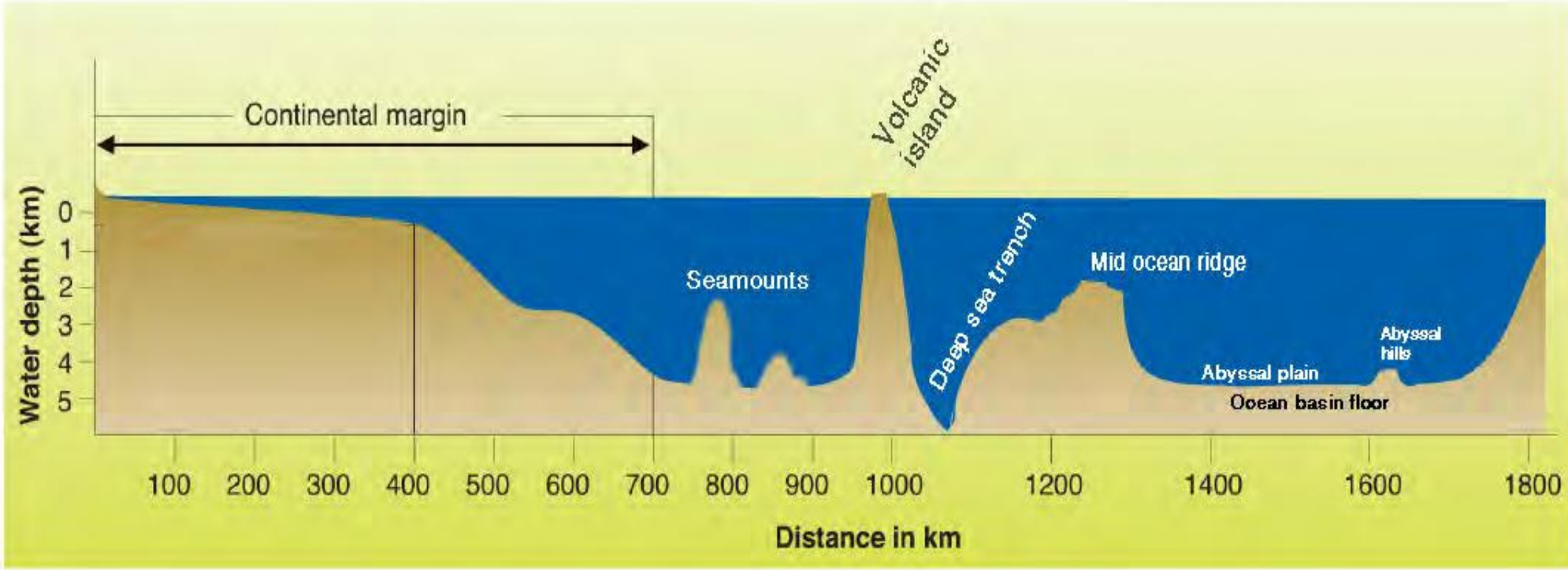
Definition

A bathymetric feature is the shape of underwater terrain

7 major bathymetric features are

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

The following is a summary diagram
– you will have to redraw this and give a brief description of each



Ocean topography divisions
Illustration Bob Moffatt

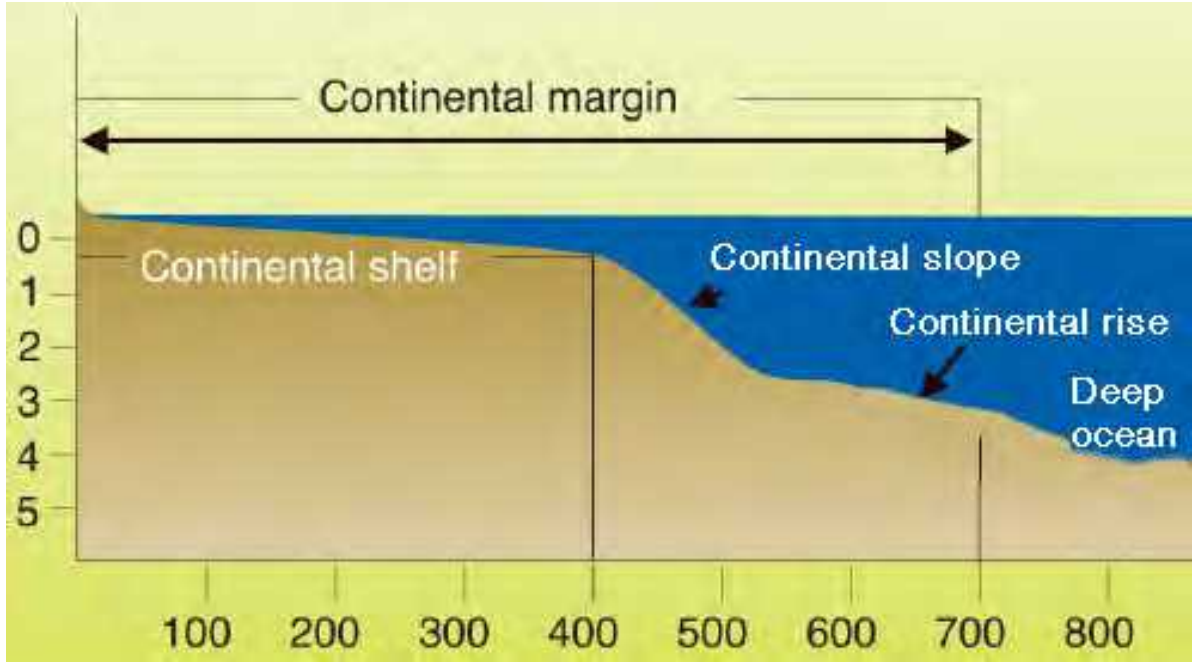
Continental margin

The continental margin has a
Shelf
Slope and
Rise

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

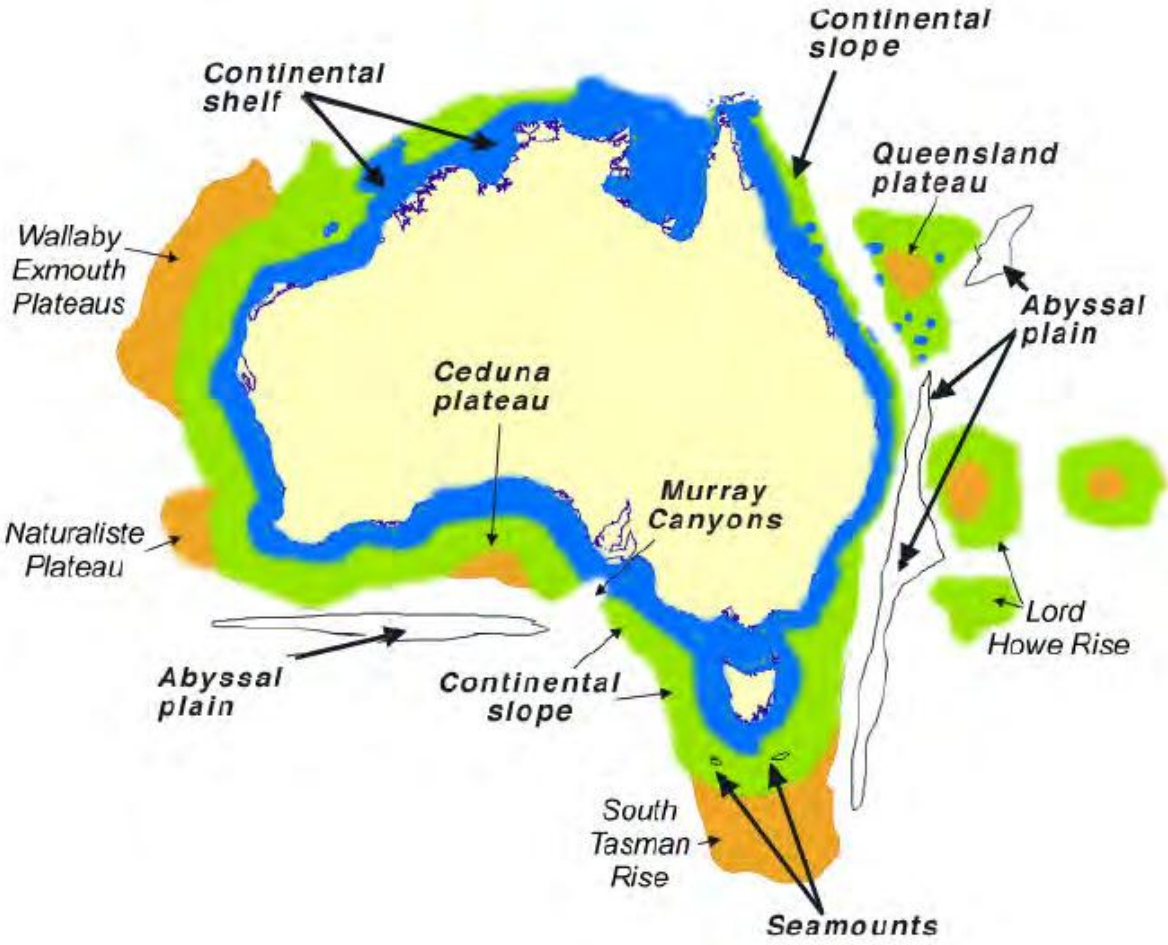
The average distance for the continental margin is 65 kilometres and its character varies from place to place.

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



Continental margin
Illustration Bob Moffatt

In Australia the margin looks like this.

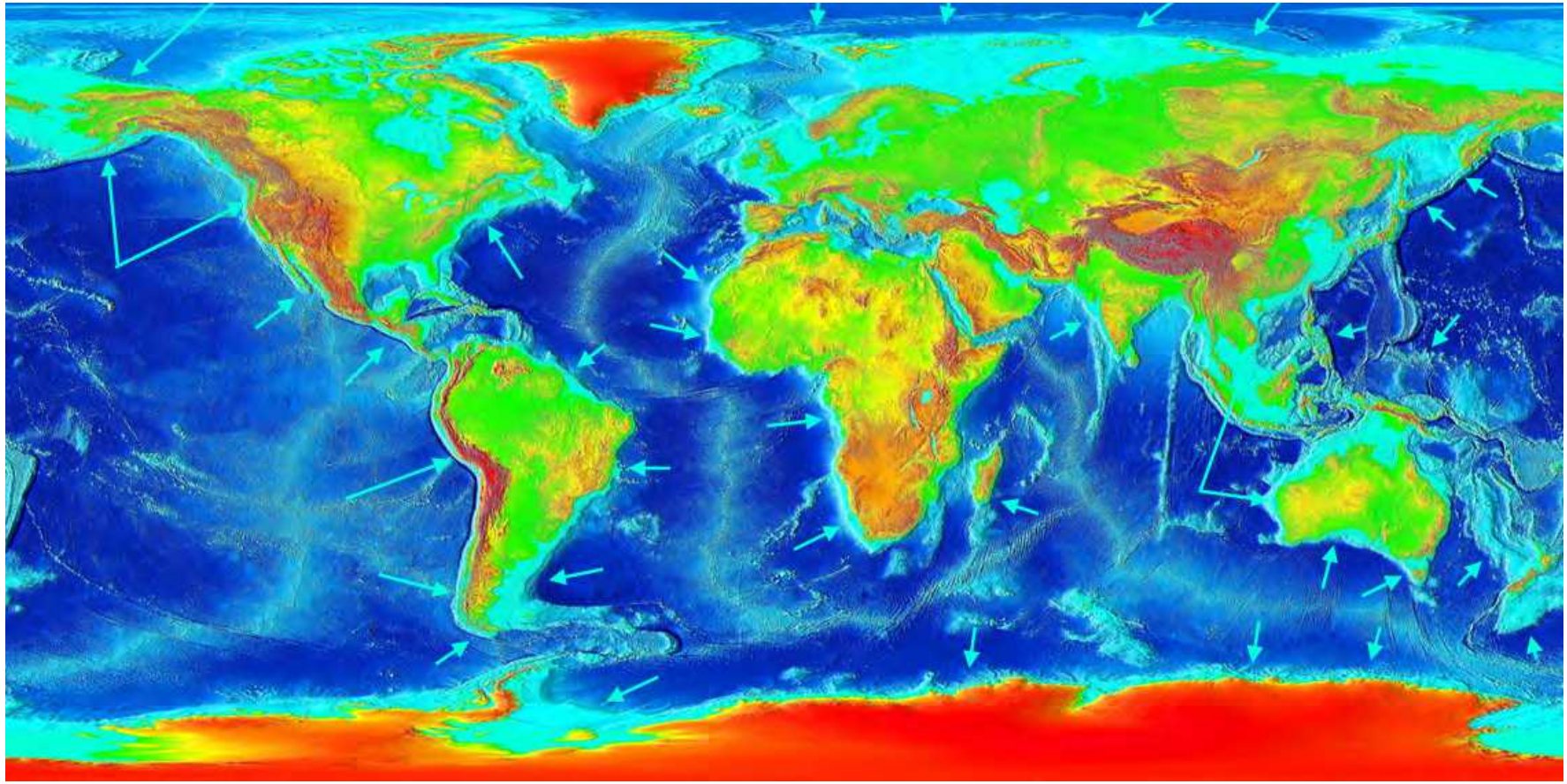


Australian continental margin

Illustrations Bob Moffatt

The continental 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.



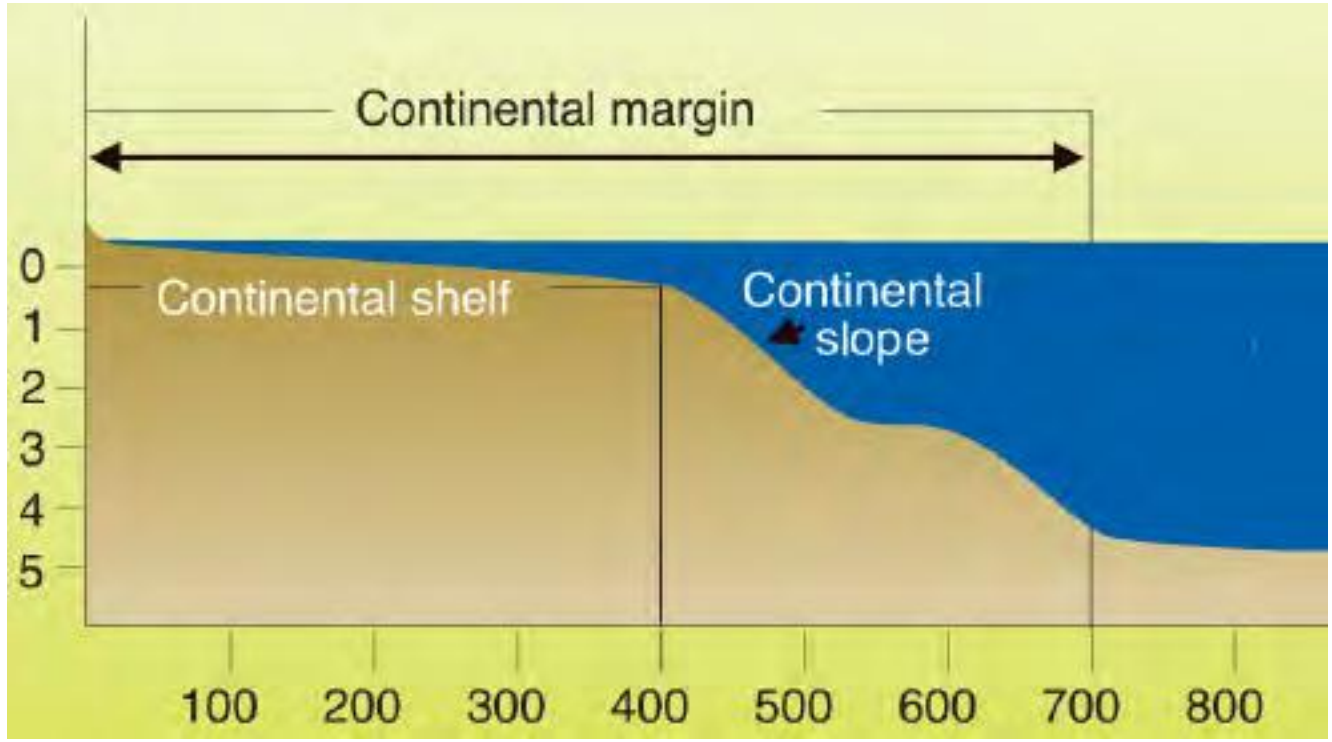
Global continental shelf, highlighted in cyan

The continental 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

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

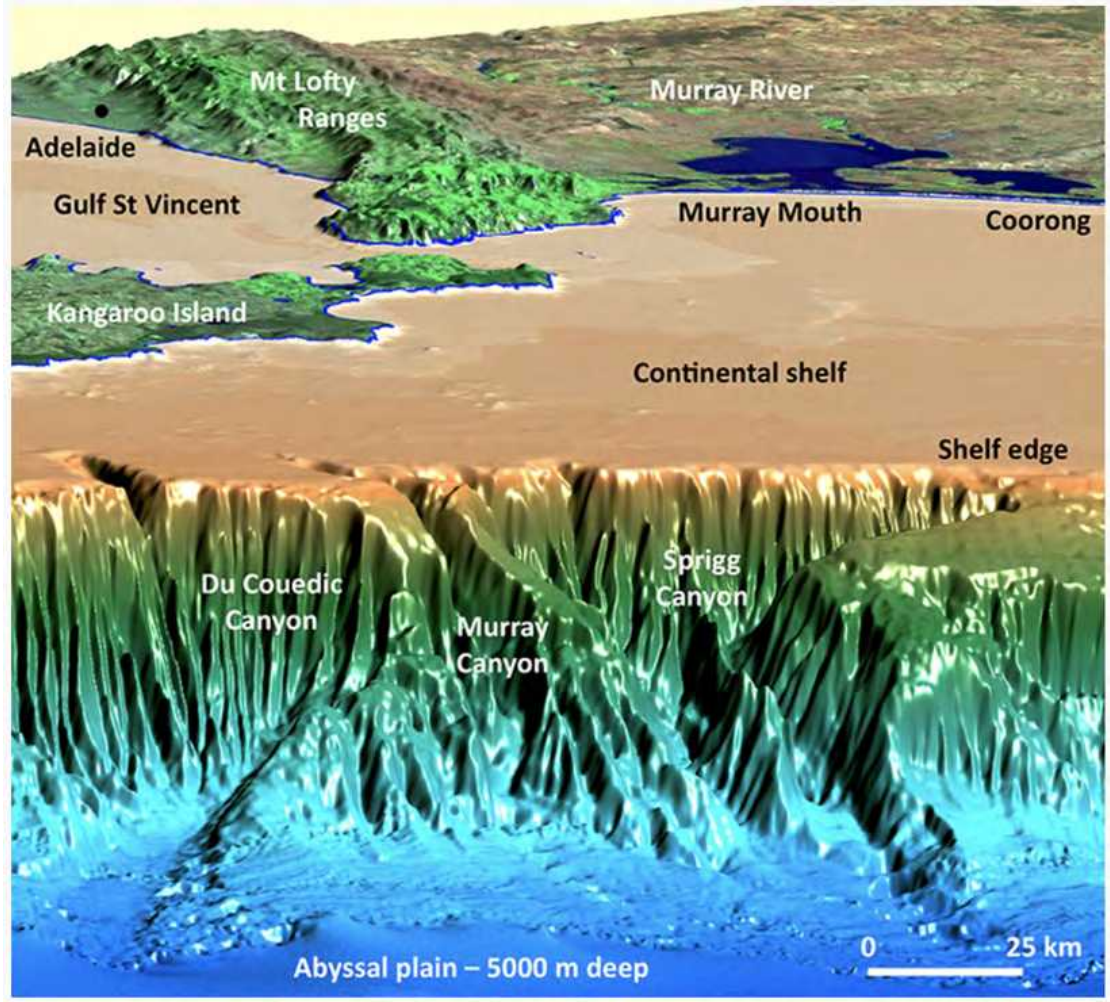
Larger valleys are called submarine canyons.

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.

References:

BLUE PLANET 2 Episode 2

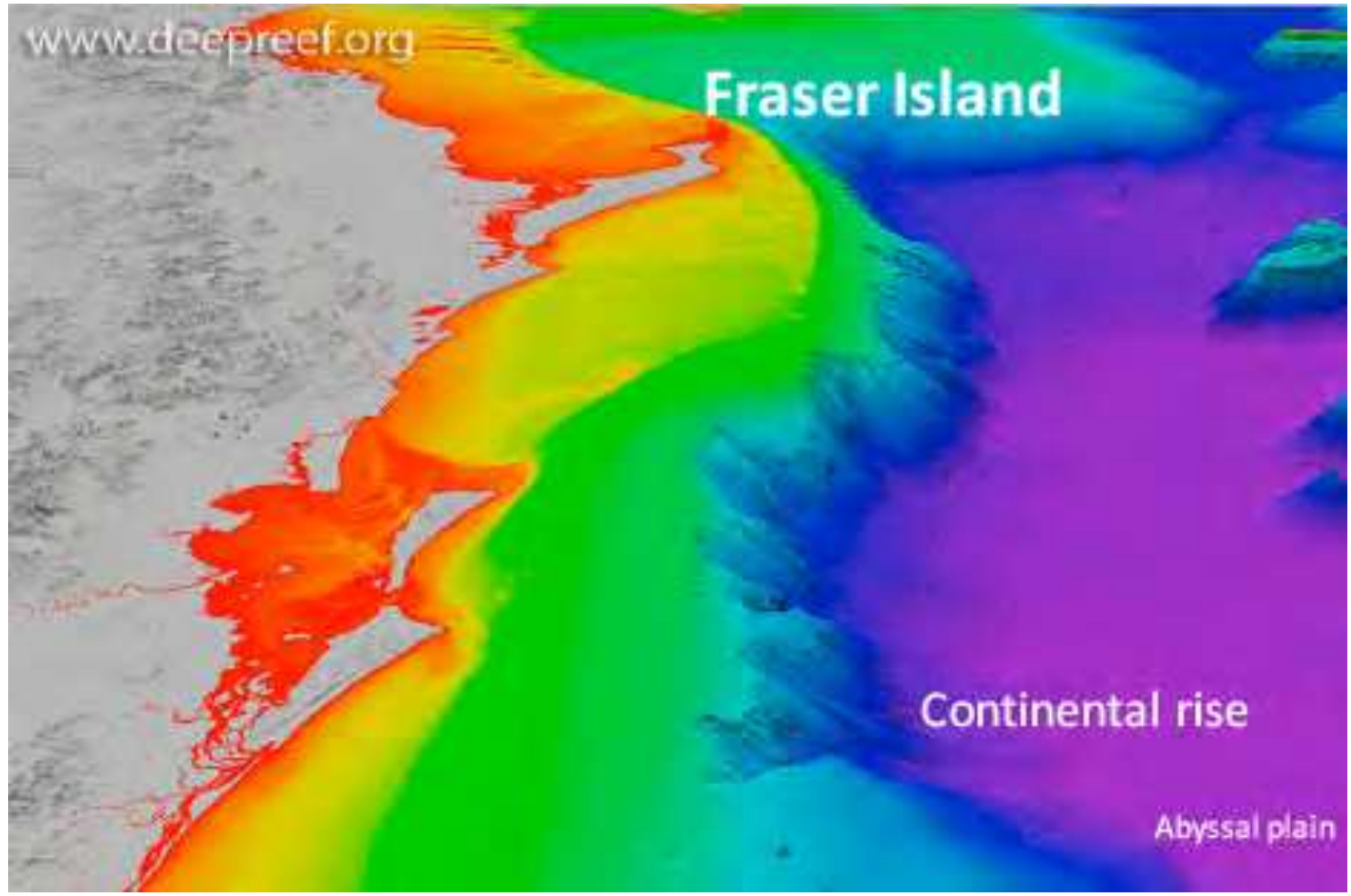


Submarine canyons off Kangaroo Island

(Supplied: Peter J Hill and Patrick De Dekker)
:http://www.abc.net.au/catalyst/stories/s838745.htm

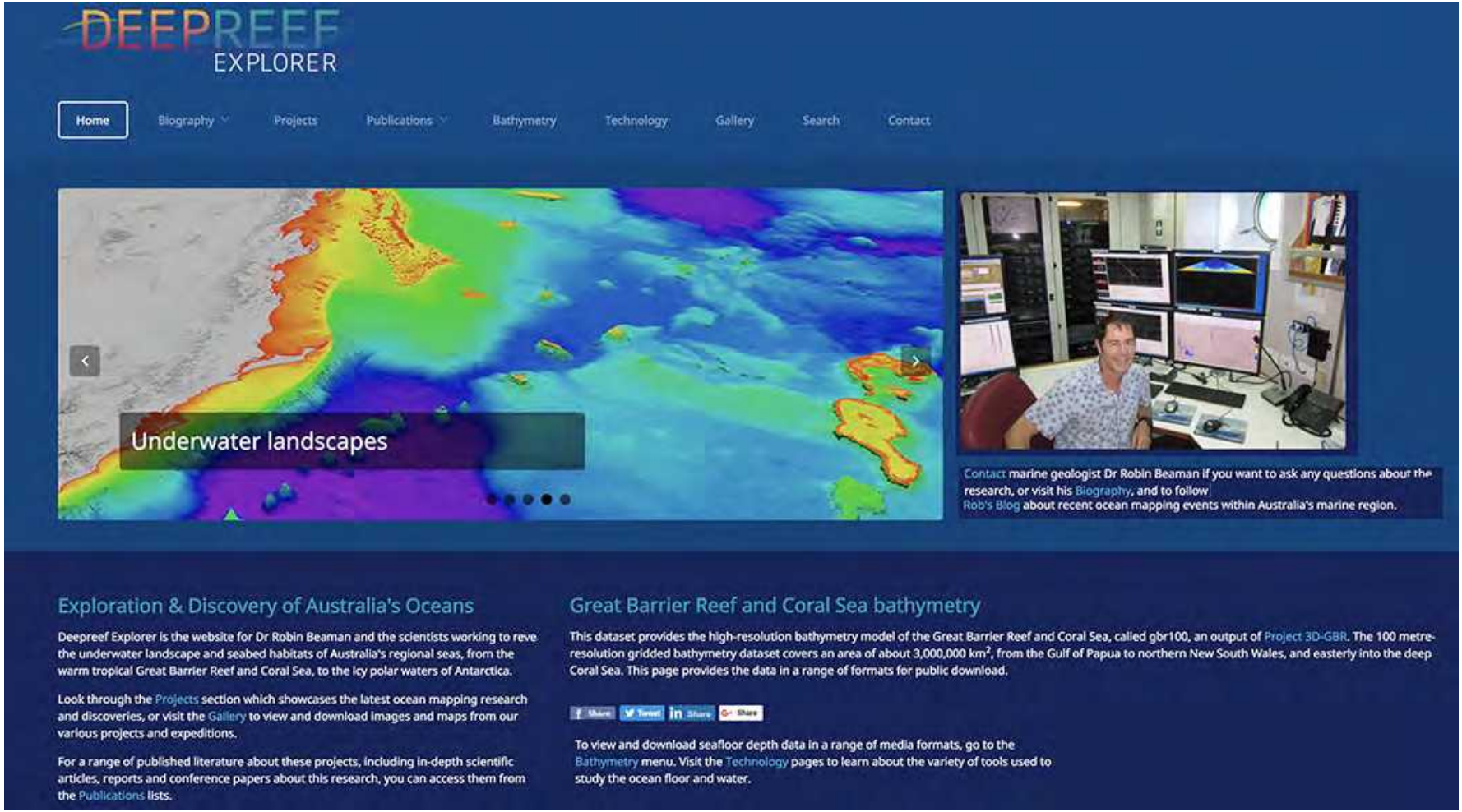
The continental rise

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



Offshore South East Queensland

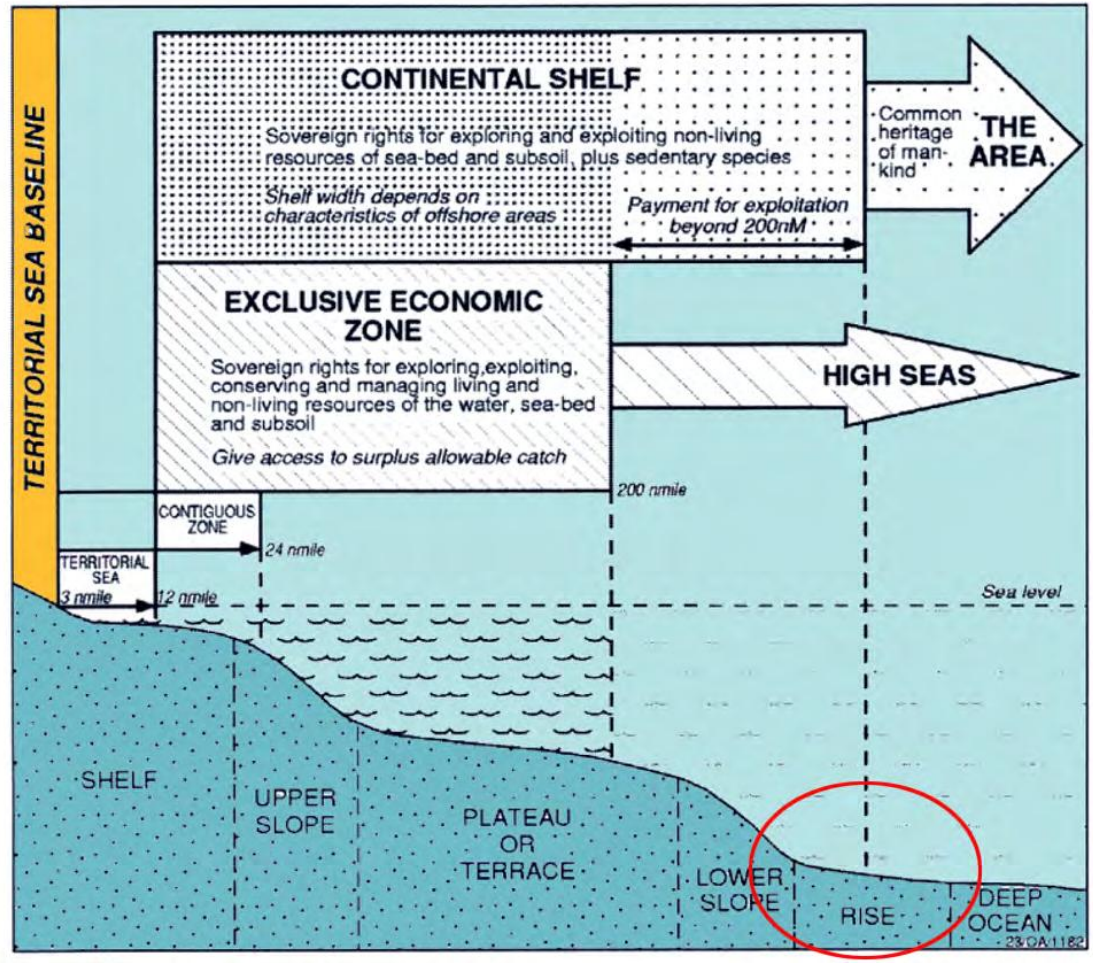
You can read more at
https://www.deepreef.org



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.

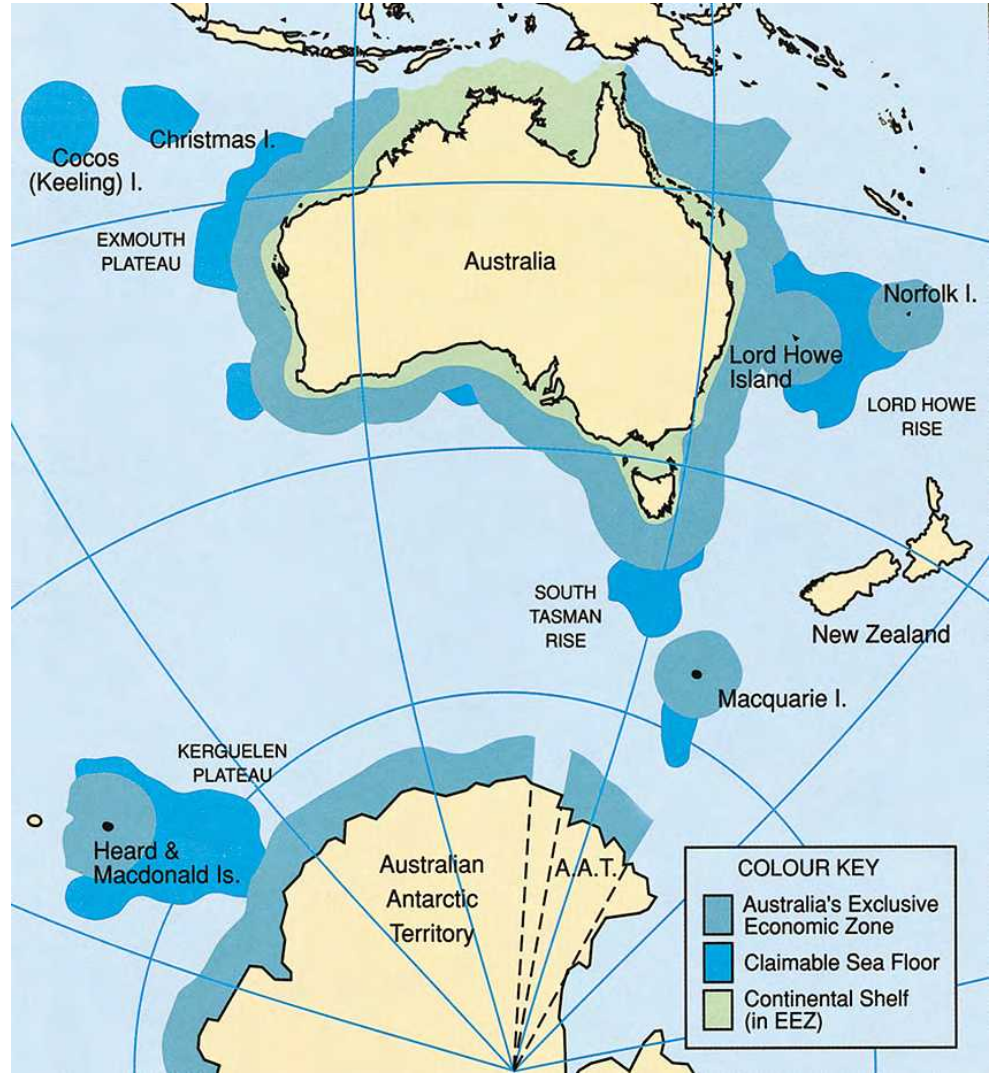


Continental rise and EEZ

Illustration Geoscience Australia

These features are important because permanent maritime boundaries can be established.

For example the Exclusive Economic Zone or EEZ.



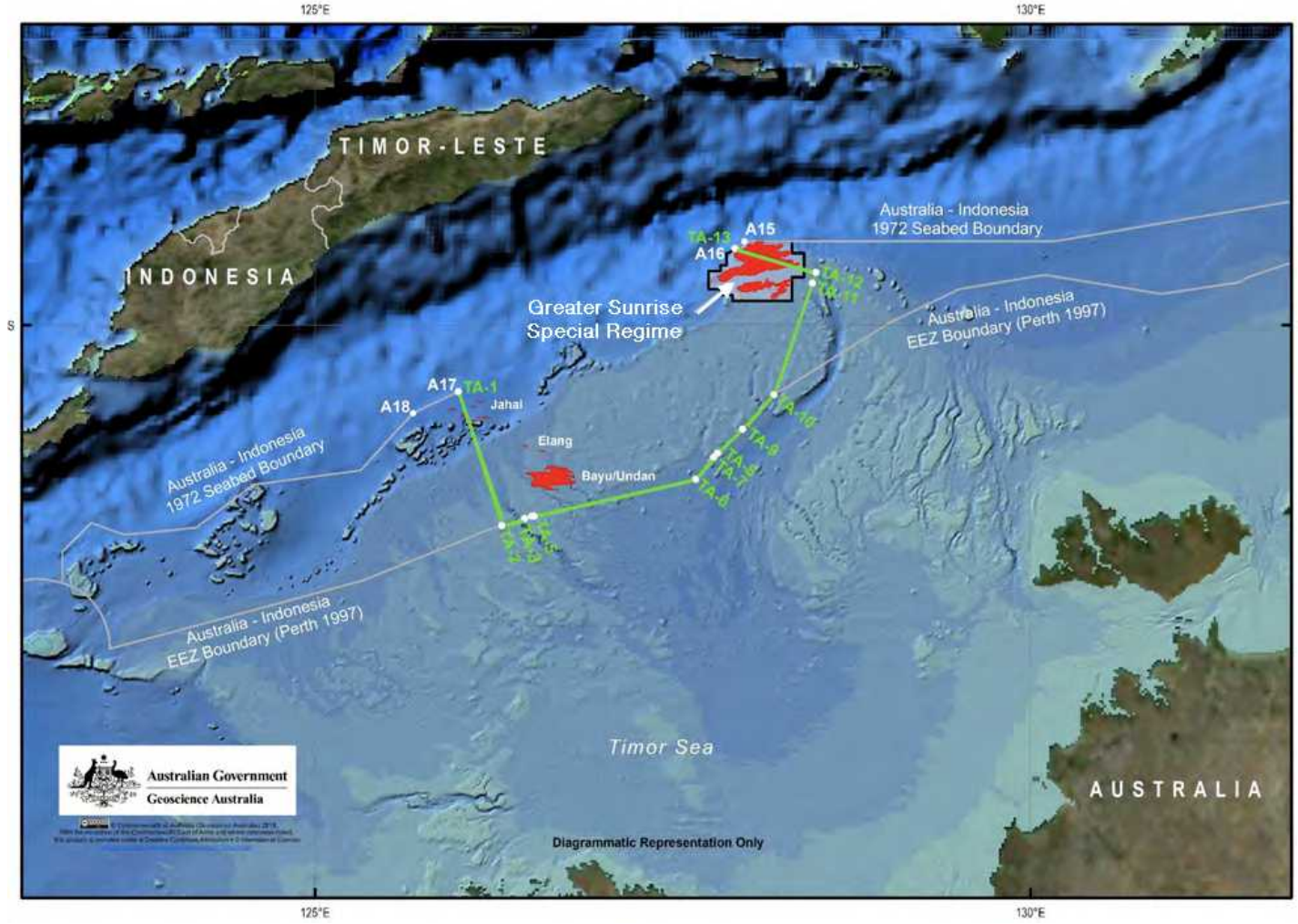
Australia's EEC

Illustration Geoscience Australia

For example, the Timor Sea's Oil & Gas Treaty.

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

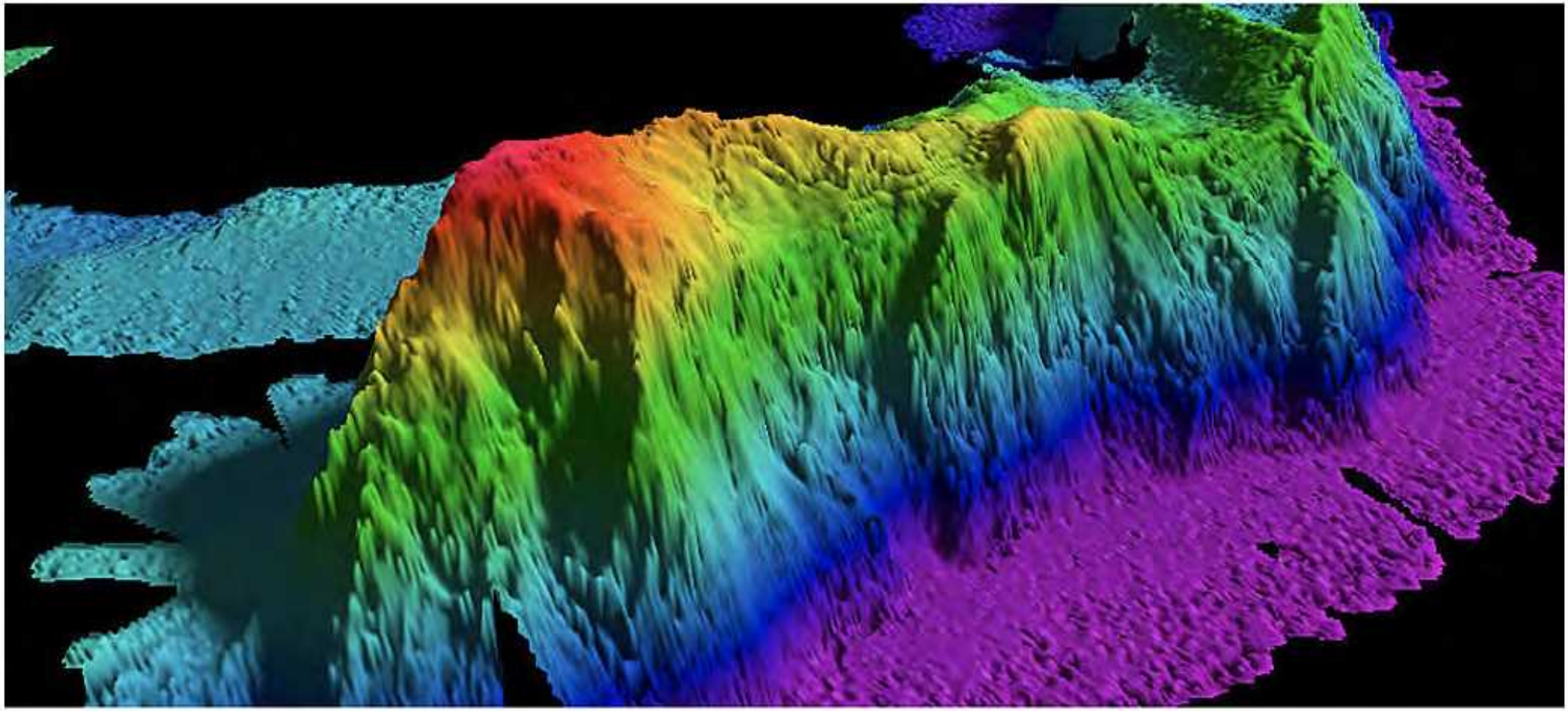
This recognises both Australia and Timor-Leste have legitimate sovereign rights as coastal states under UNCLOS.



Timor Sea agreement

Seamounts

Seamounts are undersea mountains formed by volcanic activity.

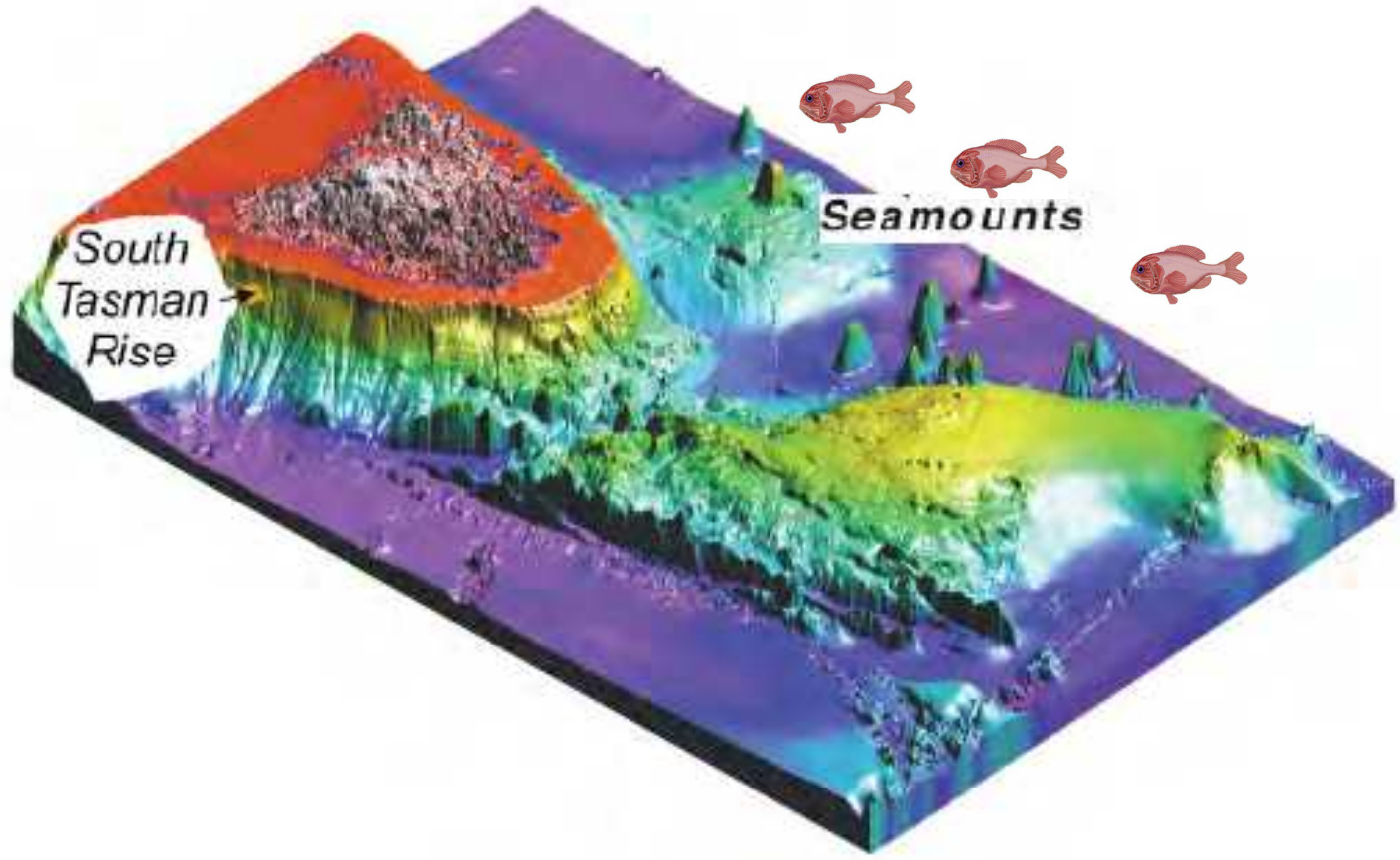


Seamount model created using multibeam echo sounder

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

Thanks to the steep slopes of seamounts, nutrients are carried upwards, (called upwellings), from the depths of the oceans toward the sunlit surface.

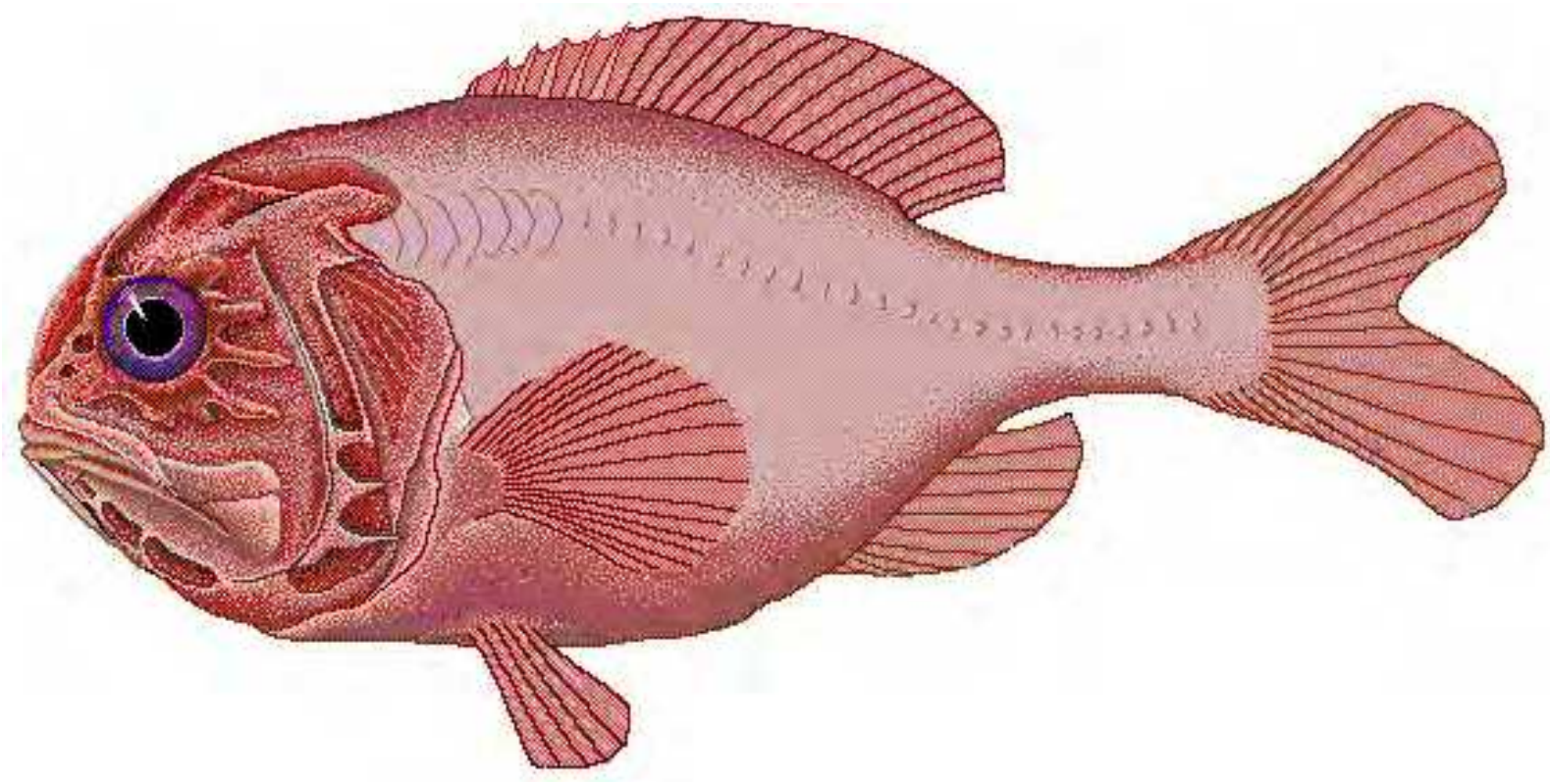
These provide food for creatures ranging from corals and fish to crustaceans.



Tasmanian sea mounts

Illustration Geoscience Australia

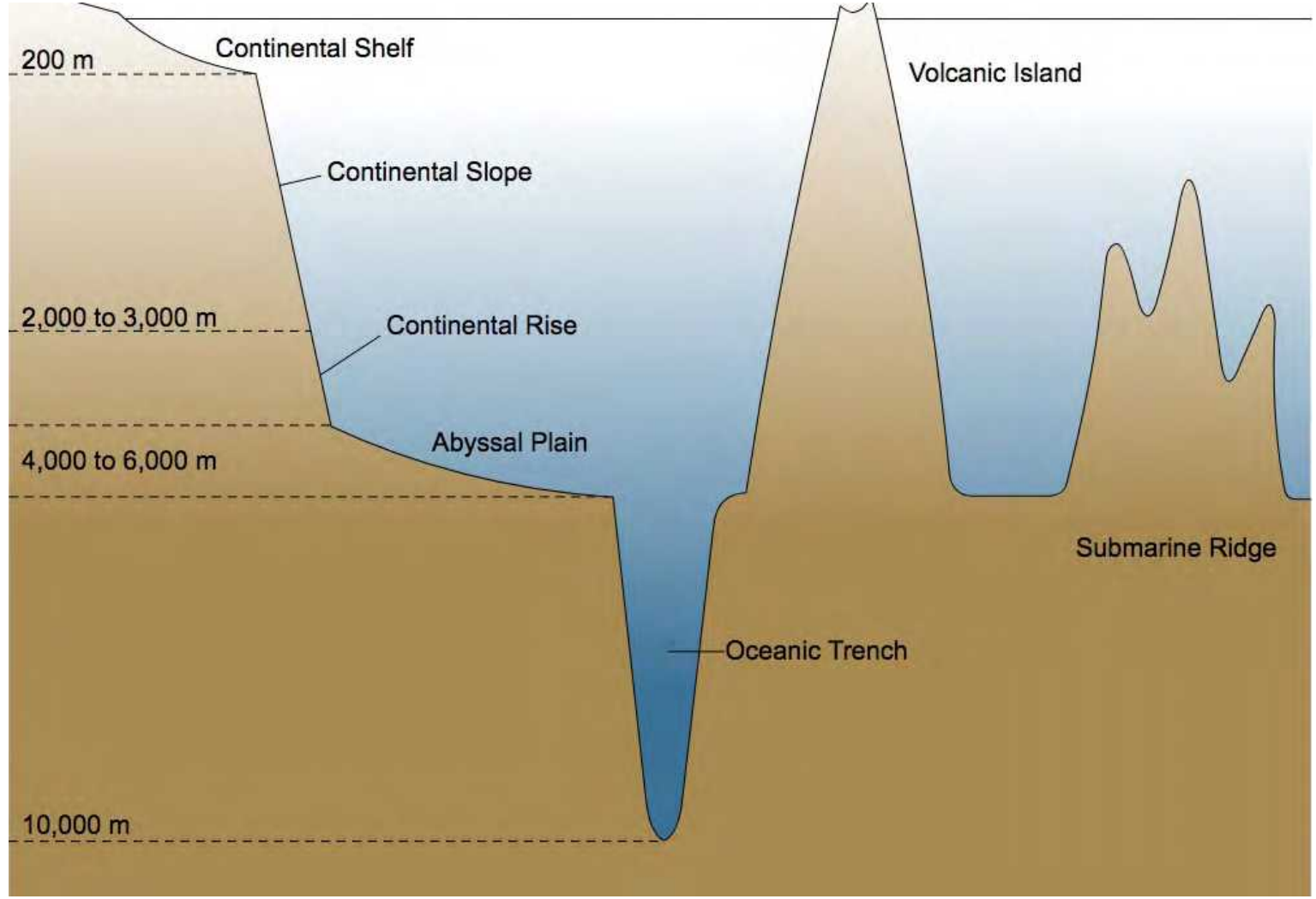
Major commercial fisheries for orange roughy occur south of Tasmania around seamounts



Orange roughy

Volcanic (high) islands

These are islands of volcanic origin



Oceanic divisions with high island

https://commons.wikimedia.org/wiki/File:Oceanic_basin.svg

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

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

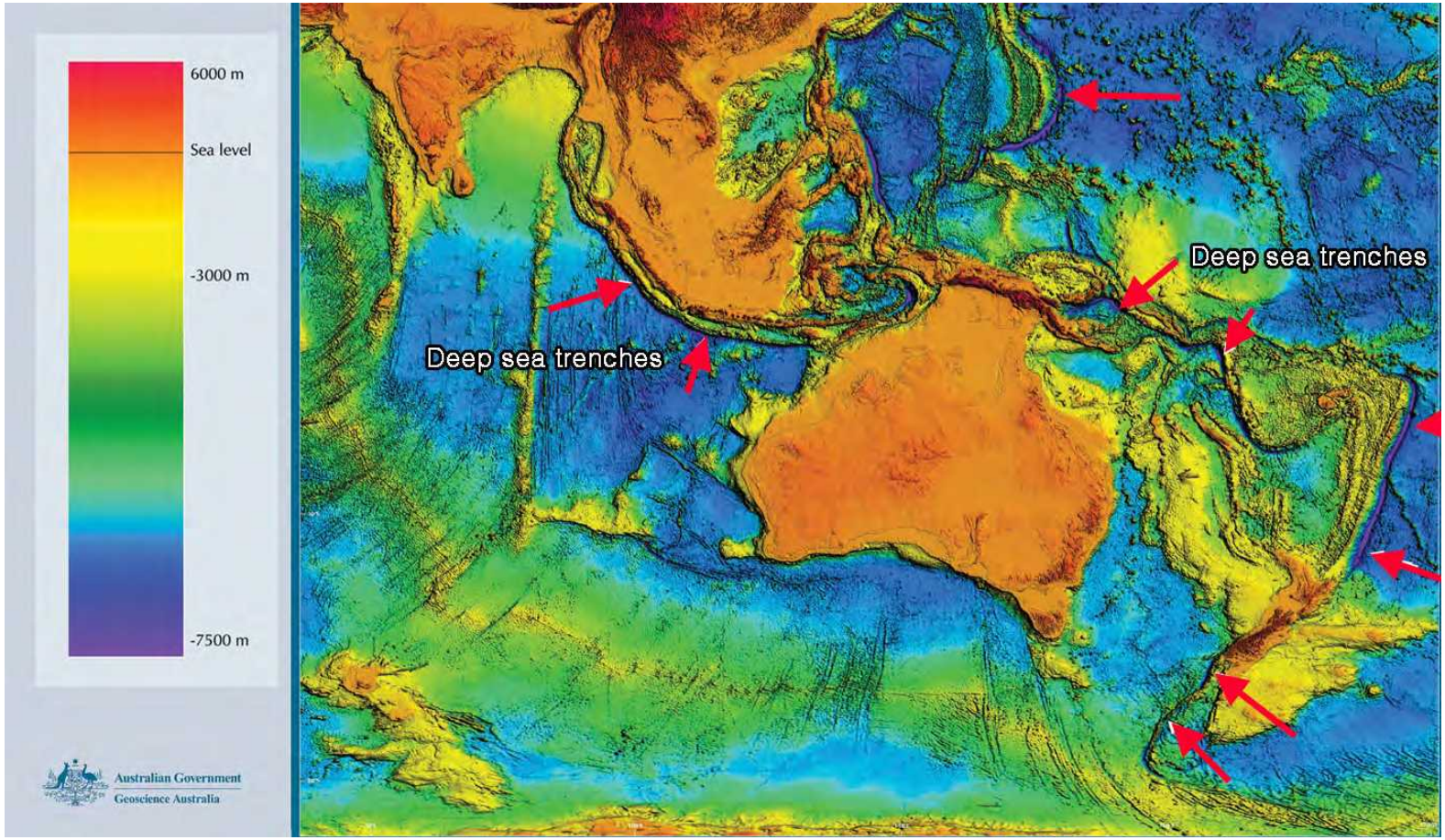
Balls Pyramid and Lord Howe Island

Image courtesy Lord Howe Museum

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

Deep sea trenches

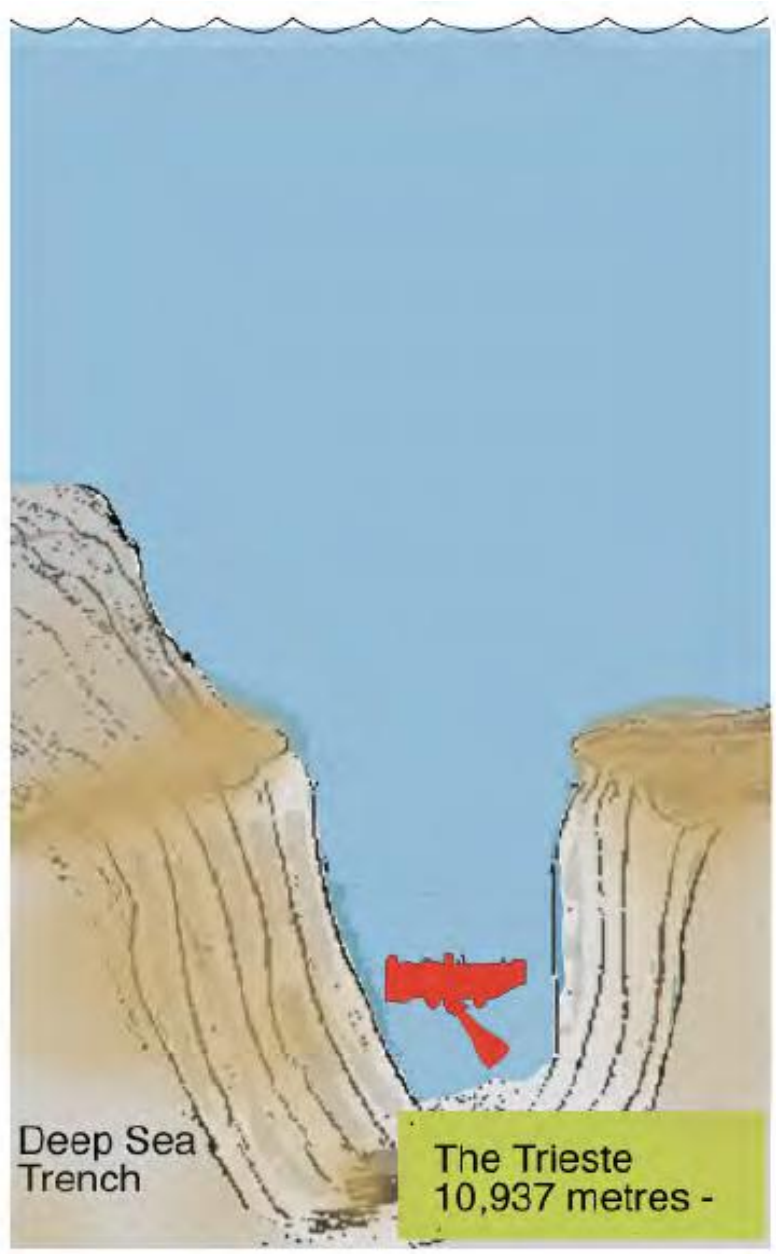
The continental slope in some places leads into deep V-shaped sea trenches.



Geoscience map with deep sea trenches

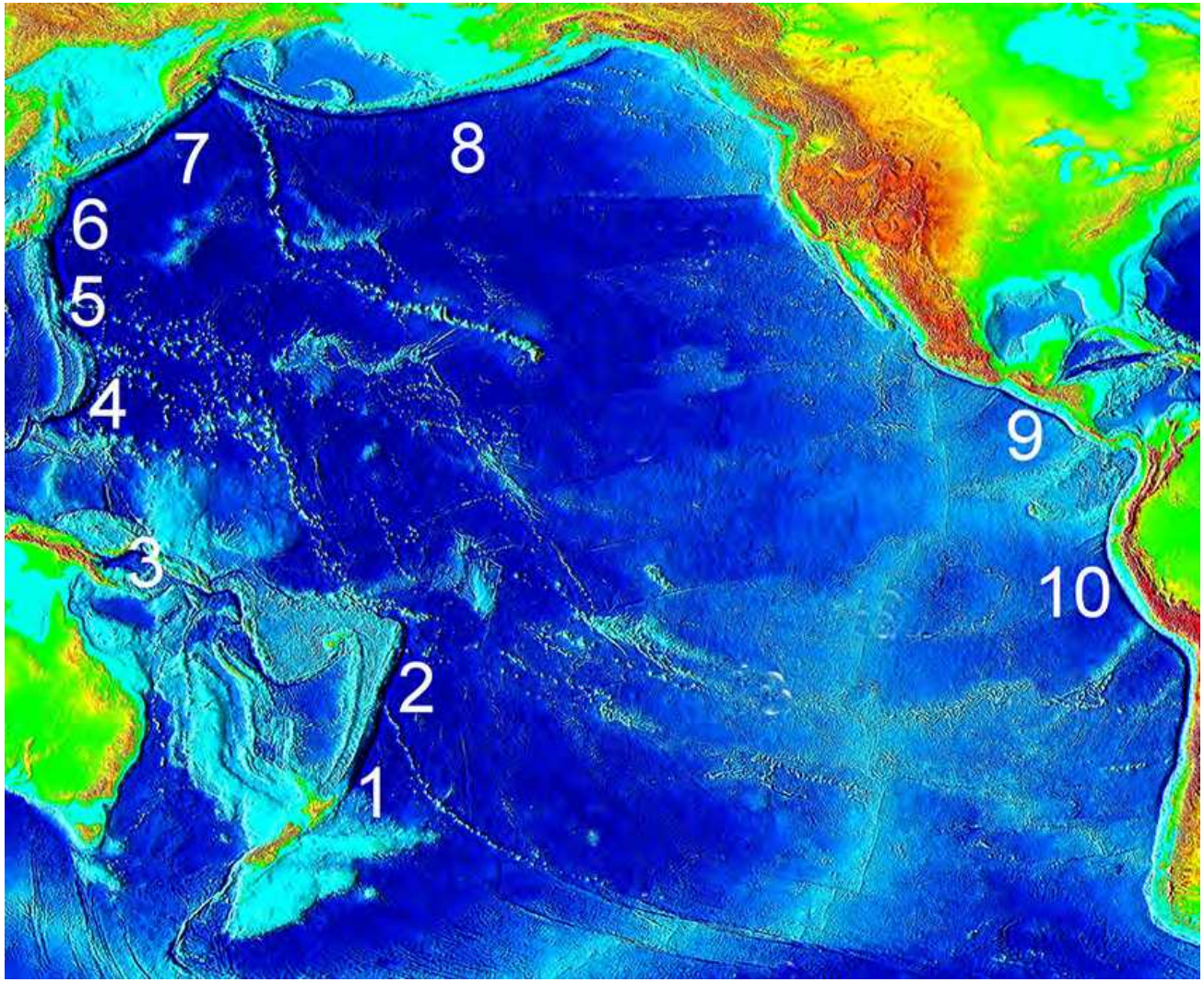
Illustration Geoscience Australia

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



Major Pacific trenches

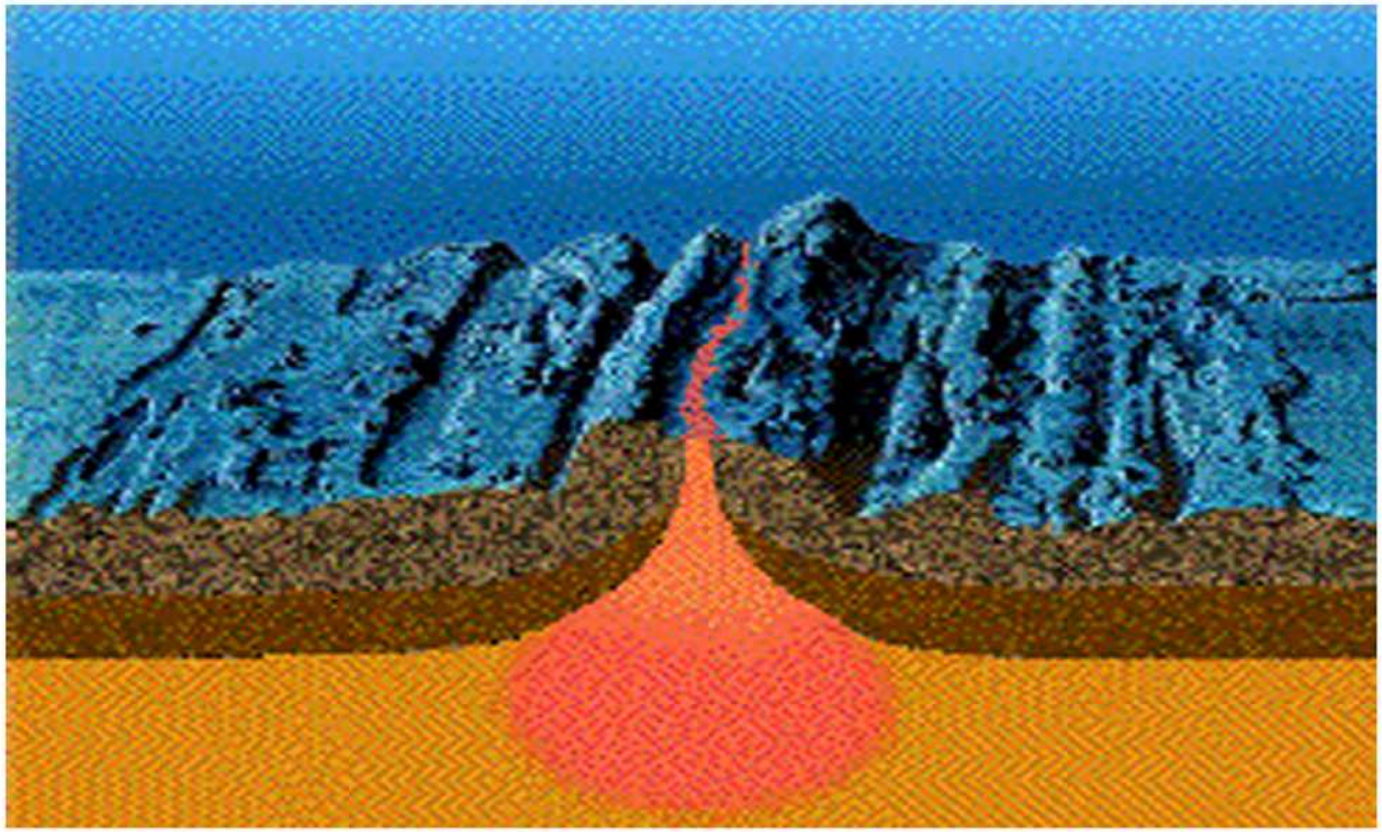
By Pacific_elevation.jpg: NOAAderivative work: Materialscientist (talk) - Pacific_elevation.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=17392152

Pacific trenches (a semi-loop)

1. Kermadec 2. Tonga 3. Bougainville 4. Mariana 5. Izu-Ogasawara 6. Japan 7. Kuril–Kamchatka 8. Aleutian 9. Middle America 10. Peru-Chile

Mid-ocean ridges

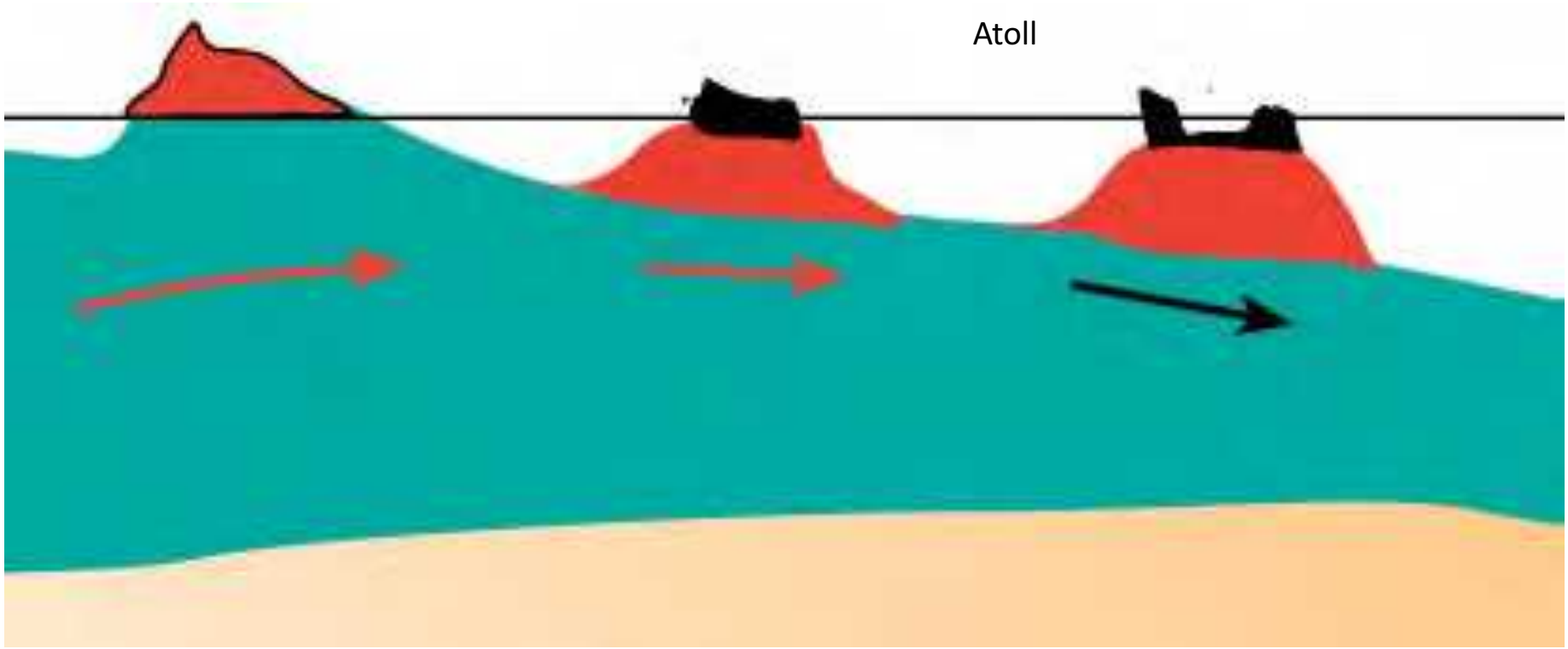
- occur in all the major oceans and make up 23% of the earth, surface
- are mountain chains up to 1,000 km wide in places and
- mostly occur in the middle of the oceans.



Mid ocean ridge

Atolls

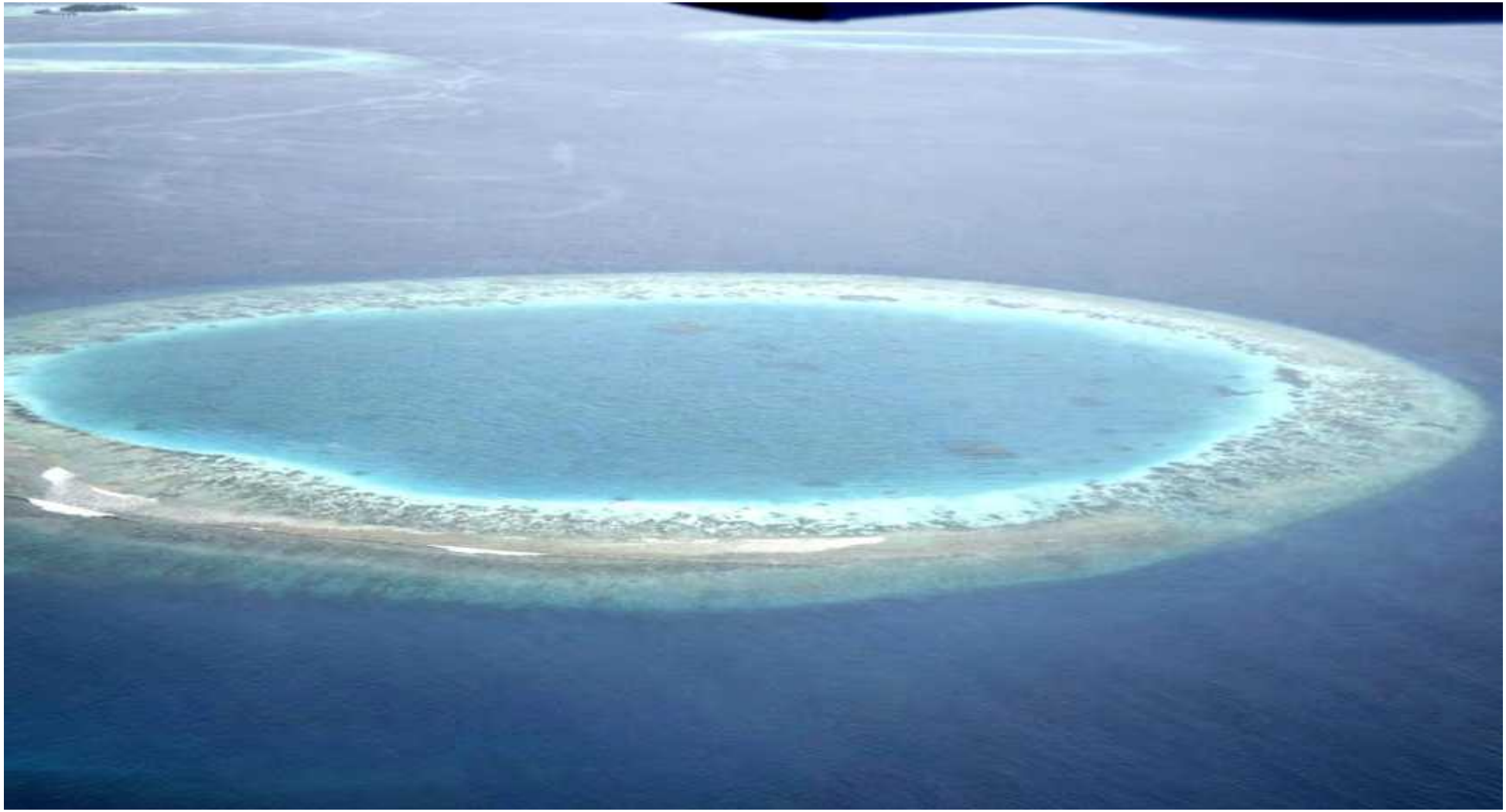
Atolls form when an extinct seamount or volcano has eroded or subsided partially beneath the water.



Atoll formation

Illustration Bob Moffatt

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
https://commons.wikimedia.org/wiki/File:Maldives_small_island.jpg

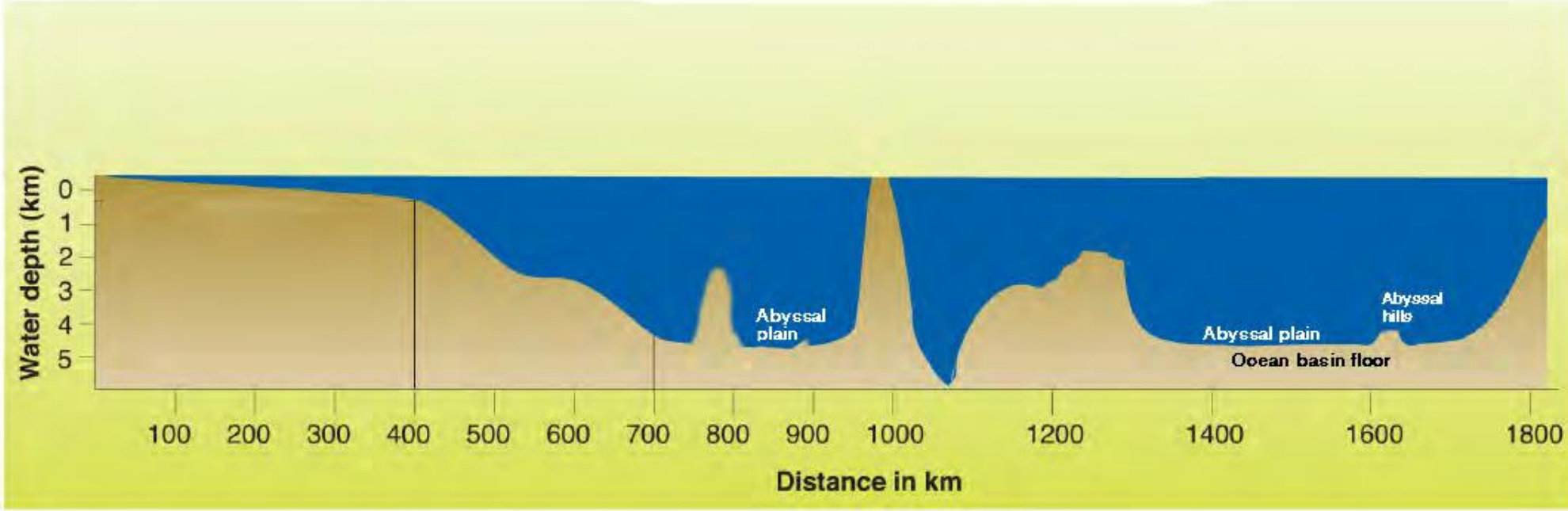
For the atoll to persist, continued erosion or subsidence must be at a rate slow enough to permit reef growth upwards and outwards to replace the lost height.

Atoll from space

By NASA/Johnson Space Center, Image Science & Analysis Laboratory [Public domain], via Wikimedia Commons https://en.wikipedia.org/wiki/Atoll#/media/File:Nukuoro_ISS013-E-28610.jpg

Ocean basin floor, including abyssal plain and hills

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

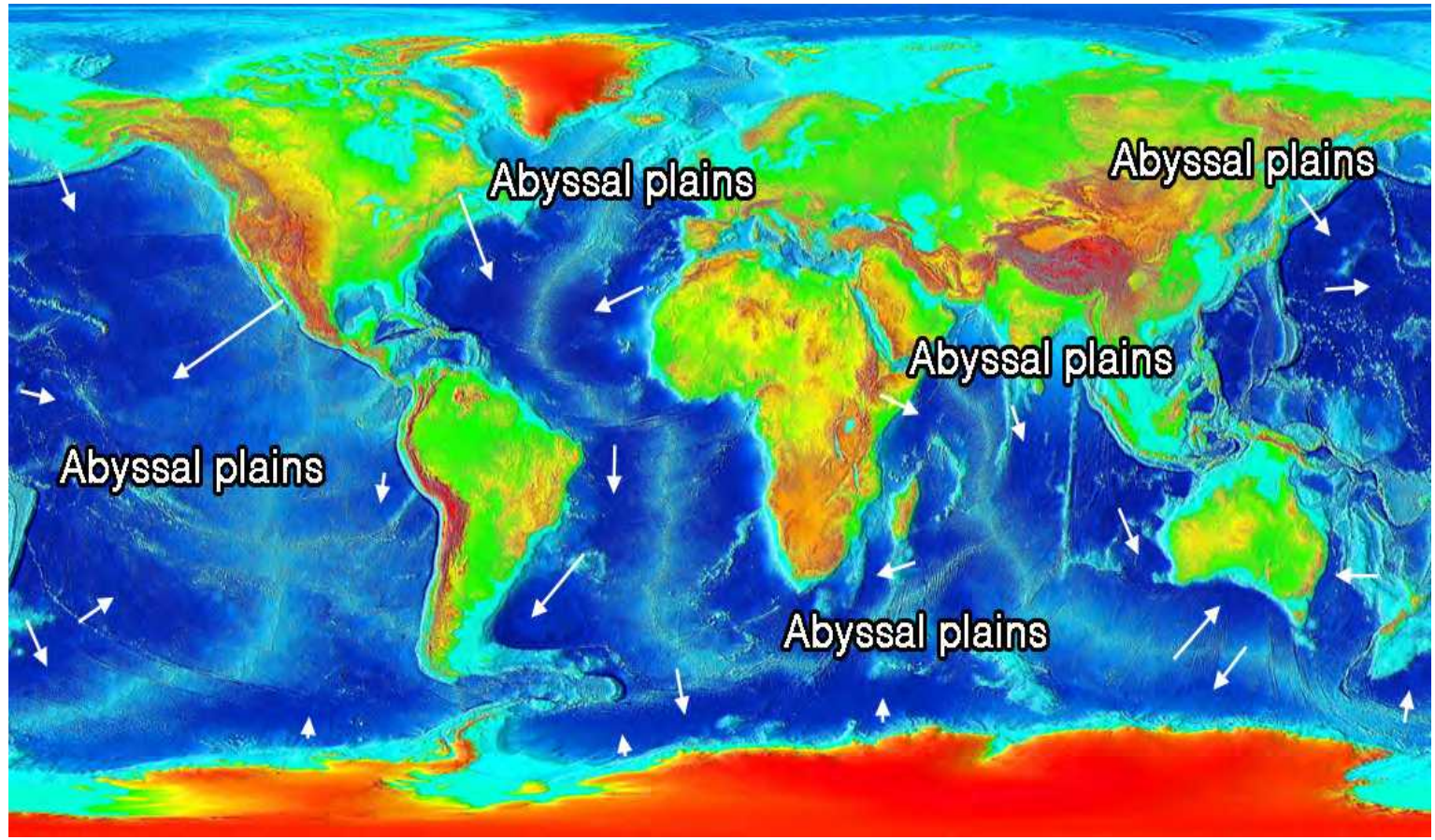


Abyssal plain and ocean basin floor

Illustration Bob Moffatt

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



Global continental shelf, highlighted in dark blue

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

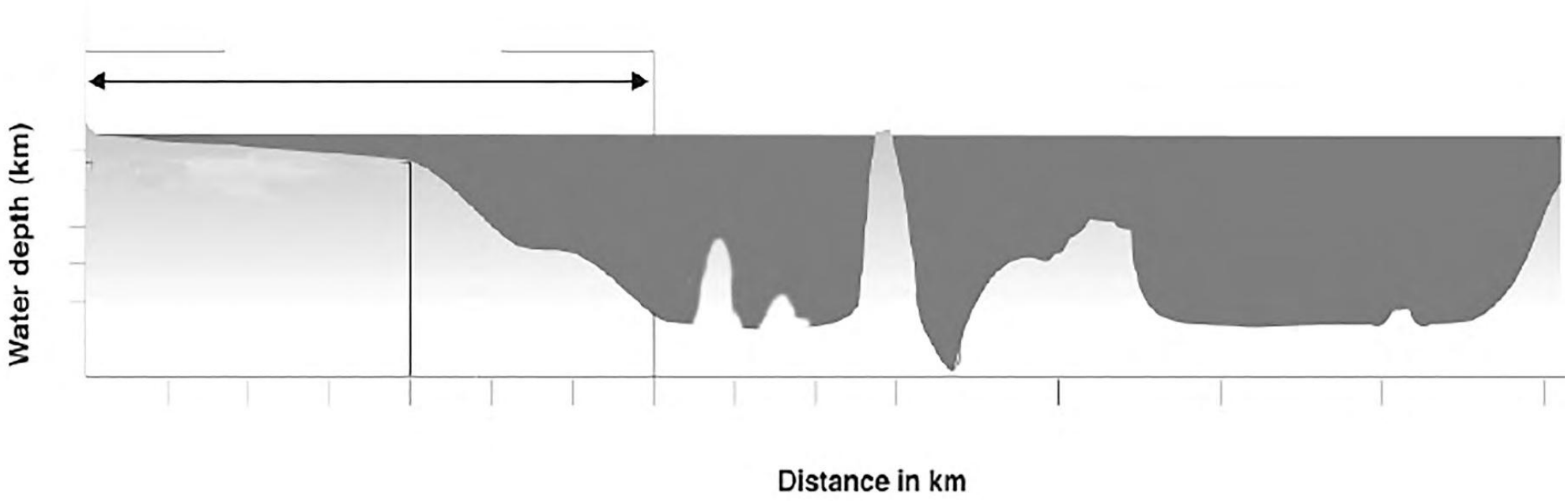
An abyssal hill is a small rise from the floor of an abyssal plain.

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

Abyssal plane NOOA

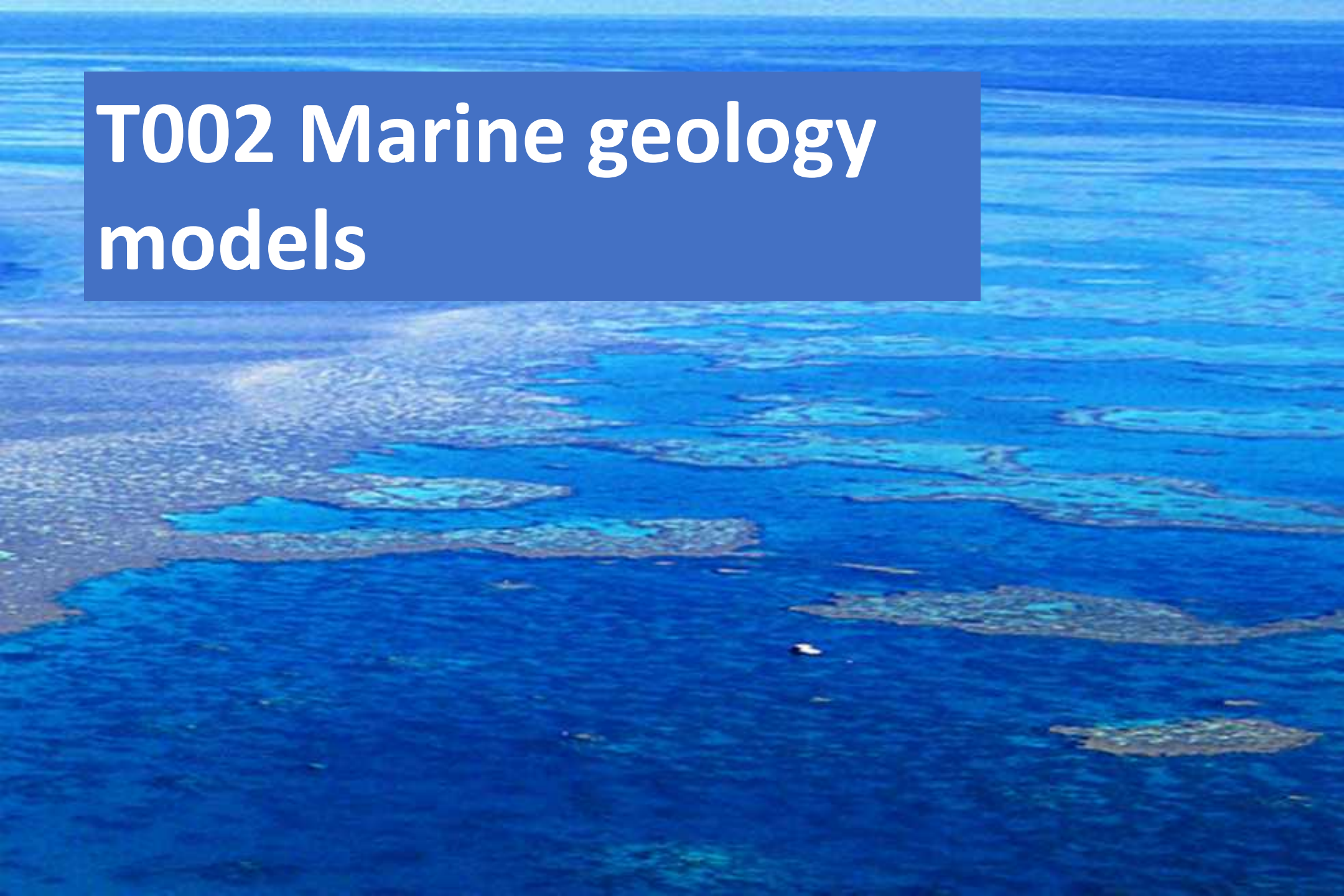
Image - National Oceanic and Atmospheric Administration

Draw 7 significant bathymetic features using the outline below.



Redraw this map to show Australian bathymetric features of the ocean floor, including the

- continental margin
- ocean-basin floor
- deep-sea trenches
- submarine canyons
- mid-ocean ridges and
- abyssal plain.



T002 Marine geology models

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

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

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

Objective 1

Use geological models to explain the following geological Earth's features including:

- Plate tectonic movement
- Continental drift
- Atoll formation
- Volcanoes
- Mountain building
- Earthquakes
- Island chains

Objective 2

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

- Ancient limestone reefs in the Northern Territory
- Great Dividing Range
- Queensland coal deposits and marine dinosaurs
- Fringing reefs, patch reefs and coral cays
- Coastline stratifications

Question 1

Complete the following tables to recall how models can be used to explain geological features. For example -

Table 1:

Earth's features	Model used to explain feature
Continental drift	Magma pushes up from deep inside the Earth forcing plates to move. Cut out of continentals also can show how you can put continents together.
Atoll formation	Oceanic plates move and gradually sink
Volcanoes	Plates subduct under others forcing magma to the surface
Mountain building	Subducting plates push mountains upwards
Earthquakes	Plates scrape past each other
Island chains	Undersea volcanoes make islands. As oceanic plates move new islands form.

Question 2

Apply this to the following Australian geological features . For example -

Table 2.

Australian feature	Model used to explain feature
Ancient NT limestone reefs	Australian plate pushed upwards forcing old reefs onto land
Great Dividing Range	Subducting plates broke off island arch forcing mountains upwards. New plate sub ducting near New Zealand.
Qld coal deposits and marine dinosaurs	Sea level and climate changes cause inland sea in Queensland. Then compression forming coal. Marine dinosaurs get trapped in swamps and preserved on to of coal deposits.
Fringing reefs, patch reefs and coral cays	Series of ice ages cause corals to grow to different depths
Coastline stratifications	Rocks on heads forms from volcanic action, then covered with sediments, then compressed and folded, eroded and finally exposed by wave action

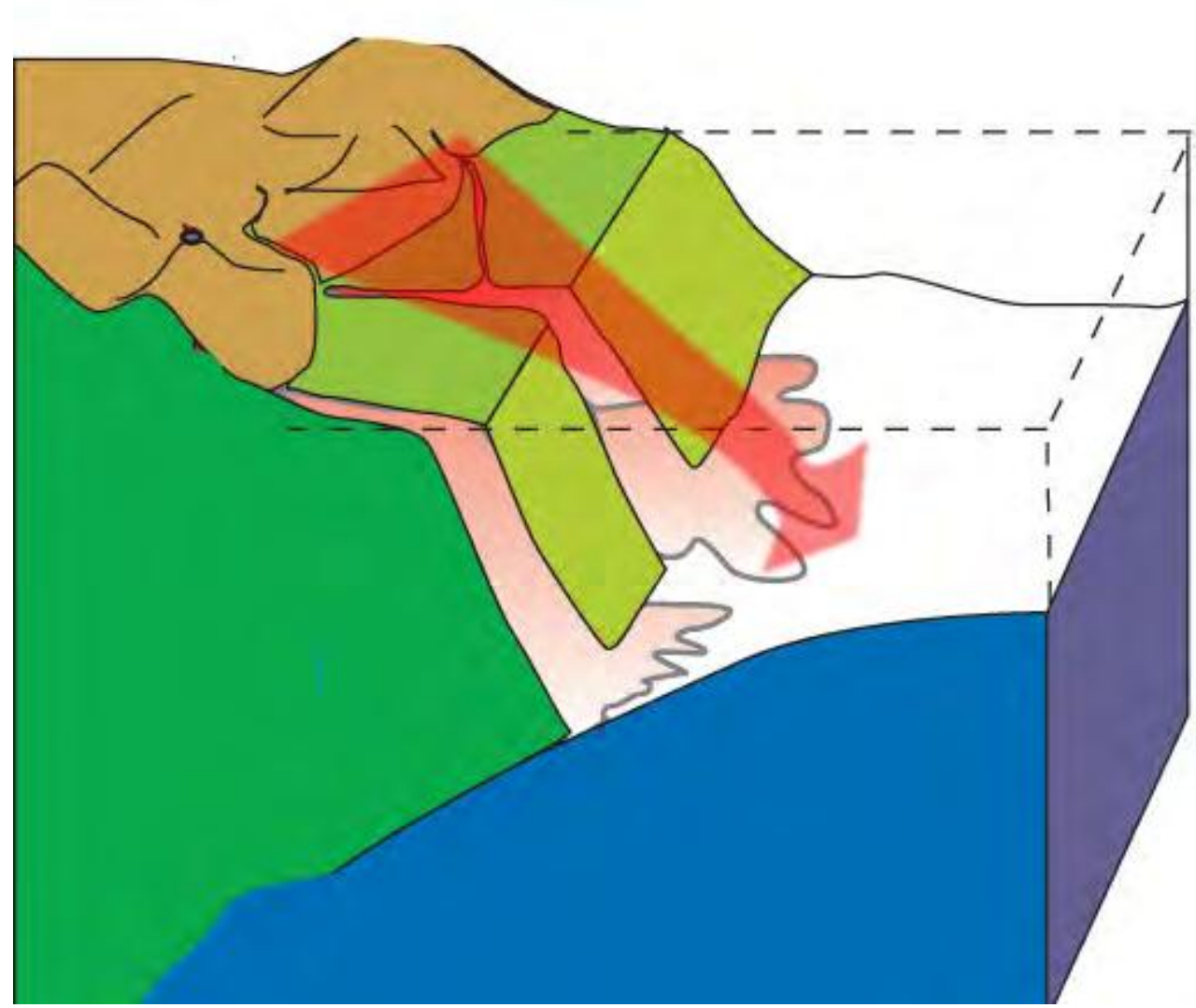
Definitions

Models explain observations and predict future observations.

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

Drawings

A drawing can show how sediments run off the land.

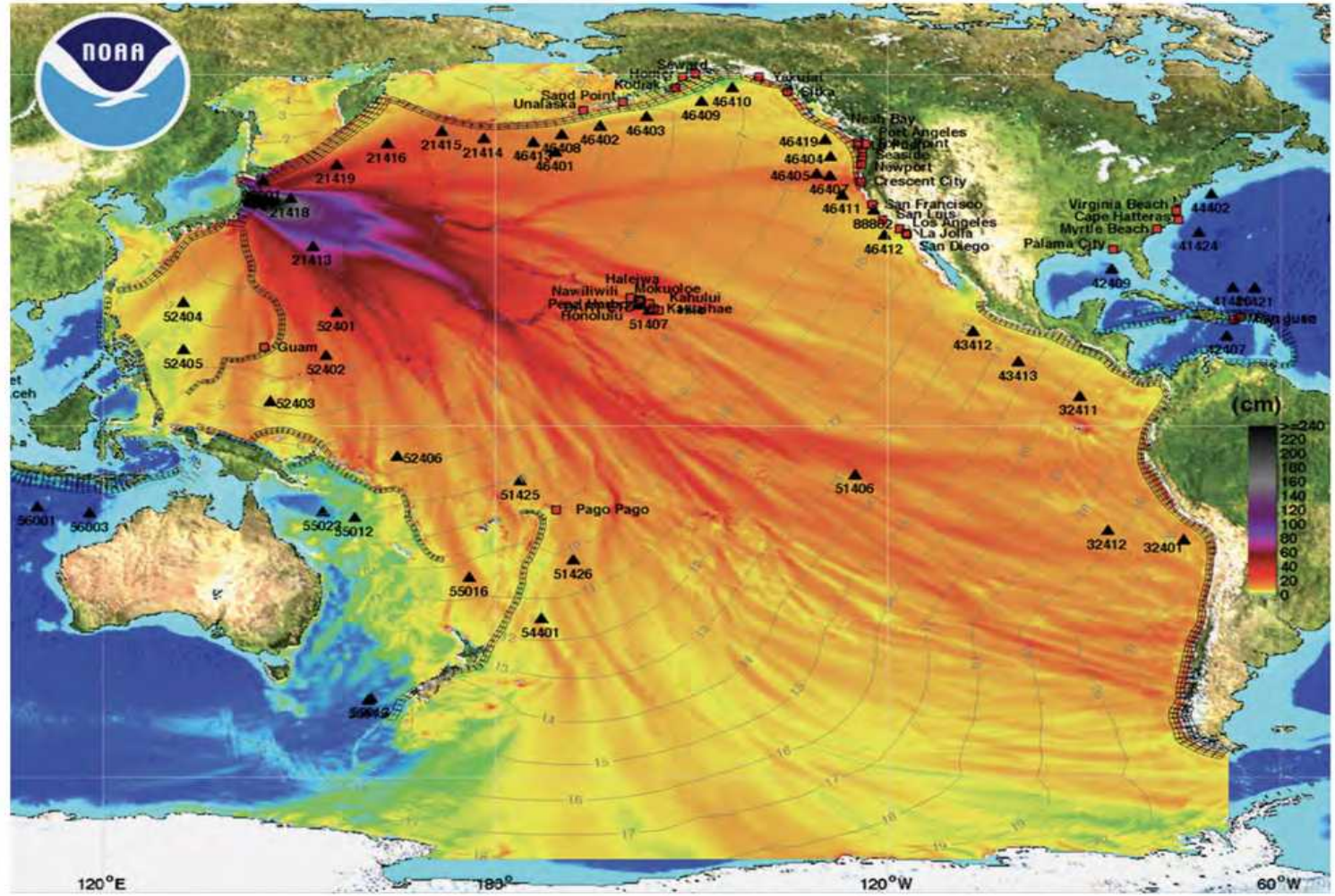


Model sediments run off land

Illustration Bob Moffatt

Maps

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

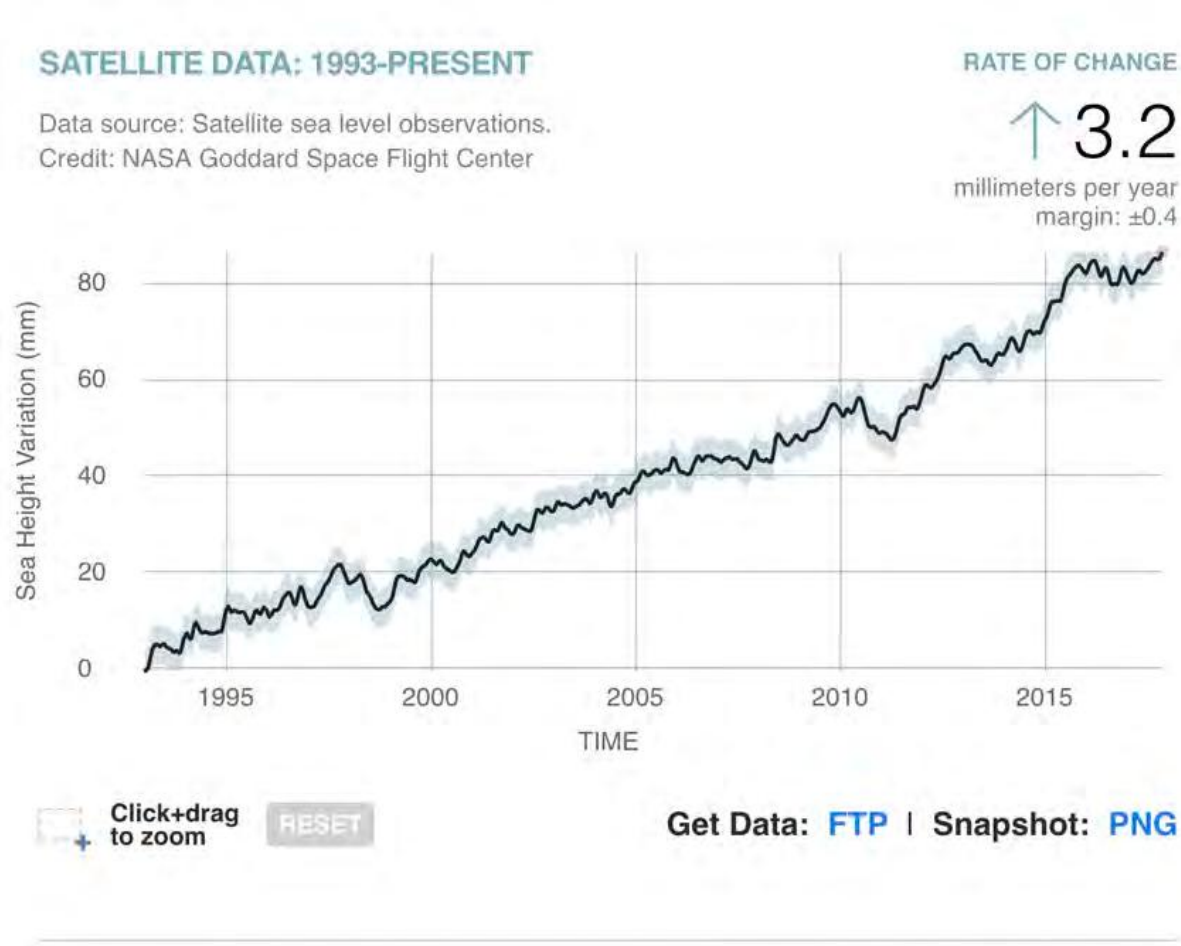


NOAA tsunami map Japan 2011

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.

Graphs

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



Graphs based on mathematical calculations

Source NASA

Three dimension al models

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

Model three-dimensional structure

Model by Bob Moffatt

Words

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 firstlv forming atolls and then seamounts.”

Equations

Equations can be used to model and predict wave speeds and heights.

Wave calculations

Worked example

Surfers at Bells Beach estimated the waves on that day to be 4 metres in height. They estimated that the time between the wave was 10 seconds or approximately 100 metres between each wave. Calculate the approximate wave speed of these waves. What is this speed in km/hr?

Working

V=L/t V= 100m/10s 1km=1000m

V=10m/s V= 10x60x60/1000

V=36km/hr ANS

QUESTIONS

1 If a surfer counts 50 waves washing onto the beach in 15 minutes, calculate:

   a. The wave period (time between waves in seconds).

   b. Wave frequency.

2. If a fisher counts 180 waves washing on the beach in 1 hour, calculate the wave's:

   a. Period

   b. Frequency

3. If waves in the sea have a length of 30 metres and a velocity of 28 m/sec, calculate the wave period.

4. A Tsunami that was caused by an undersea earthquake that occurred off the coast of North America reached Christmas Island in the Pacific Ocean in 6 hours. It was estimated it had travelled 5,000 km

   Calculate the speed at which the wave moved. Calculate the time it would have reached the Hawaiian Islands, which are located 2,000 km from the epicentre of the earthquake. Calculate how long it would be before the next wave hit the island if the wavelength was 300 km.

5. Why would larger waves overtake smaller waves at sea?

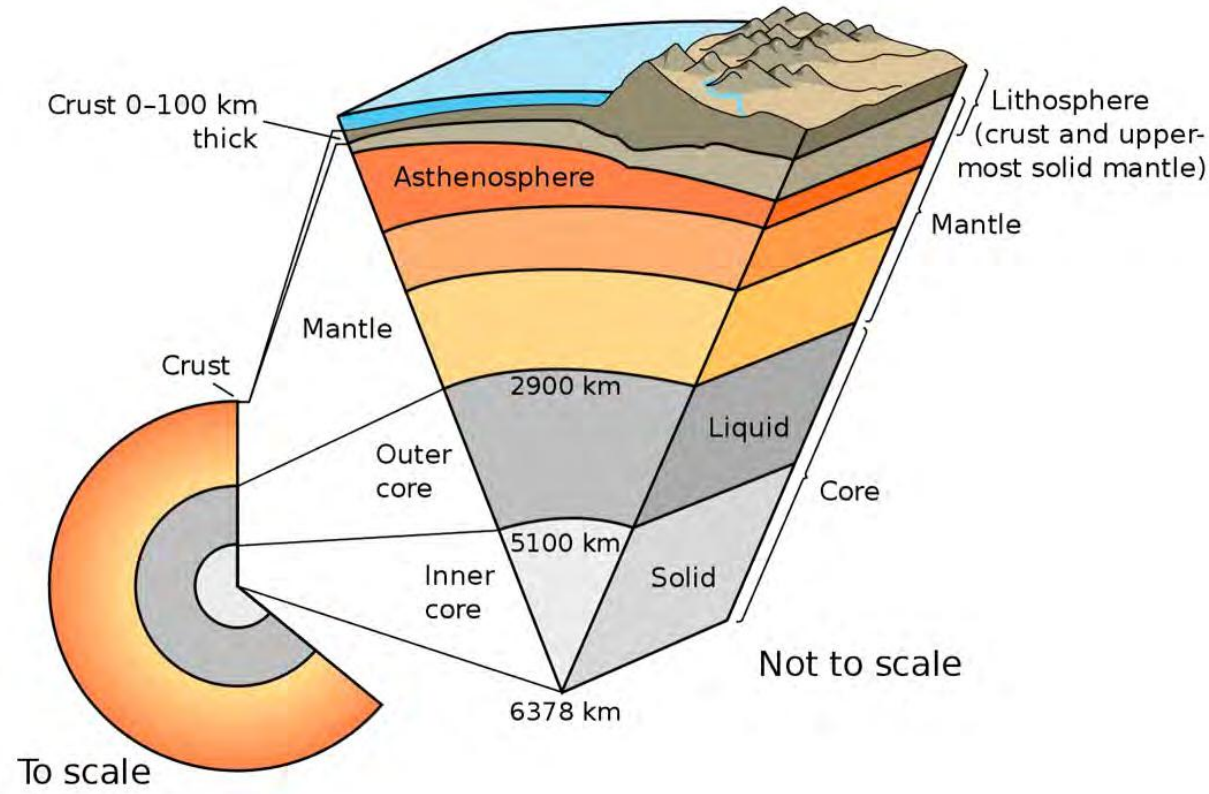
6. Who might be interested in these observations or calculations and why?

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

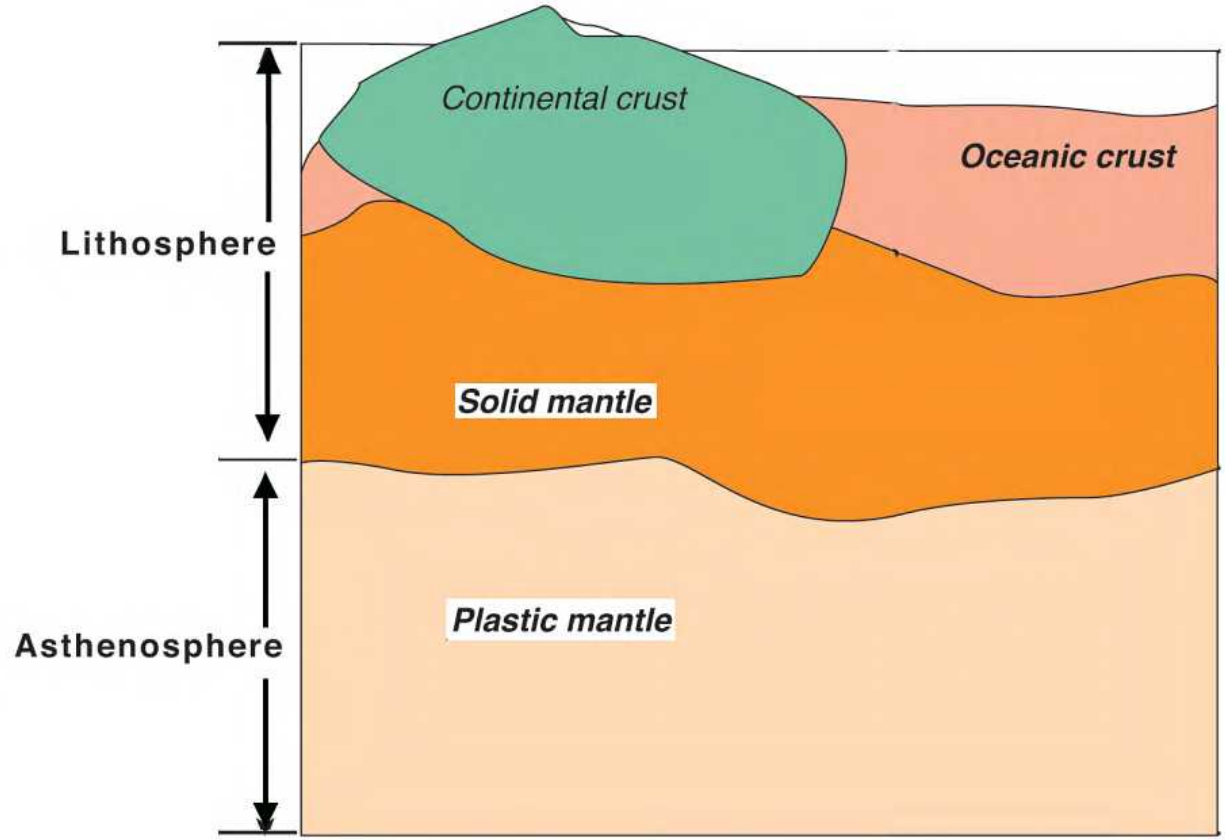
By derivative work: Anasofiapaixao Earth_internal_structure.png: USGS (Earth_internal_structure.png) [Public domain], via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Earth-cutaway-schematic-english.svg

The crust and mantle are divided into two spheres:

- Lithosphere and
- Asthenosphere.

The lithosphere consists of:

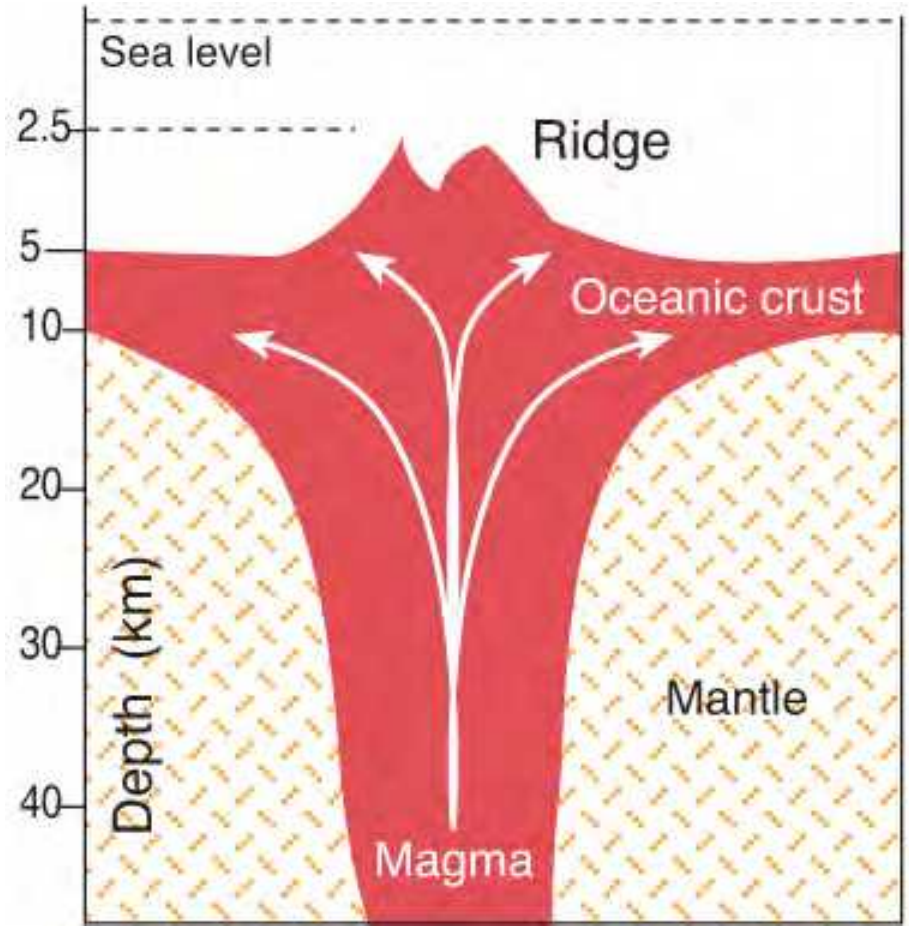
Continental crust
Oceanic crust and
Solid mantle.



Lithosphere and asthenosphere A
Illustration Bob Moffatt

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.



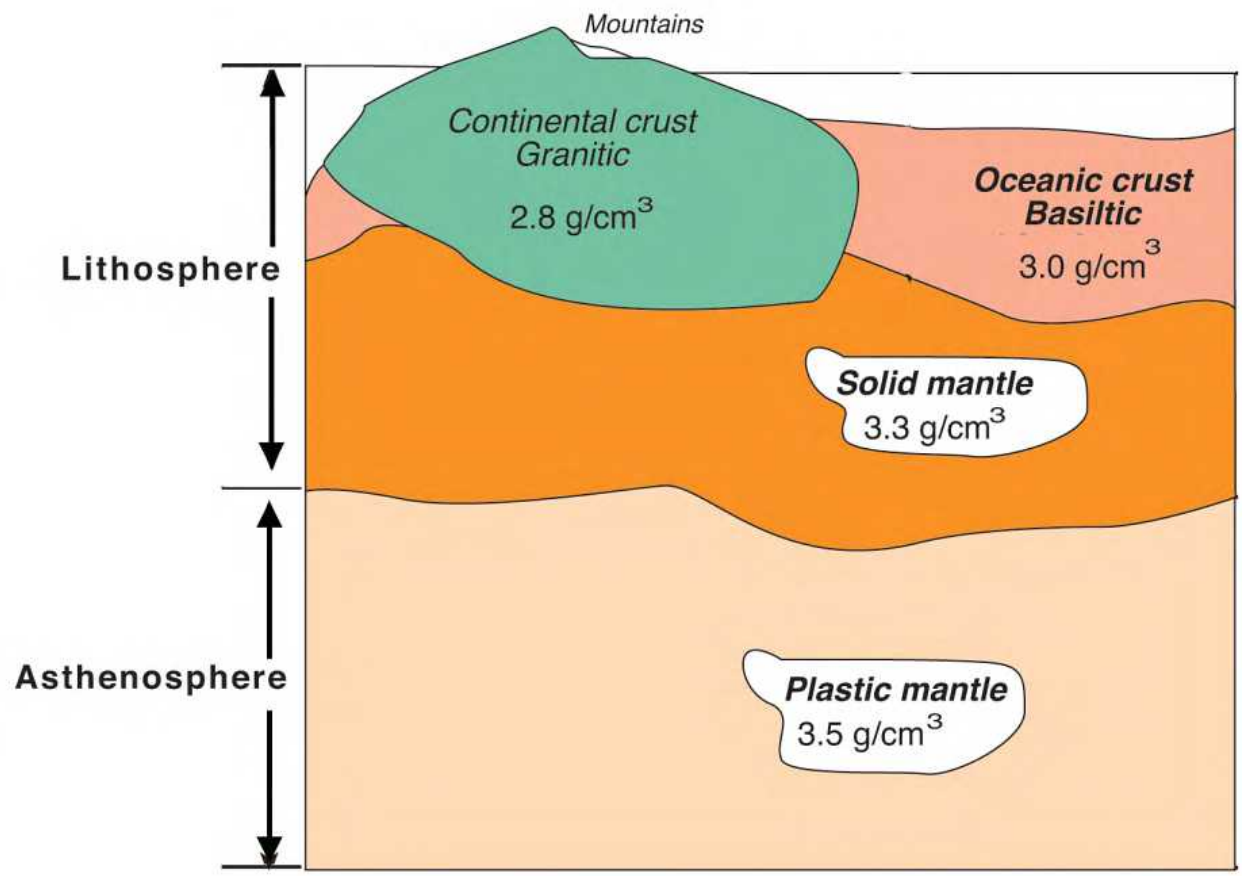
Magma rising through mantle

Illustration Bob Moffatt

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.

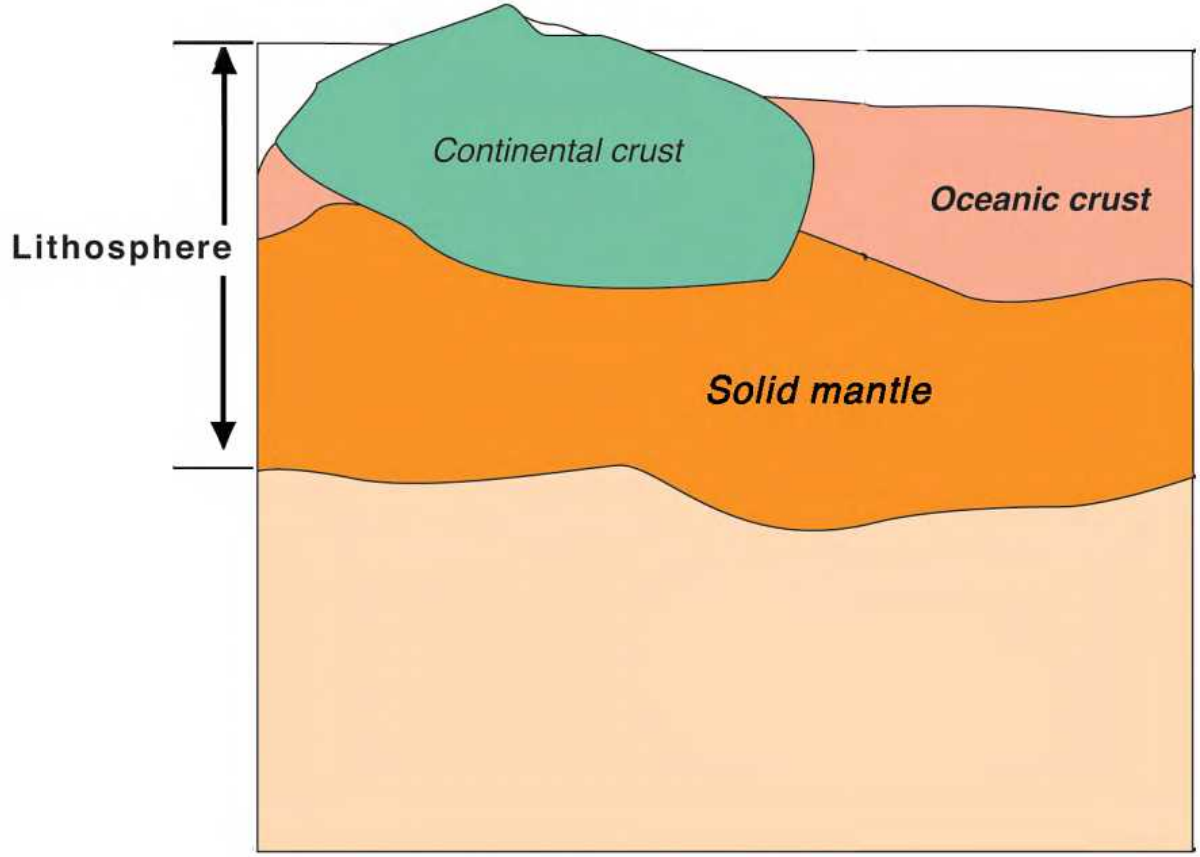


Lithosphere and asthenosphere

Illustration Bob Moffatt

The lithoshpere is above the asthenoshpere.

It has continental crust, oceanic crust and solid mantle.

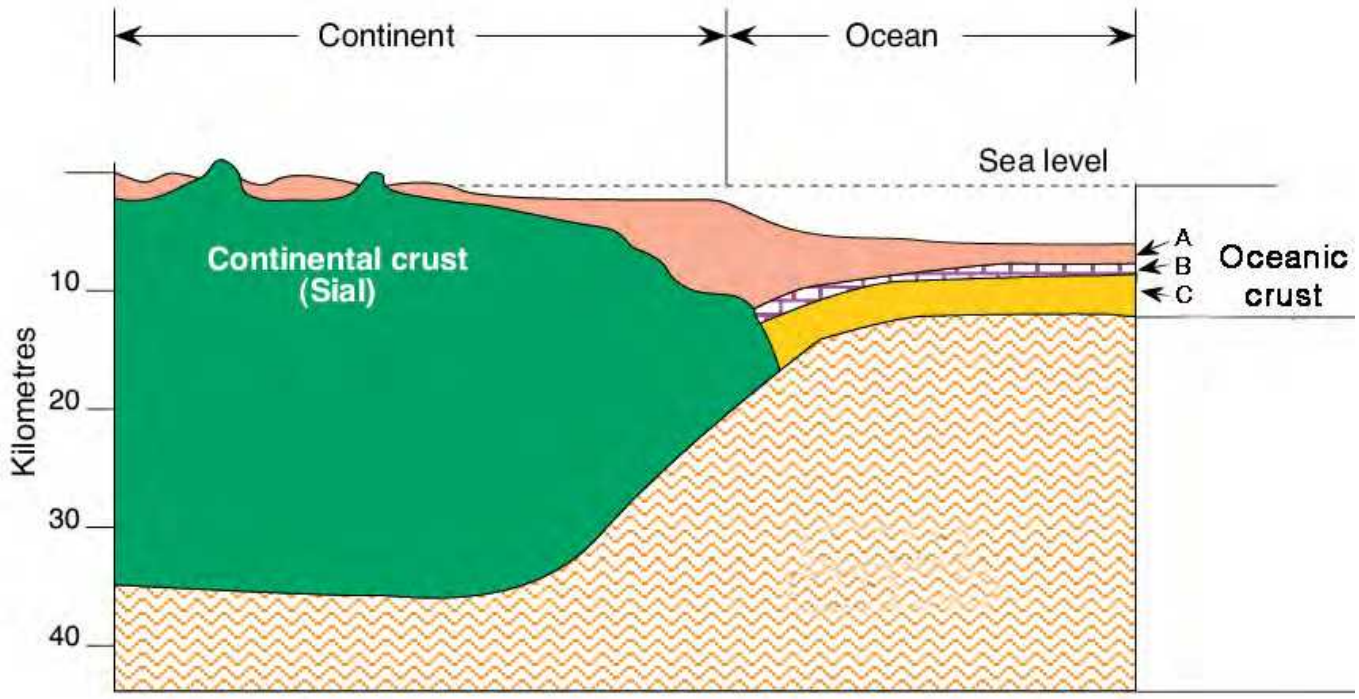


Lithosphere

Illustration Bob Moffatt

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

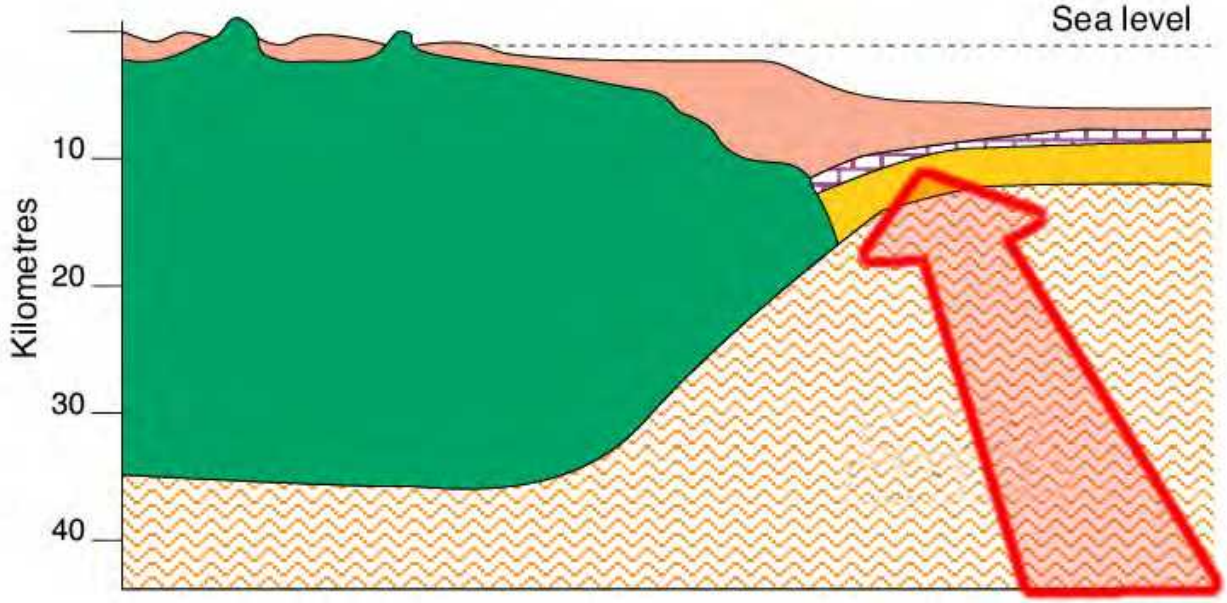
Oceanic crust is composed of high density basaltic rock and has three layers which are
- made of sediment eroded from the land.
- mixed with lava and sediment.
- made up of basalt.



Oceanic crust has three layers A, B and C

Illustration Bob Moffatt

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



Oceanic crust showing movement
Illustration Bob Moffatt

We can see folding and fracturing if we look closely at the coastal landscape of Australia.

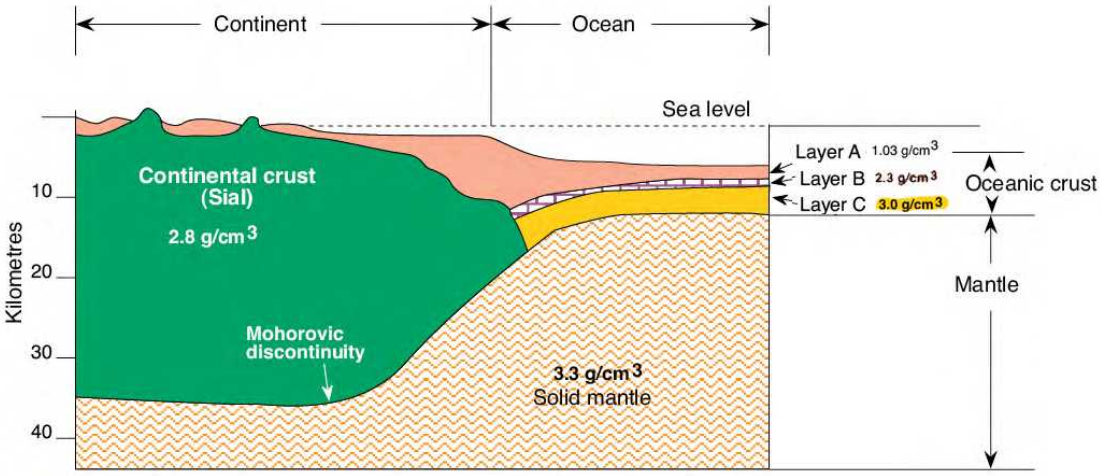
Nares Point Kimberley folding and fracturing

Photo Ian Morris

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

A diagram is used to explain the feature.

Here is the model



Here is the model applied

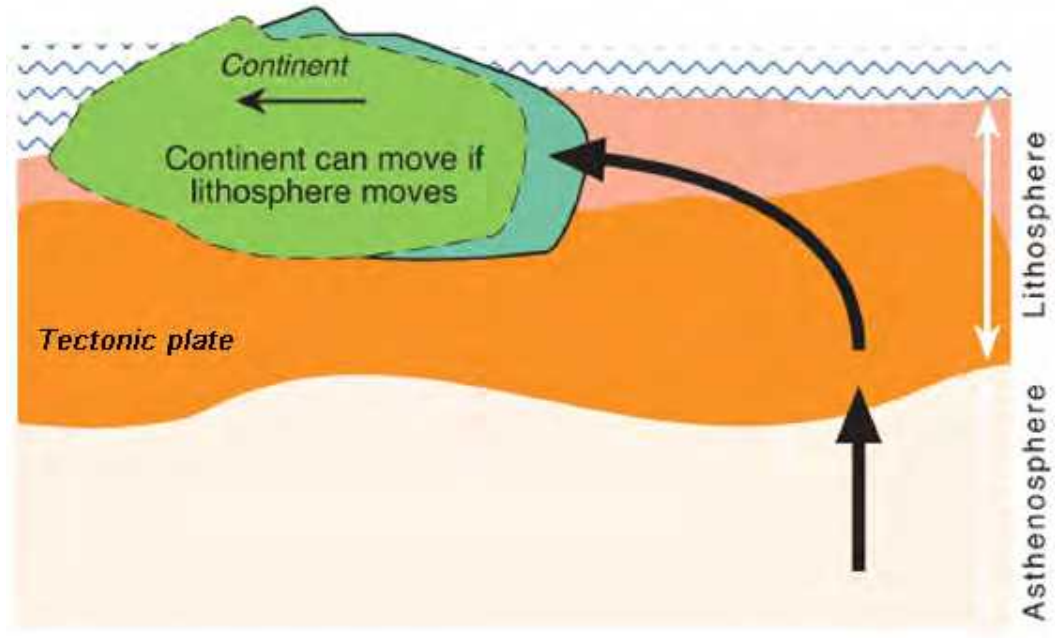
Model application to mantle folding

Illustration Bob Moffatt Photo Ian Morris

Continental drift and plate tectonics

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

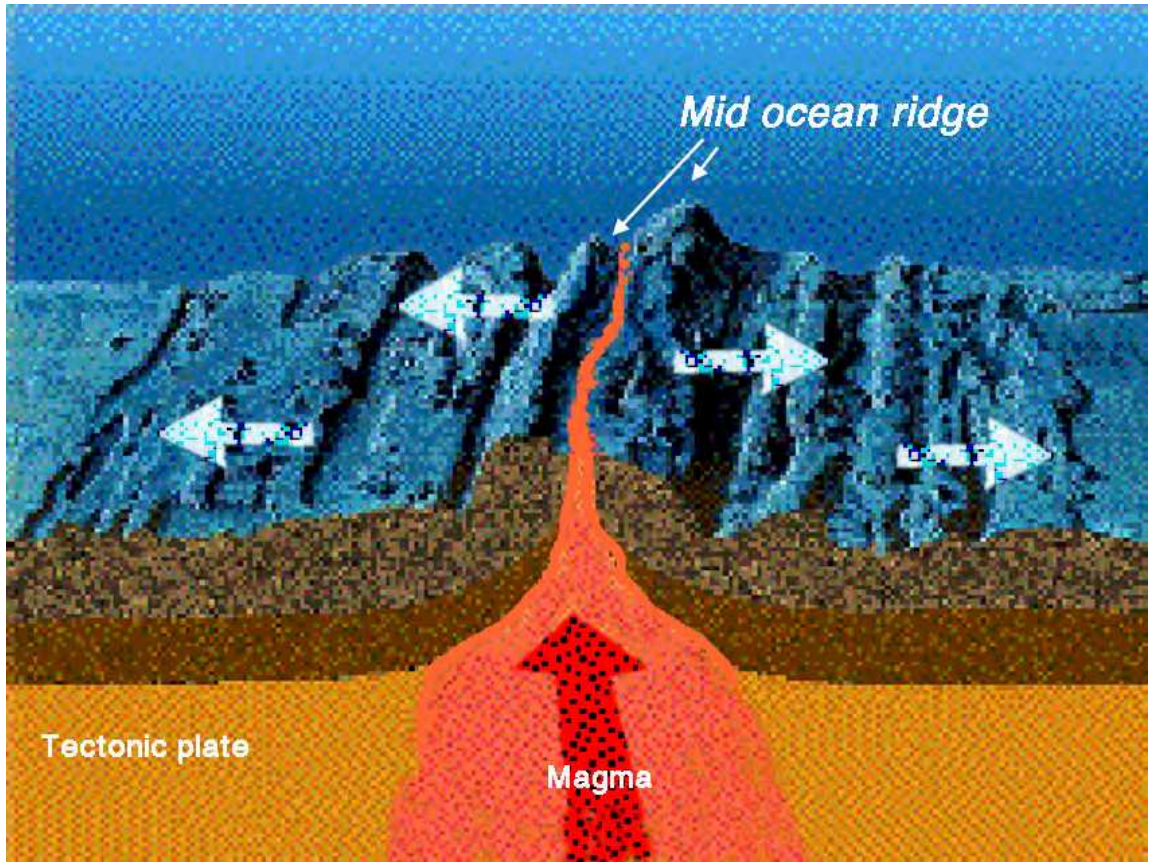
These parts are called tectonic plates.



Continents can move on tectonic plates

Illustration Bob Moffatt

Forces generated by rising magma causes these plates to move (divergent), and can result in a mid-ocean ridge forming.



Mid ocean ridge

By USGS [Public domain], via Wikimedia Commons

This can be shown in an experiment with rice crackers and golden syrup.

Brad Lawrence

Golden syrup and biscuit tectonics experiment

Video by Brad Lawrence

Apparatus:

- large tin of Golden Syrup
- large beaker, 5 dm^3
- packet of thin biscuits
- Bunsen burner, tripod and heatproof mat
- access to a freezer

Pour the syrup into the beaker and leave in the freezer for 1 hour. Do not allow it to freeze, simply reduce the temperature to gain maximum viscosity.

Break a biscuit in half carefully and place the two halves, touching, on the surface of the syrup. The biscuit halves need room to move apart, so ensure that the two halves are not too big (nibble pieces off the edges if necessary).

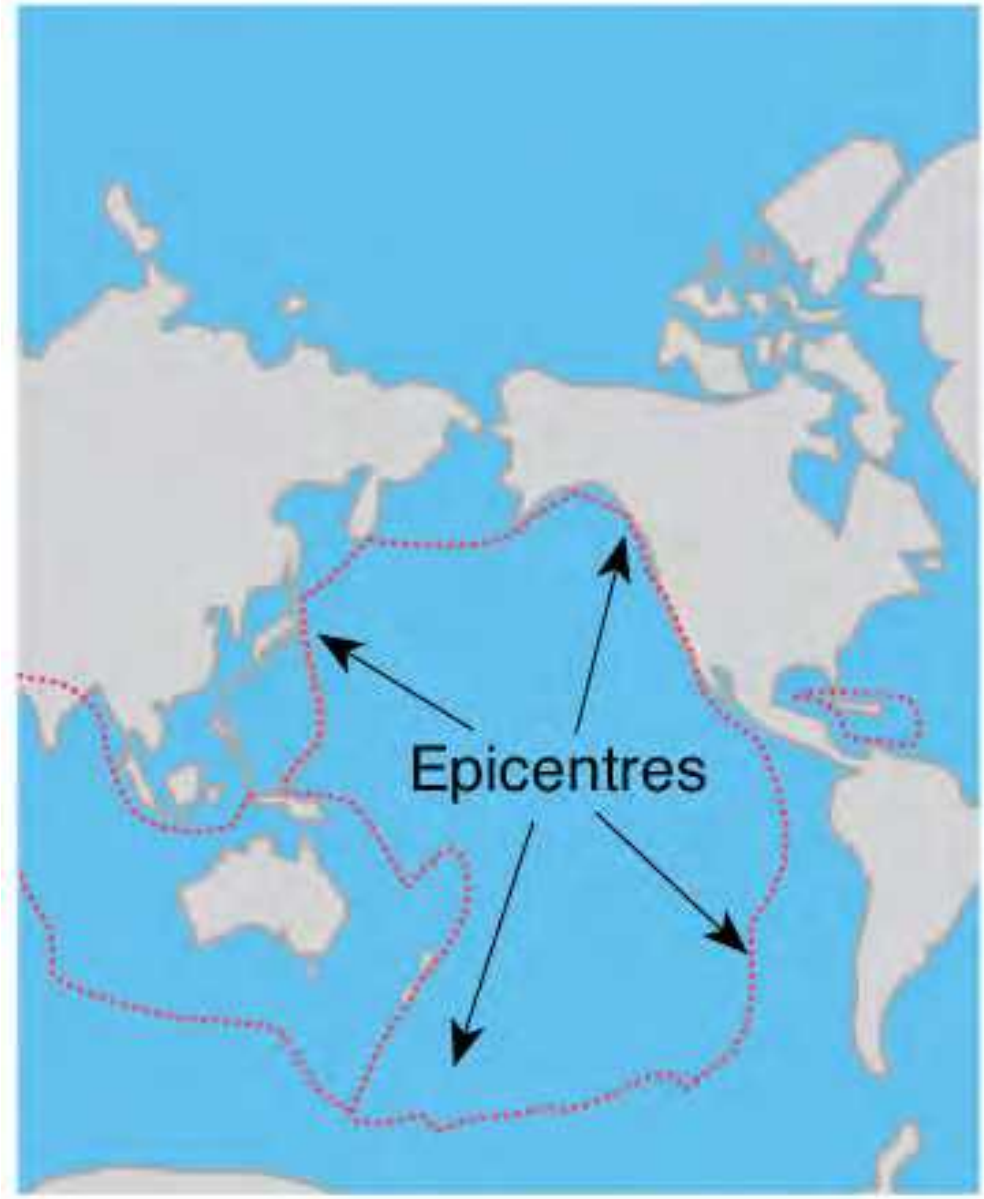
Place the beaker and contents on a tripod without a gauze in place to ensure localised heating.

Heat the beaker using a low blue flame directed at the centre of the beaker's base. Slowly the central cone section of the syrup will change in colour as its temperature rises and its viscosity falls.

Reference

http://www.rsc.org/Education/Teachers/Resources/jesei/mantle/teachers.pdf

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



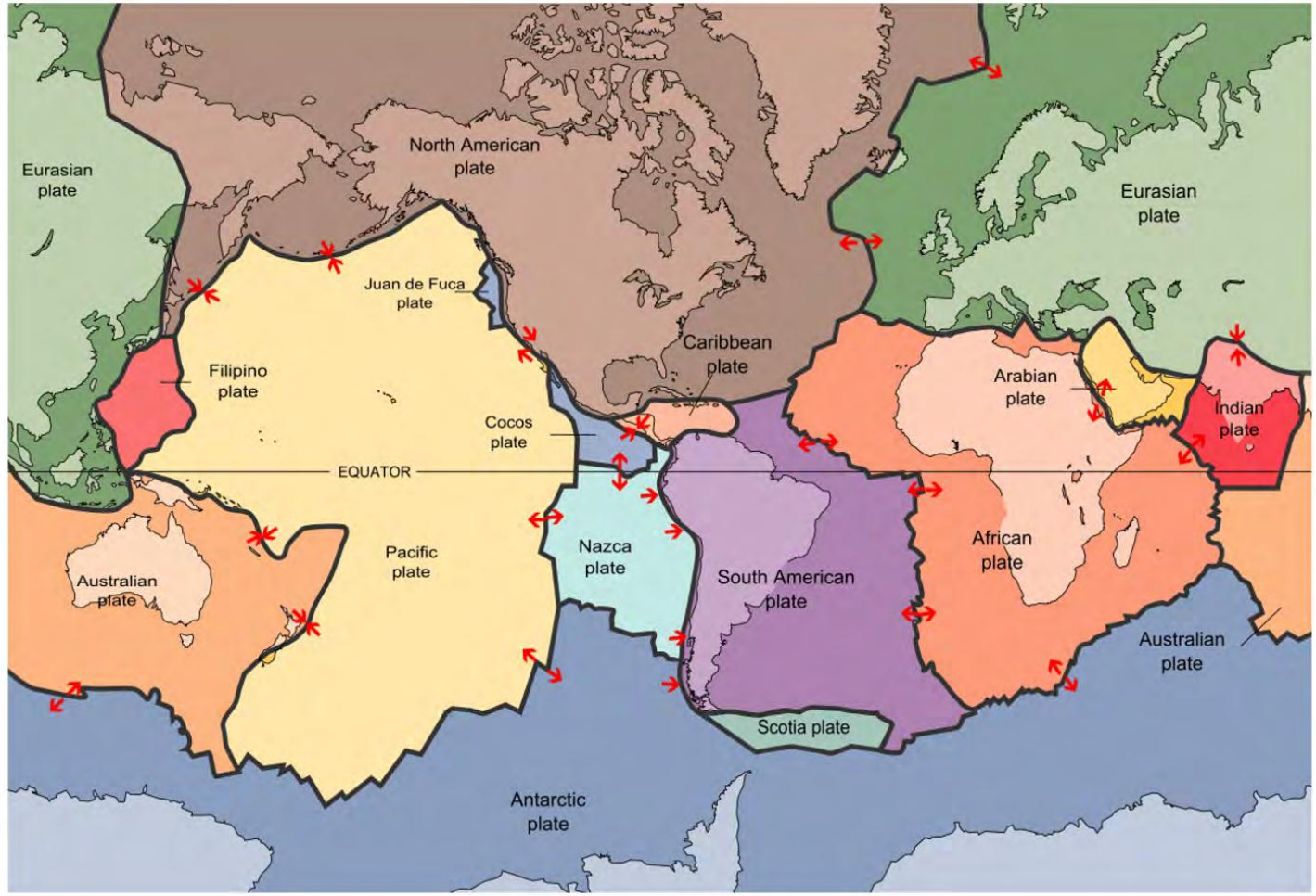
Pacific Ocean earthquake records

Illustration Bob Moffatt

“This leads scientists to conclude that where the earthquake epicentres occur, these are the edges of tectonic plates.”

Words are used to describe the feature.

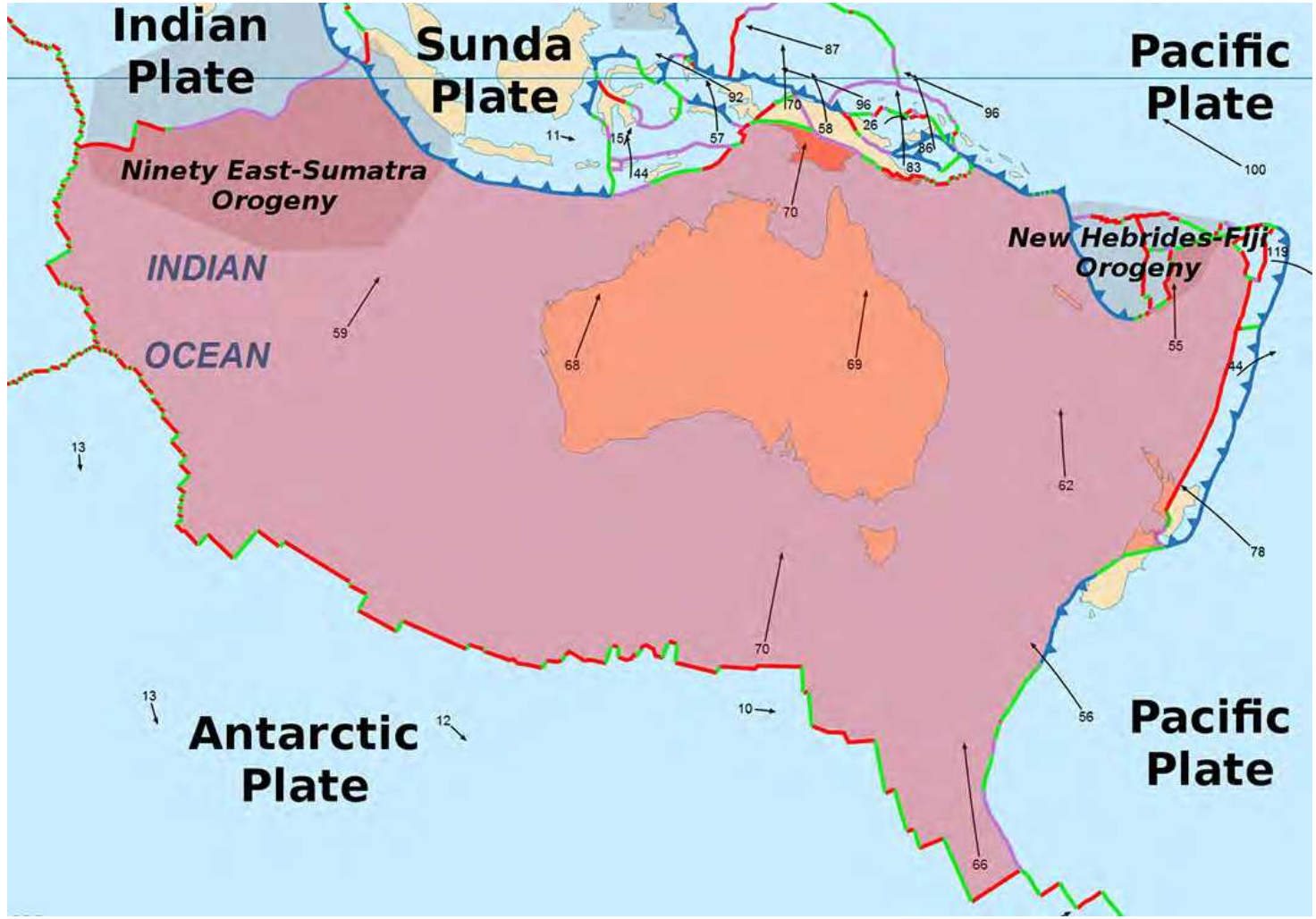
The major plates of the Earth can be summarized in a diagram.



Earth tectonic plates

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

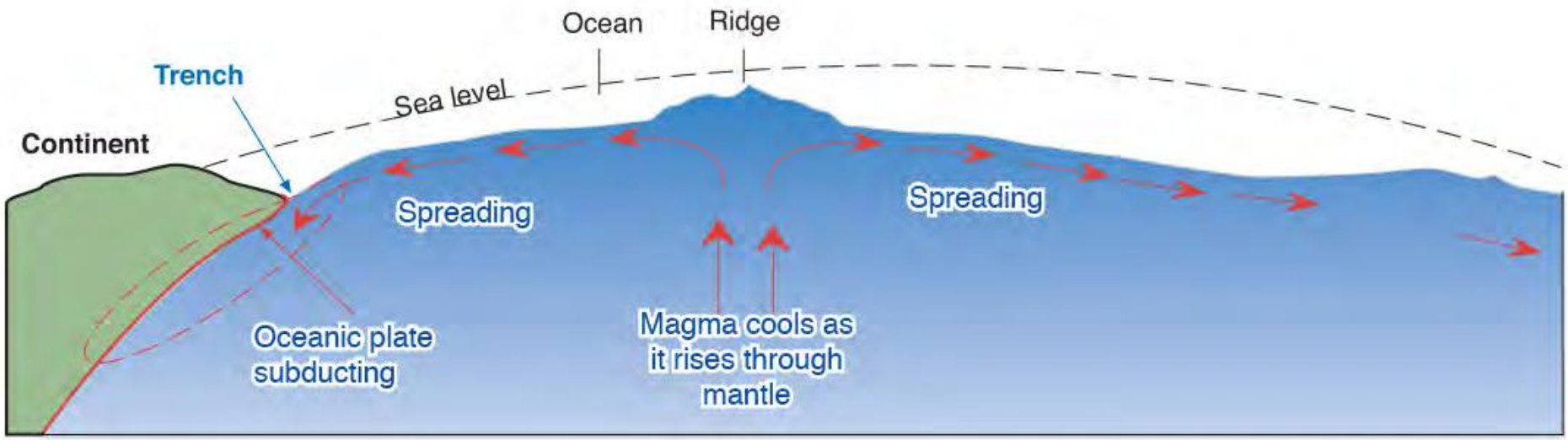
The Australian plate is moving north at a rate of 62–70 mm per year or the rate at which your fingernail grows.



Australian plate movement and direction

Places where earthquakes occur can be related to deep ocean trenches and are described as places where two plates collide (convergent) and the most dense plate slides under the other (subduction).

Places where magma rises and forces the plates to separate are called mid-ocean ridges.

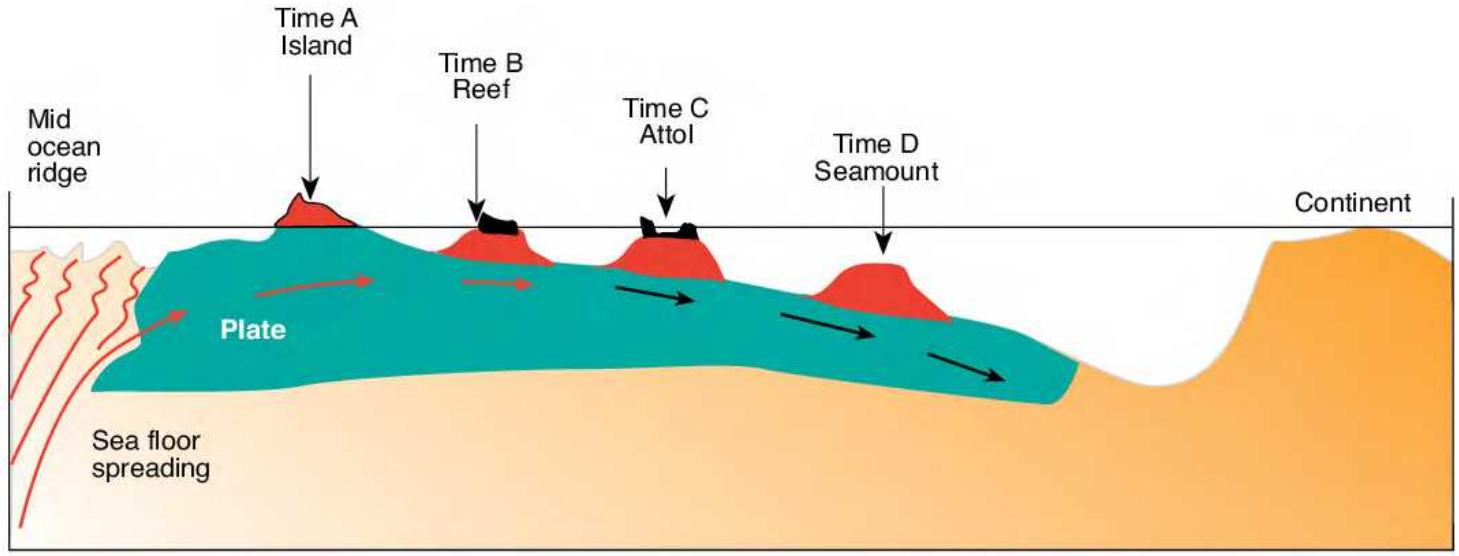


Ocean plate movements

Illustration Bob Moffatt

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

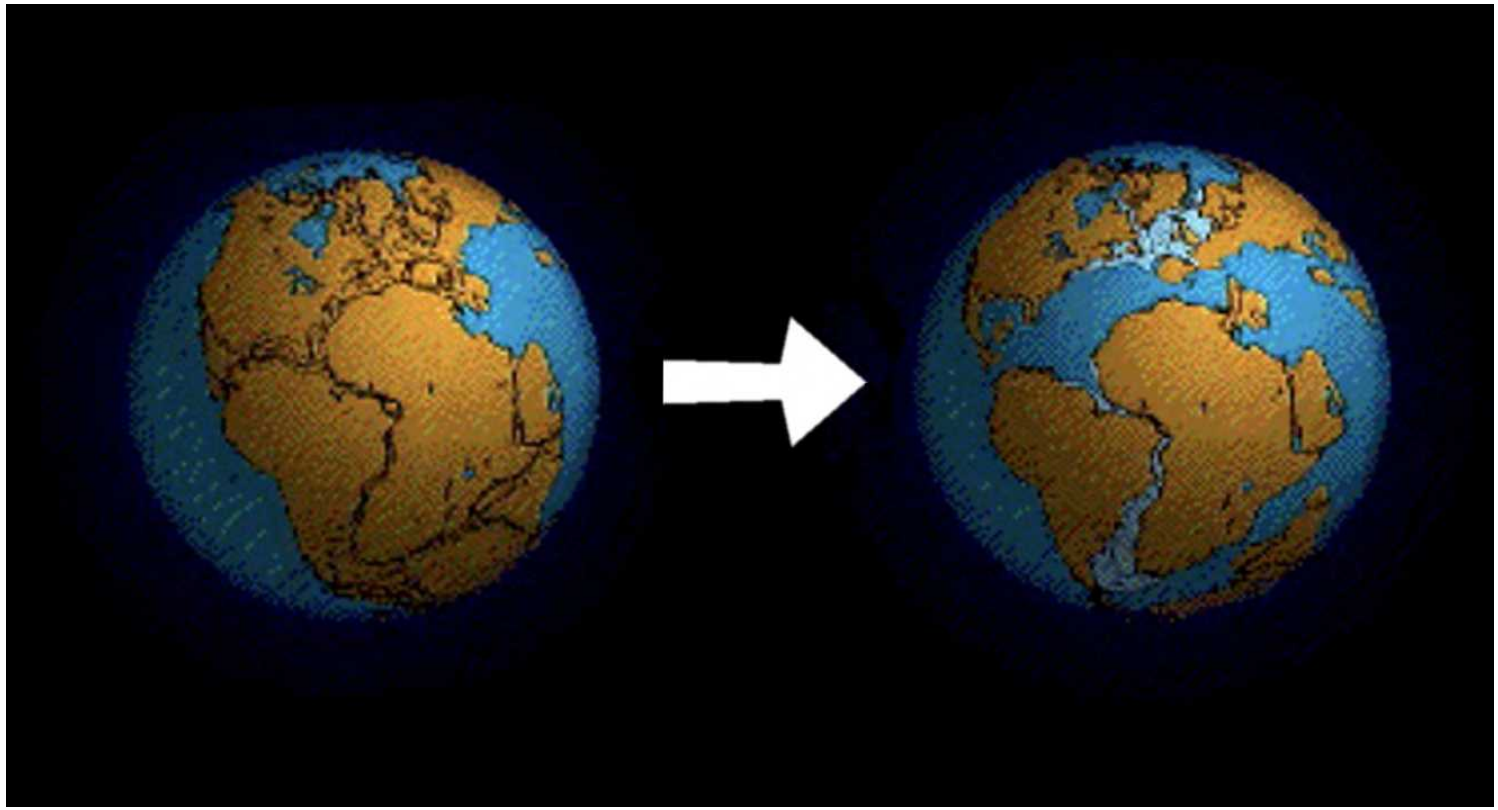
Consider an island moving on a plate.
In time the island will change to a reef, then an atoll and finally a sea mount.



Island movements on a plate

Illustration Bob Moffatt

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.

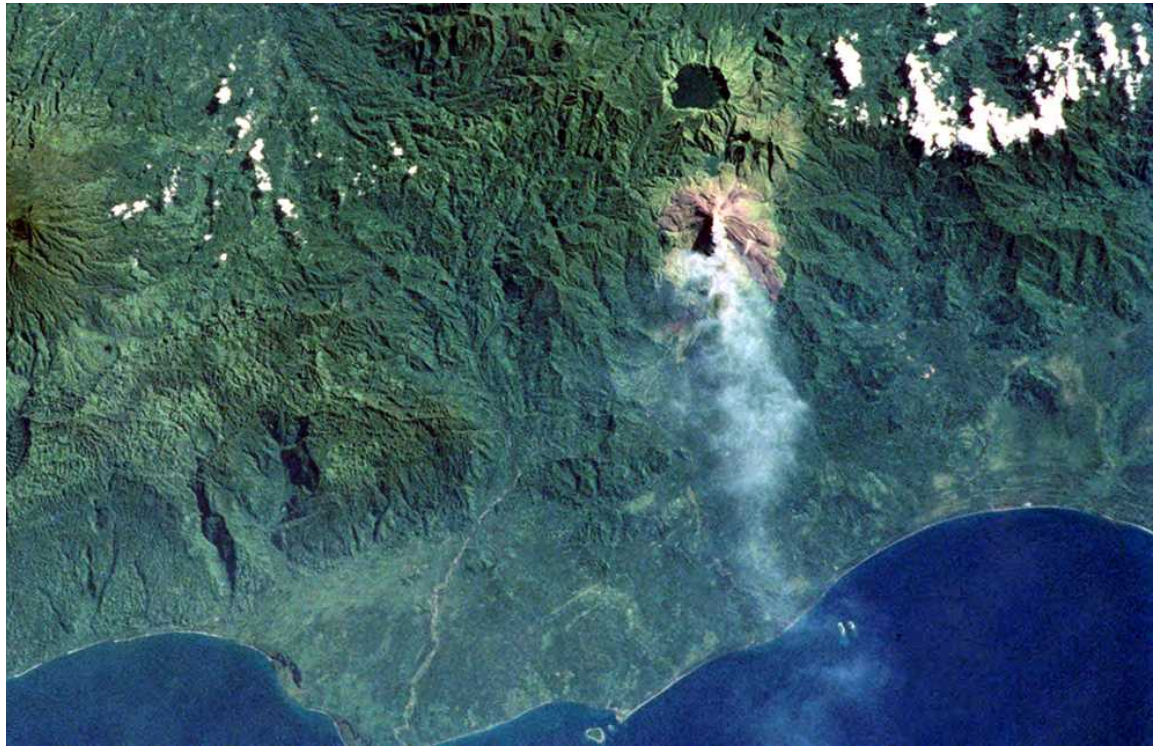


Continental drift

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

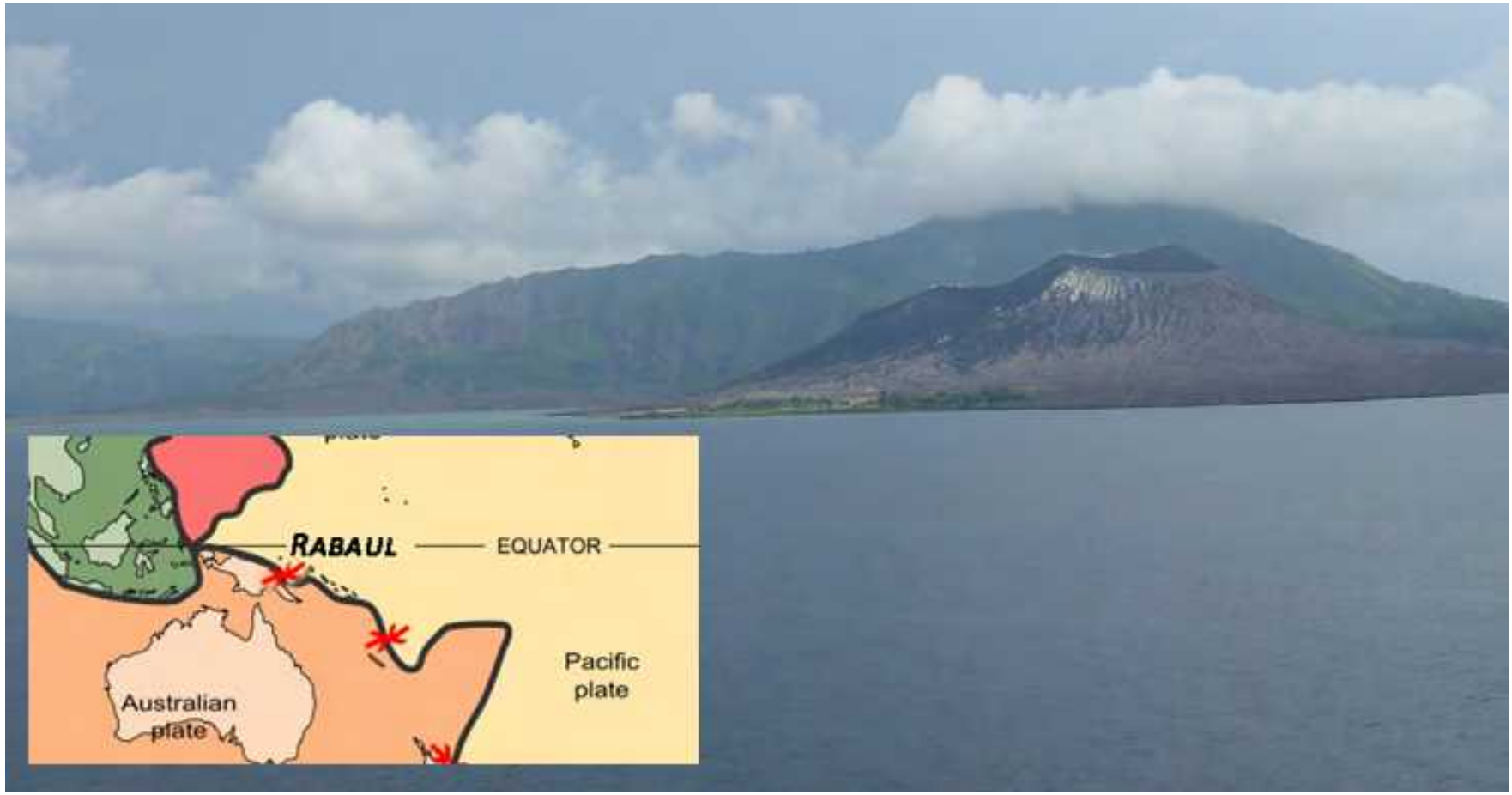
Volcanoes and mountain building

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



Aerial view of New Guinea volcano

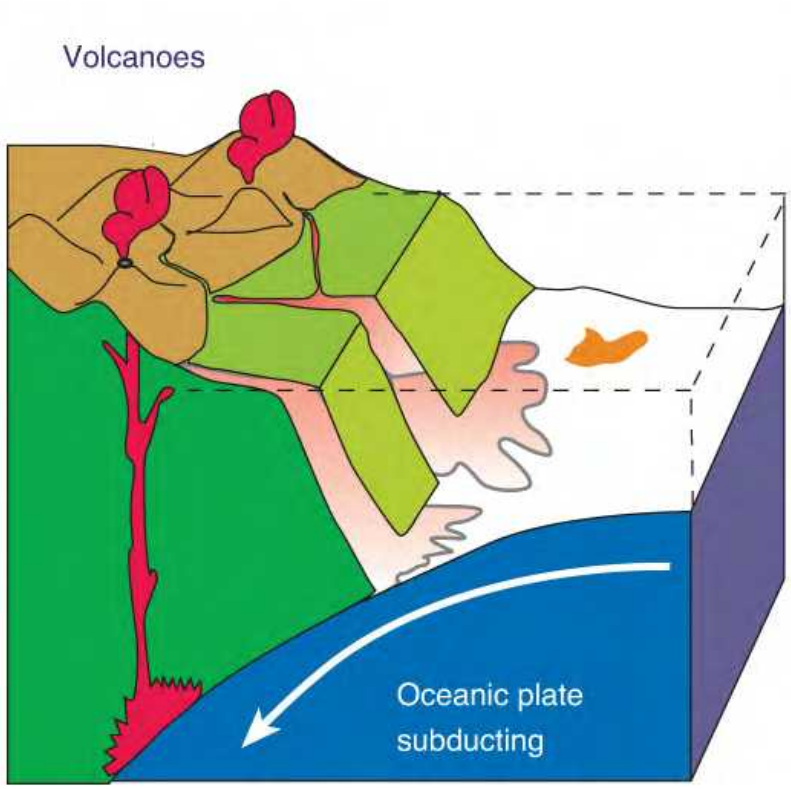
Just north east of New Guinea lies the active Rabaul volcano where the Pacific plate subjects beneath the Australian plate.



Rabaul volcano and map

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

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

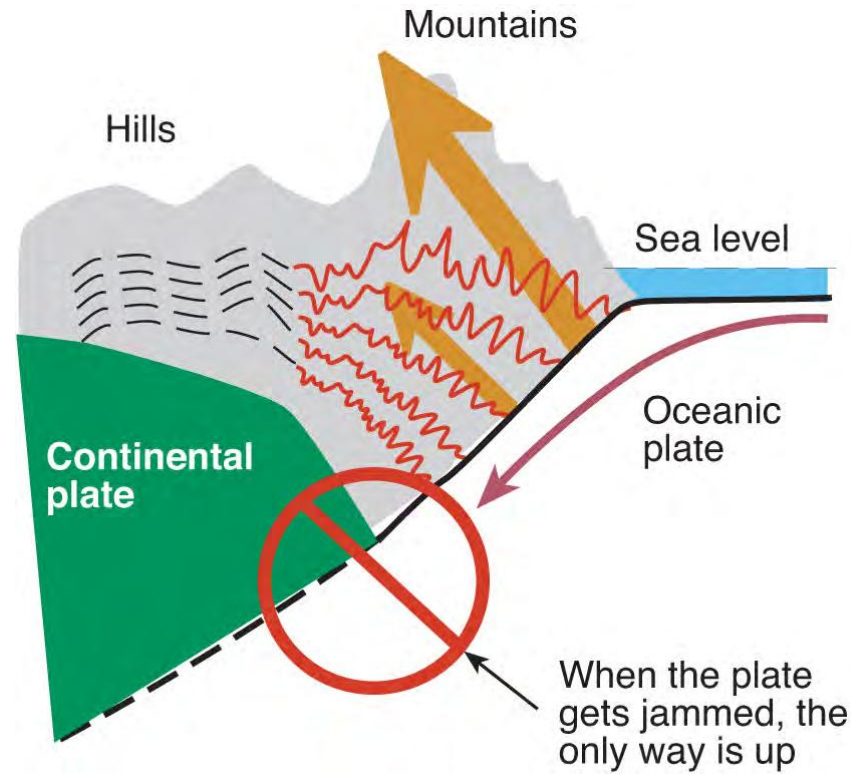


Ocean plate subduction and volcano

Illustration Bob Moffatt Volcano AAP

When plates move, they take with them continental crust.

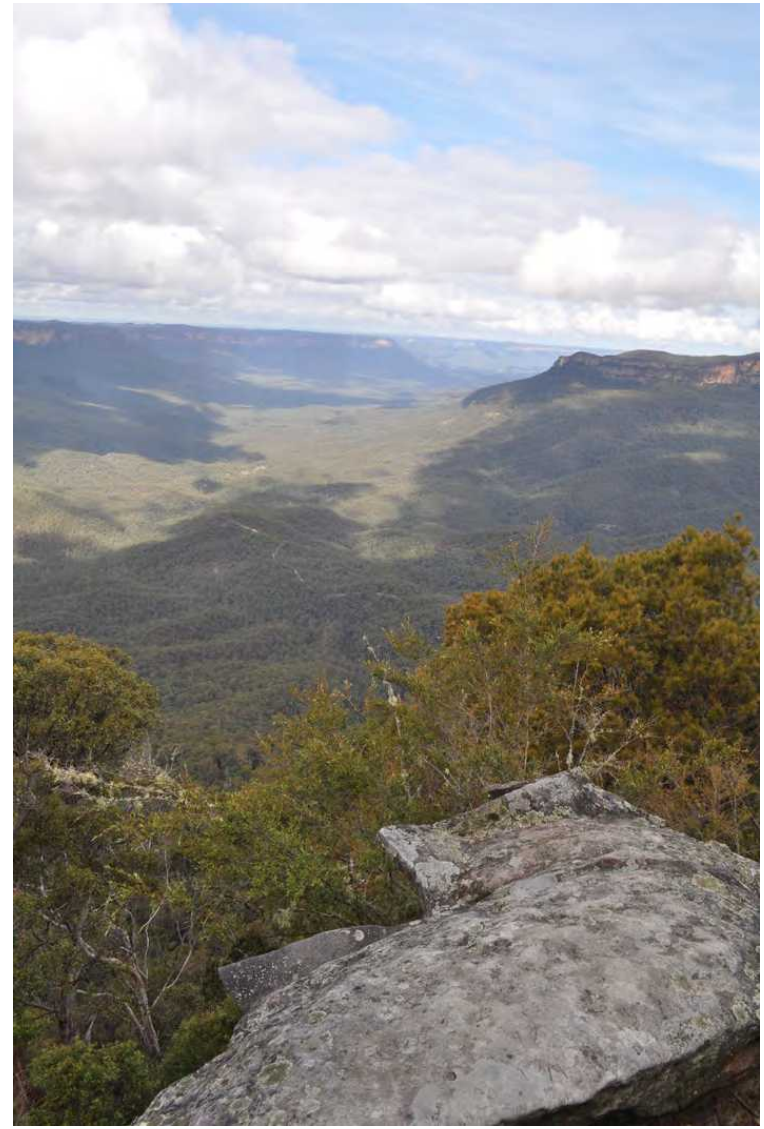
When these plates collide the continental crust is pushed up into mountain ranges.



Mountain building model

Illustration Bob Moffatt

An example is Australia's Great Dividing Range. It runs through three states, along the east coast of Australia and is 3,500km long.



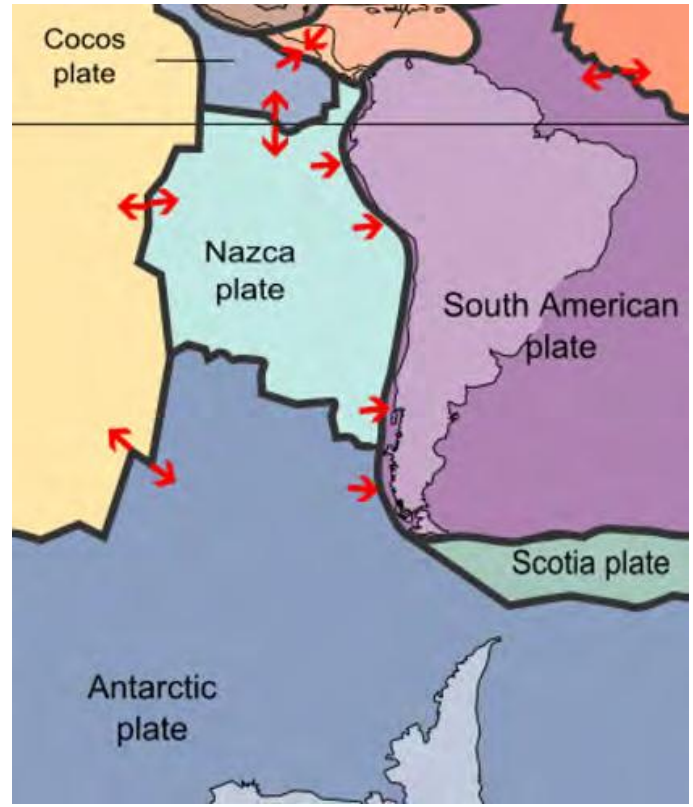
Great dividing range in Victoria and Queensland

Photos Bob Moffatt

The Andes mountain range in South America extends along most of the west coast has been pushed up by the collision of the Nazca plate and the South American plate.

Andes mountains South America

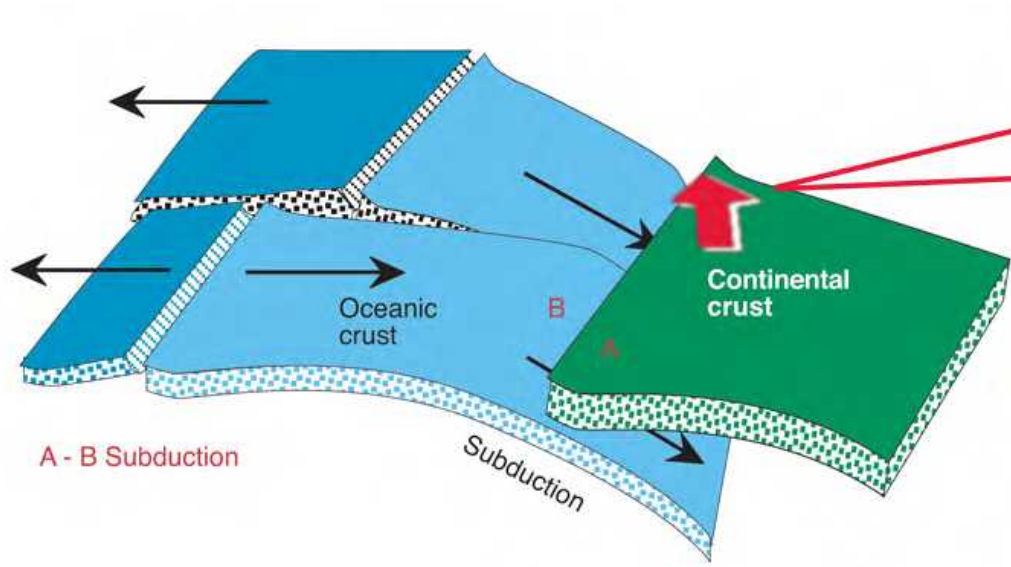
Photo Bob Moffatt



Nazca plate

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

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

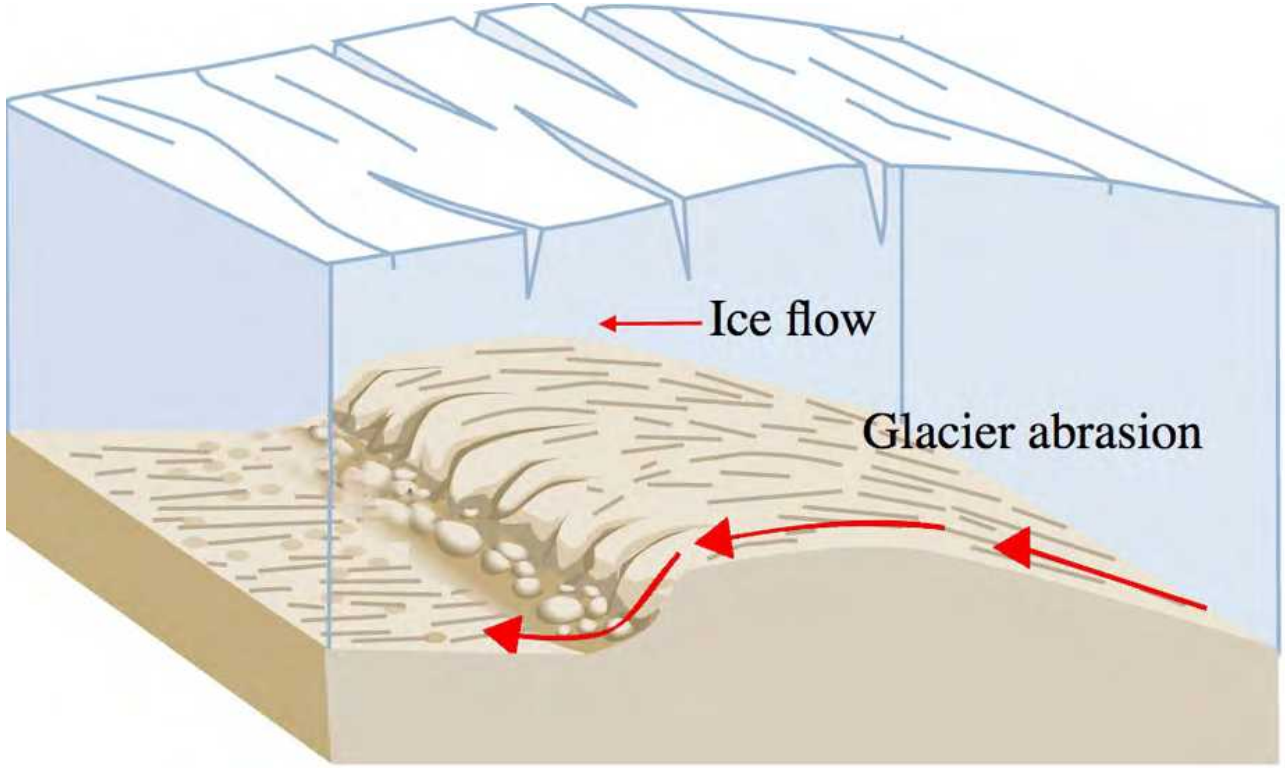


Model shows Andes mountain formation

Illustration and photo Bob Moffatt

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

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

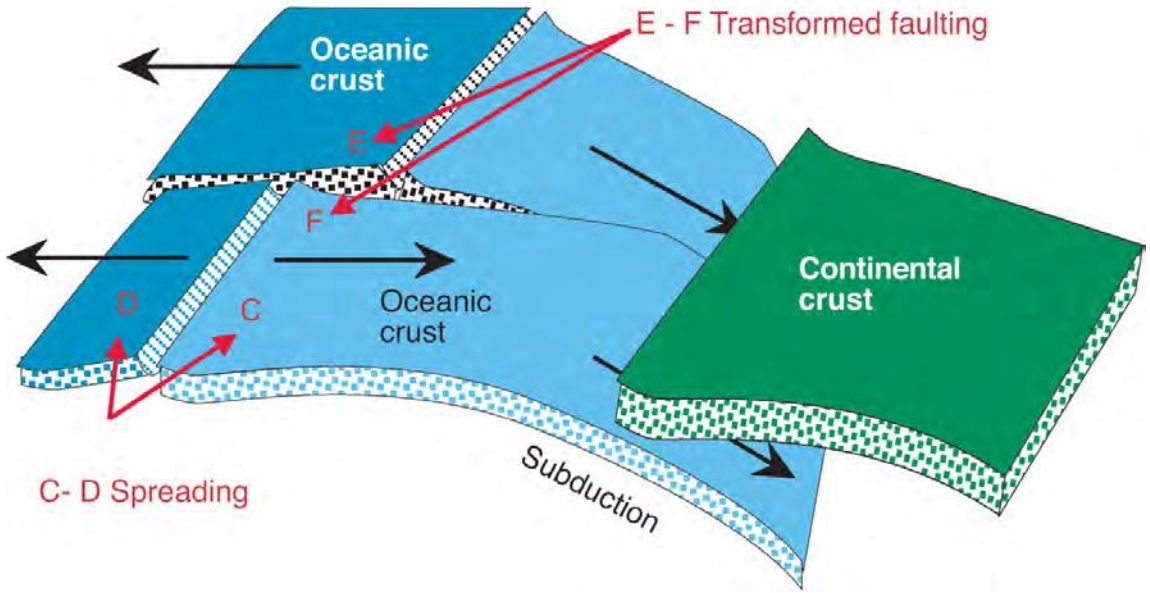
P{hotographs Bob Moffatt

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

This model is used to explain Earthquakes.

Effect of an Earthquake

Photograph Sherwood Maynard University of Hawaii (copyright)

San Andreas Fault

Illustration Bob Moffatt

An earthquake is an example of a transformed fault .

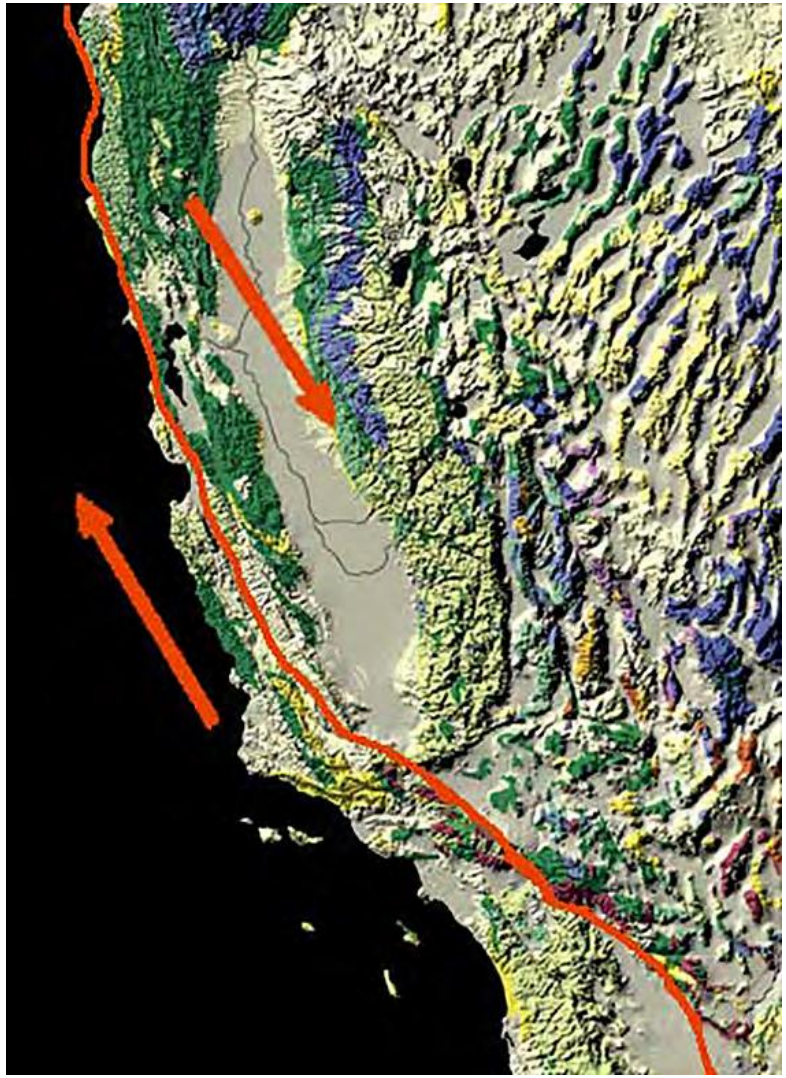


Diagram of San Andreas Fault

By Kate Barton, David Howell, and Joe Vigil – http://nationalatlas.gov/articles/geology/features/sanandreas.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=1347277

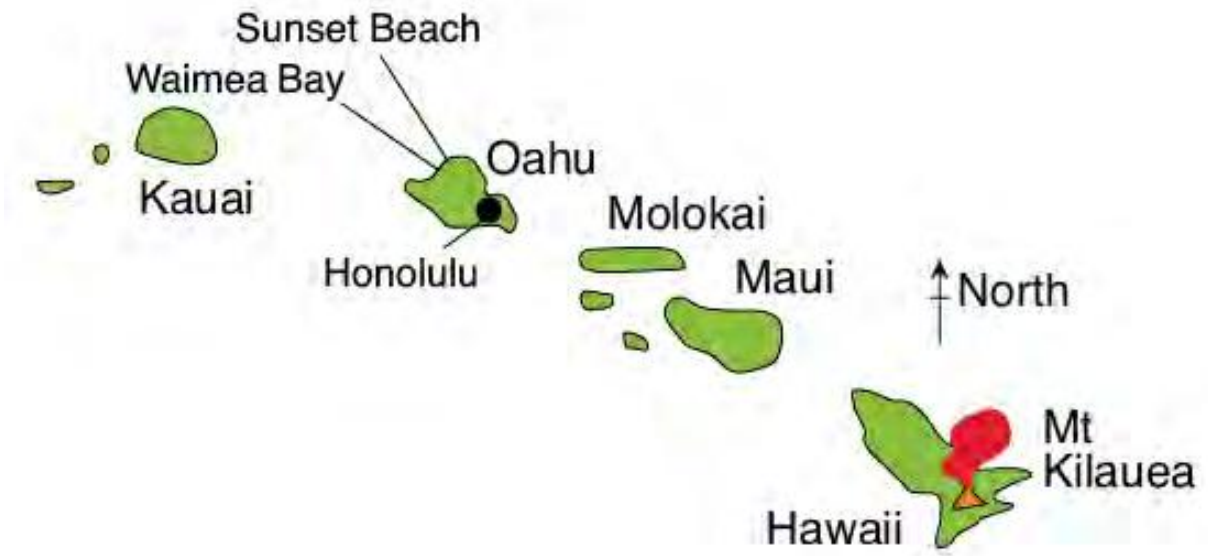
Island chains

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

Normally Mt Kilauea is not a dangerous volcano and people can walk up to the crater and watch it erupt.
But as the crater moves over the hot spot it can spew larva with dramatic effects.

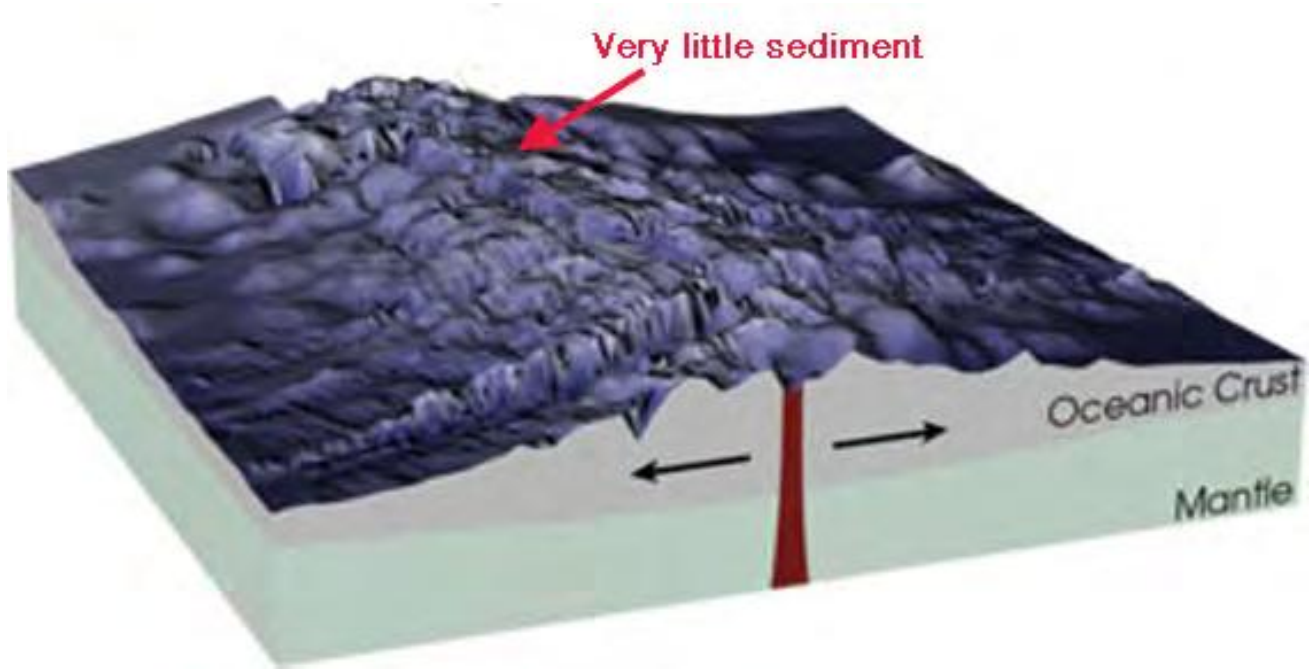
Mt Kilauea Hawaii

Lava from a fissure slowly advancing down a street 2018.

By United States Geological Survey - https://www.usgs.gov/news/kilauea-volcano-erupts, Public Domain, https://commons.wikimedia.org/w/index.php?curid=68847255

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

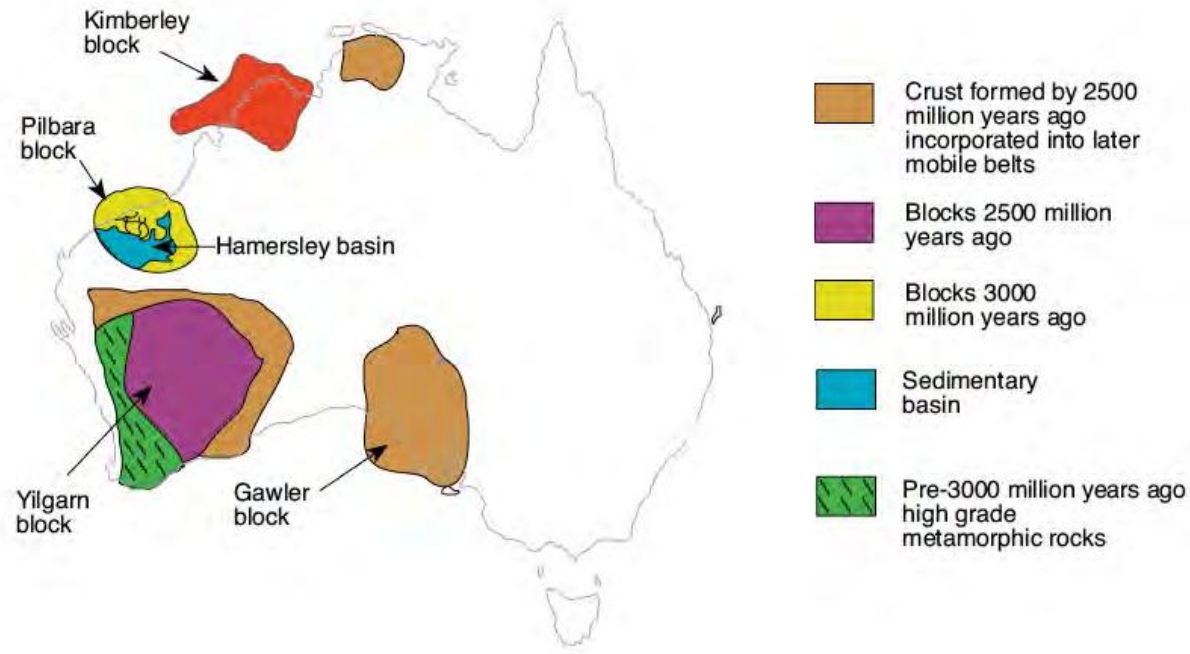
This is the area where the ocean floor is spreading and the new crust is being formed.



Mid ocean ridge

Ancient reefs in Auztralia and continental drift

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



Australia 2500 MYO

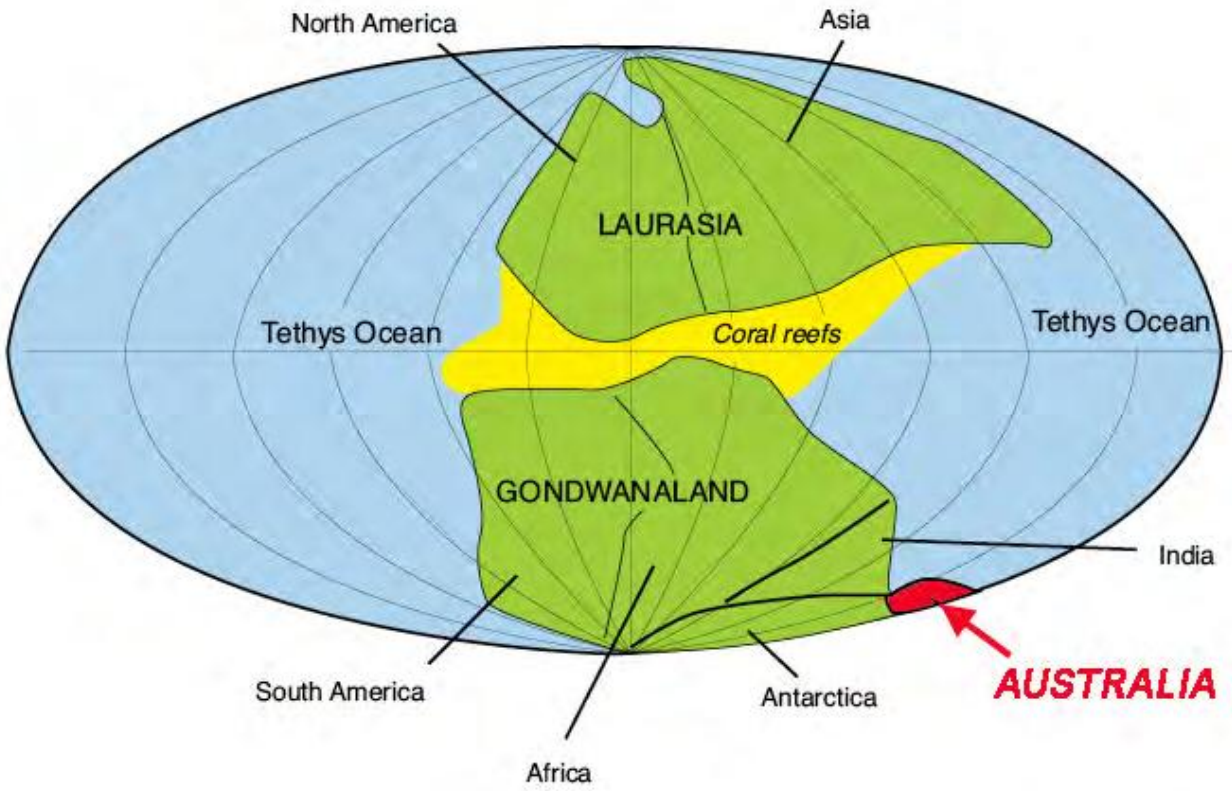
Illustration Bob Moffatt (after Perspectives of the Earth)

Continental drift

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

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
Paleozoic	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
Precambrian	Ordovician	500 mya	First fish
	Cambrian	600 mya	First marine invertebrates
	Precambrian	4600 mya	The beginning of life in the Sea

Geological time

Illustration Bob Moffatt

Stratigraphy

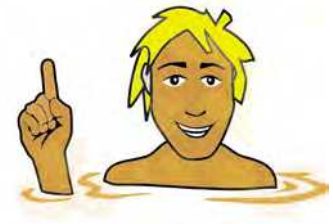
is the branch of geology concerned with

- the order and relative position of strata and their relationship to the geological timescale,

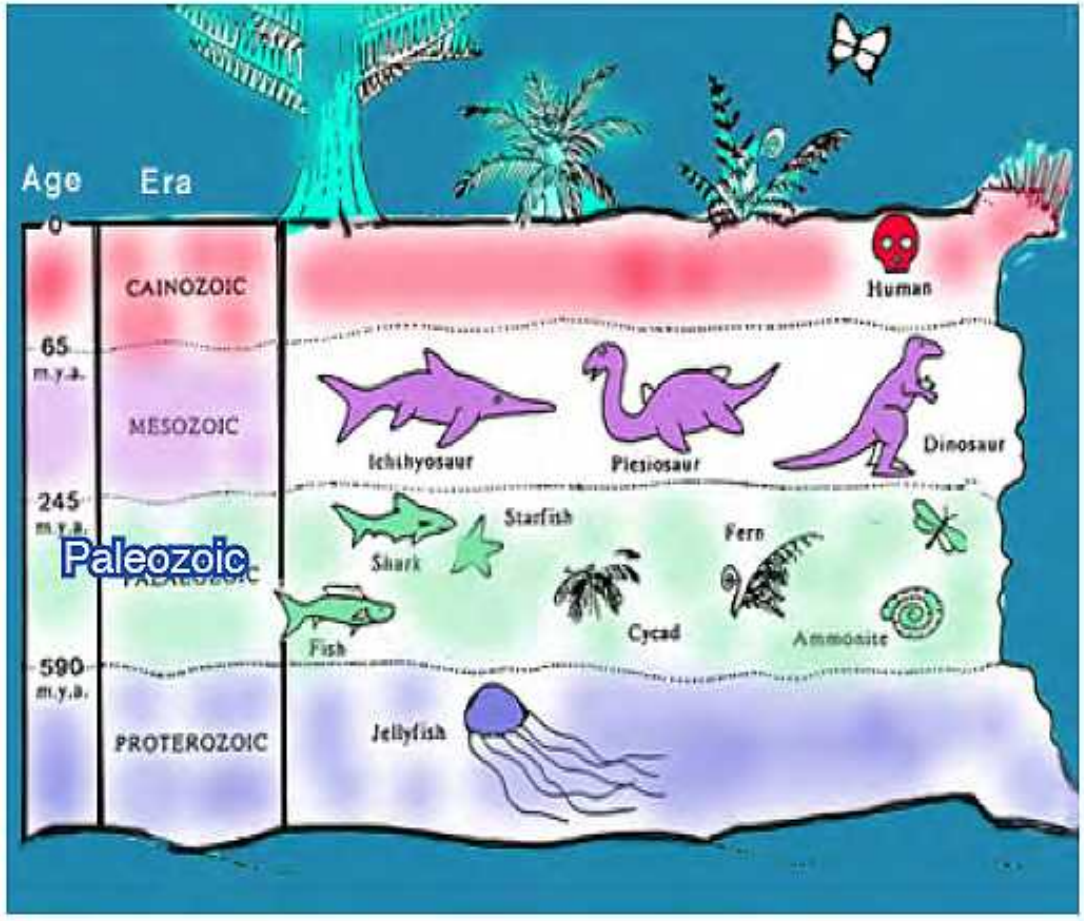
- the analysis of the order and position of layers of archaeological remains

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

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

Geological Time Scale

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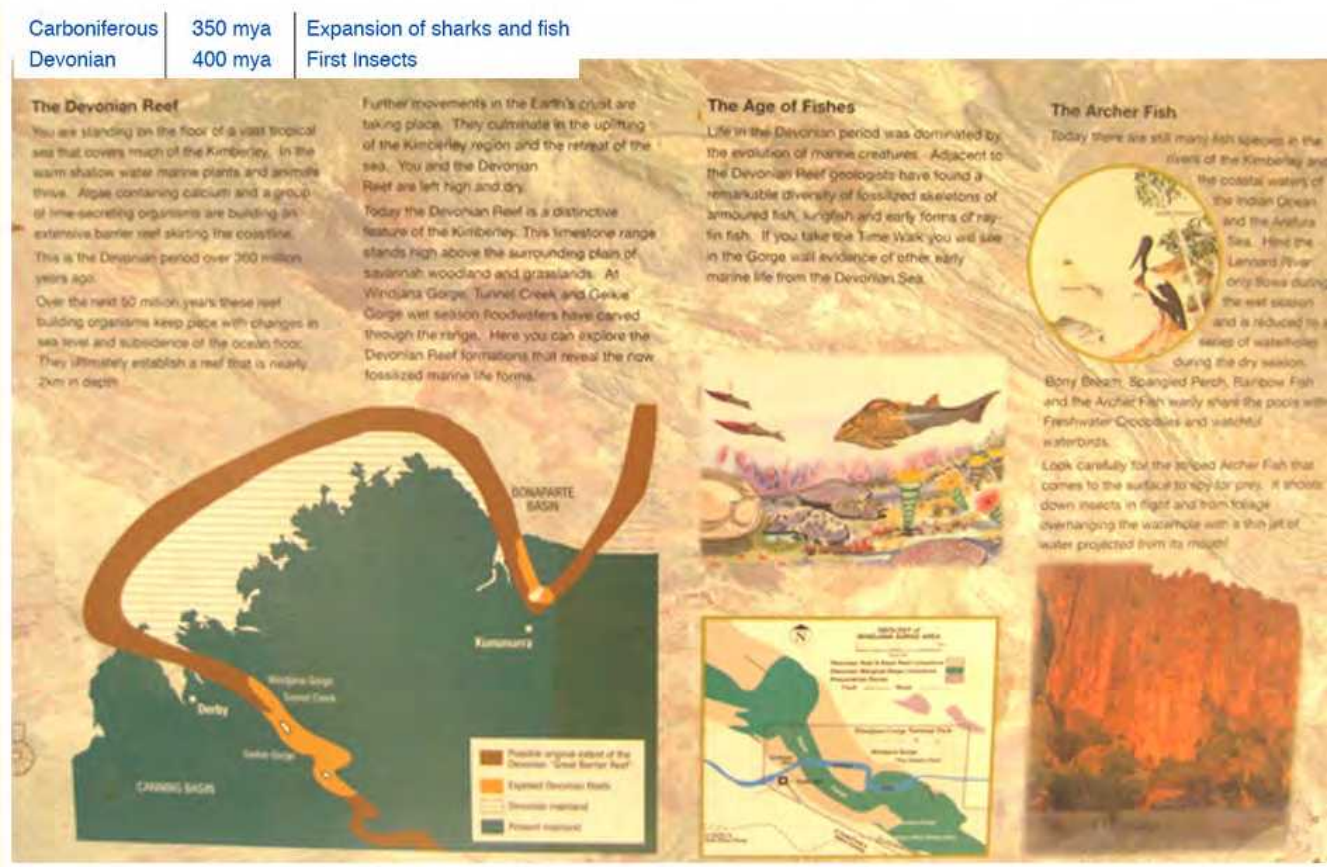


Devonian reef Kimberley region

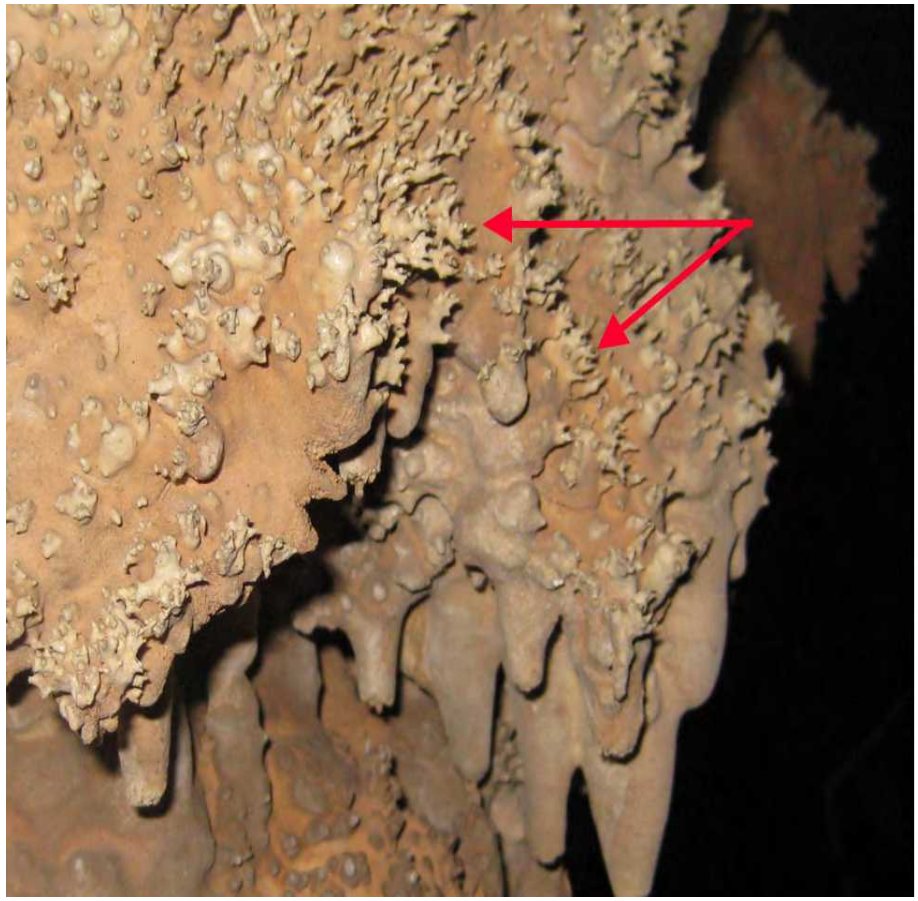
Photo Bob Moffatt

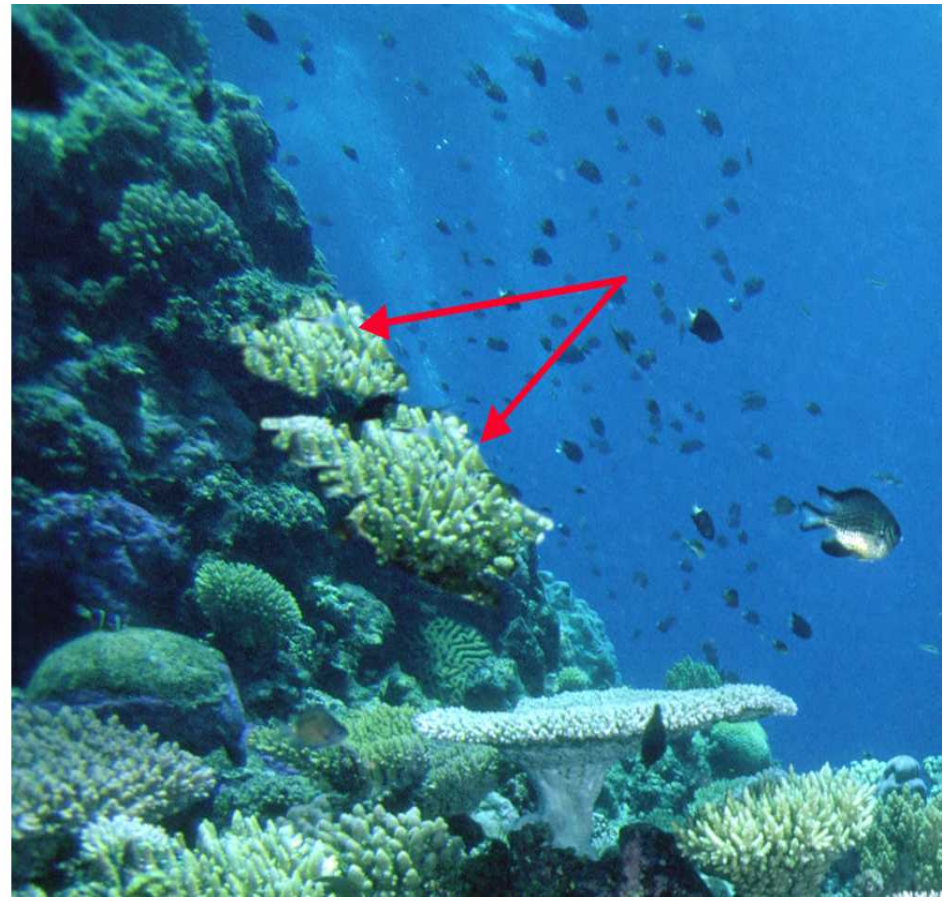
Solid limestone reefs containing a huge variety of fossils laid down as they died in the ancient seas.
The fact it is now on land suggests that it must have been pushed up out of the water by plate subduction.

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

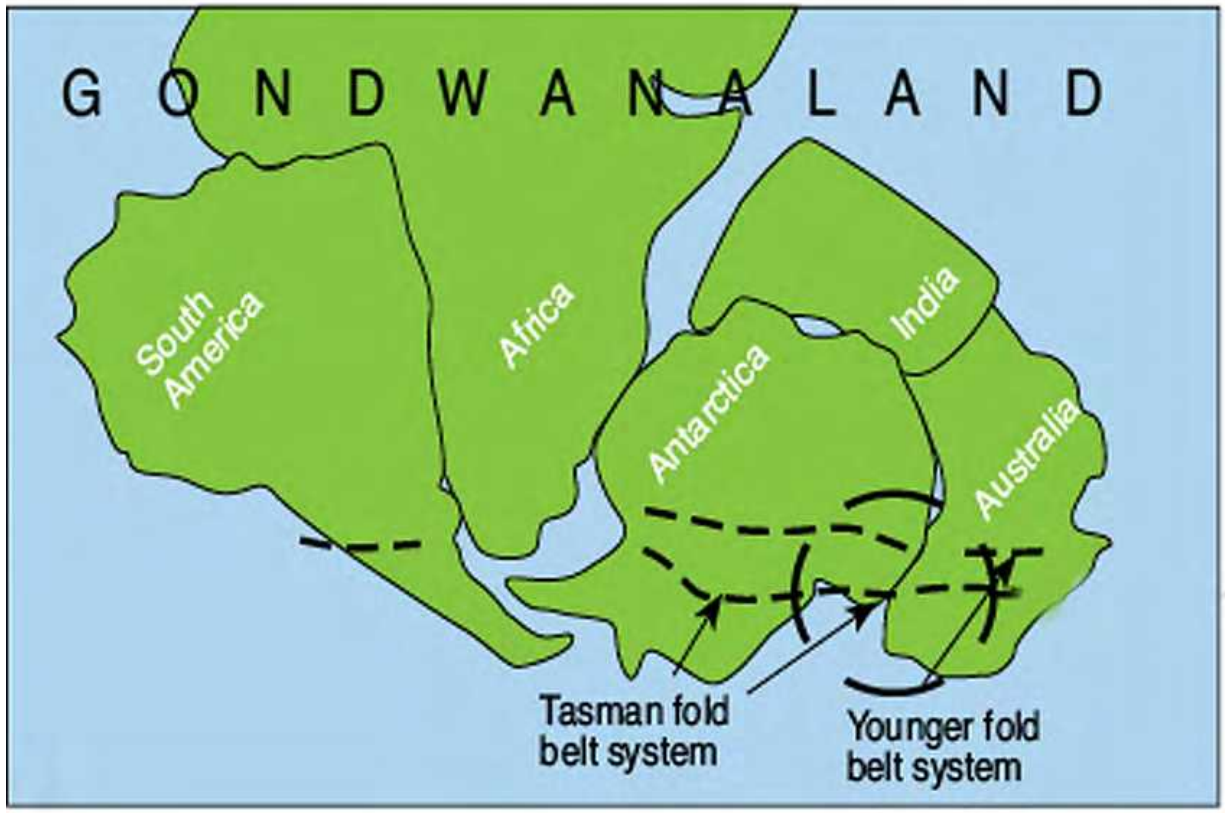
Examples you can see are fossil nautili.

Windjana George and fossils

Photo Bob Moffatt

The Great Dividing Range

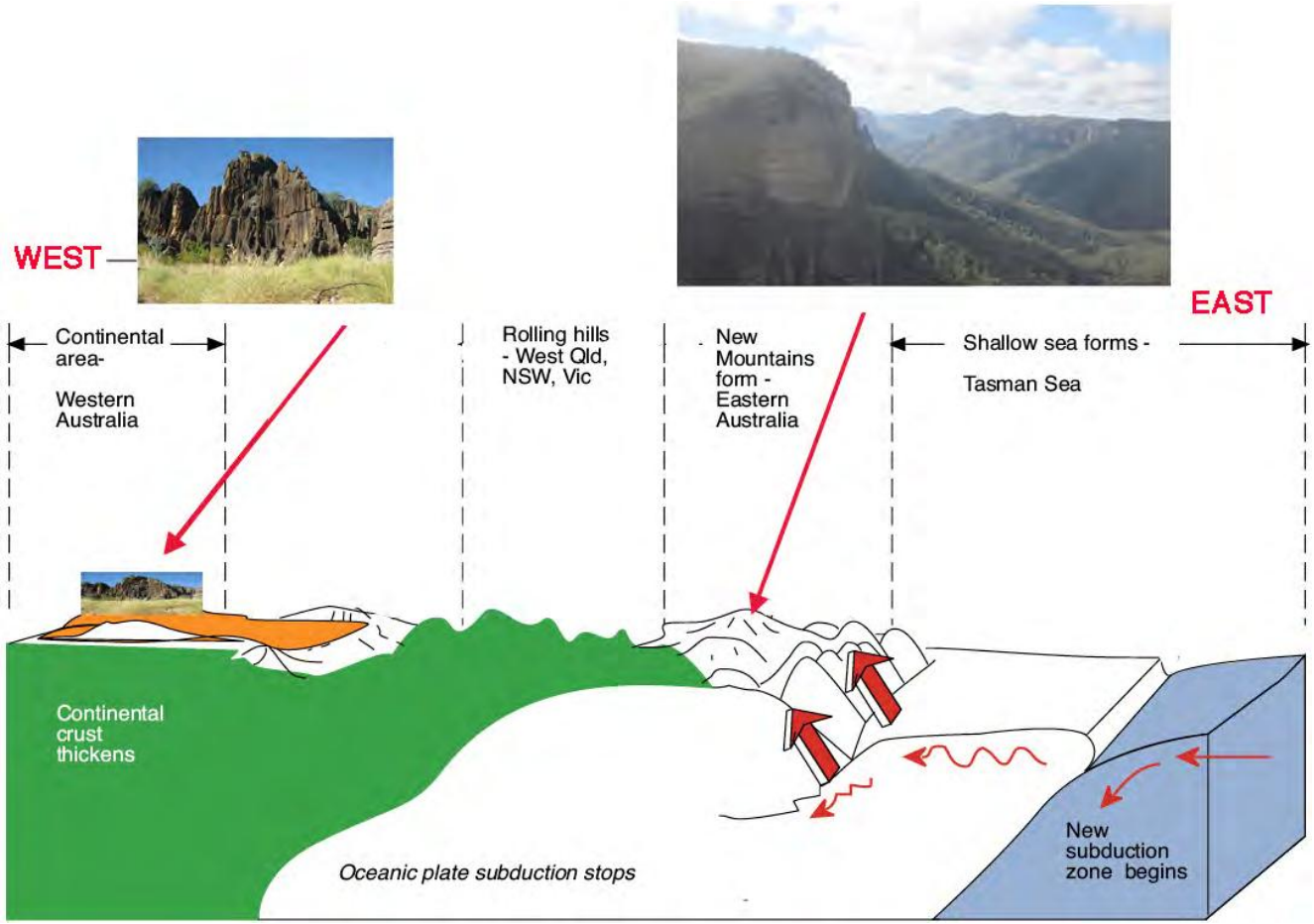
In the Paleozoic era, two thirds of the Australian landmass had formed and was joined to a super continent called Gondwana.



Gondwanaland

Illustration Bob Moffatt

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.

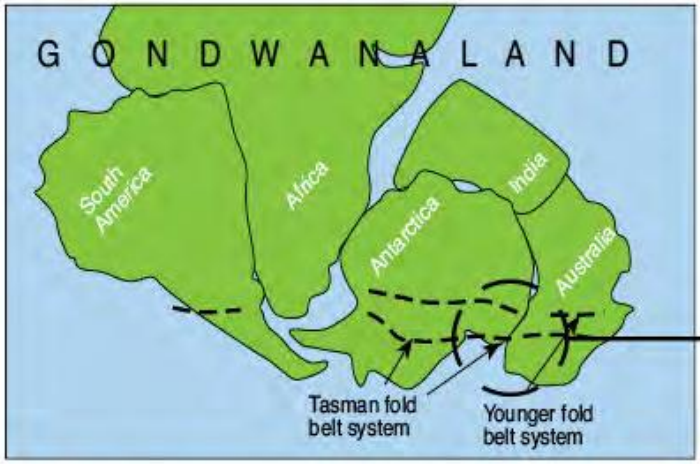


- To the east of this volcanic range lay a deep ocean trench with oceanic crust subducting in the Tasman Sea area.
- To the west lay our ancient reefs

Aus 600 - 400 MYO East west comparison

Illustration and photos Bob Moffatt

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

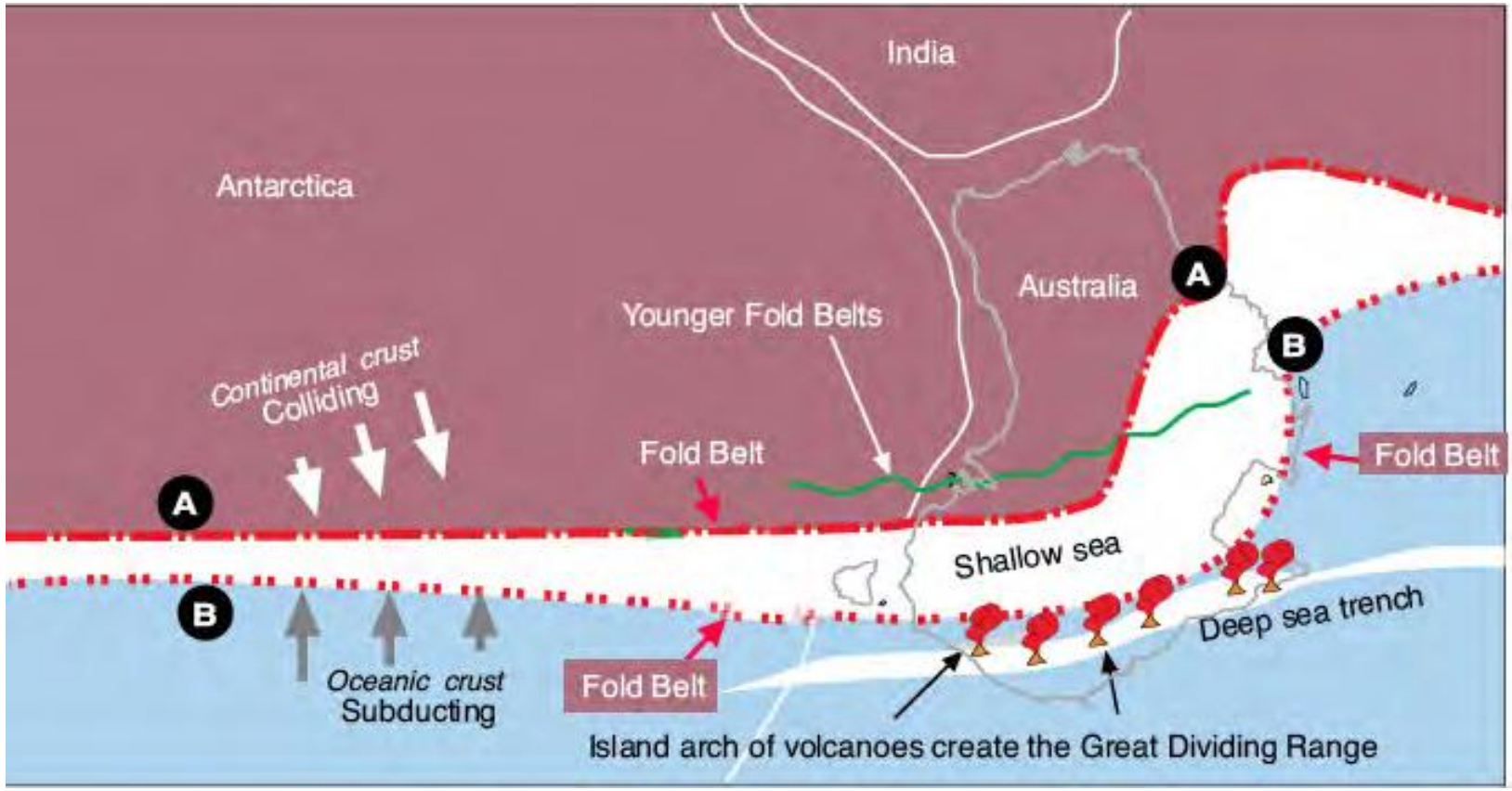


600 - 400 million years ago

Australia 600 - 400 MYO Island arc

Illustration Bob Moffatt

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



Australia 600 - 400 MYO fold belt systems

Illustration Bob Moffatt

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

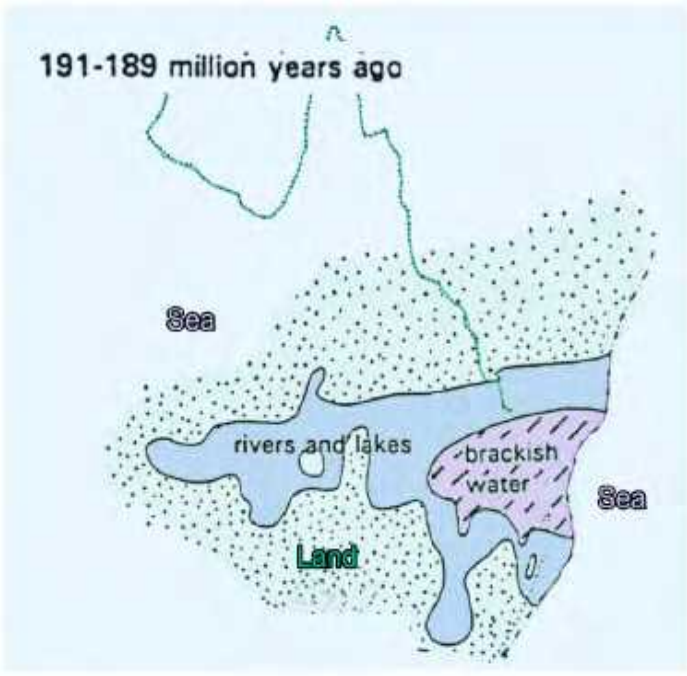
Photo Bob Moffatt

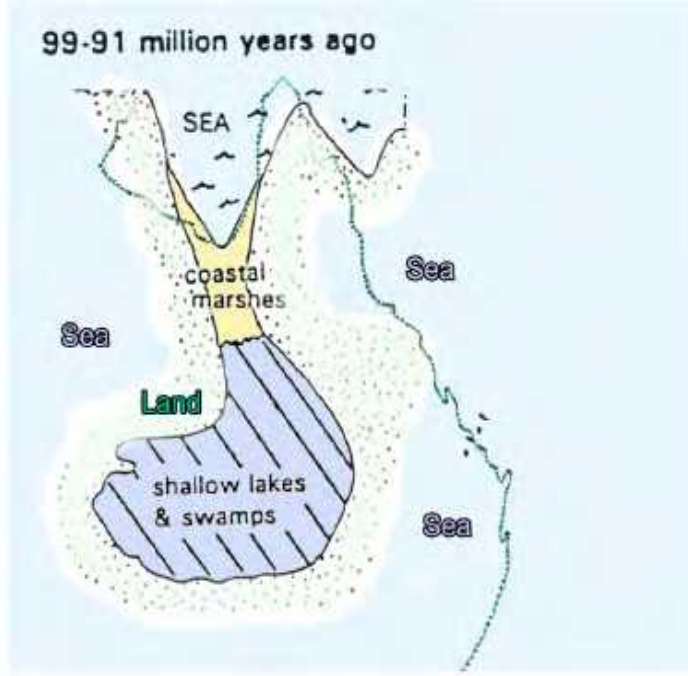
Queensland coal deposits and marine dinosaurs

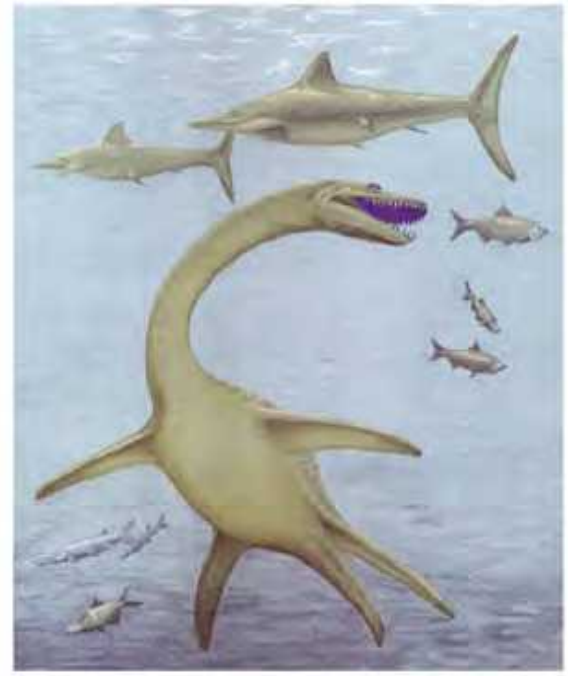
This was also the time the massive coal deposits were laid down in the Bowen basin in Queensland.

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

Barrier Reef formation

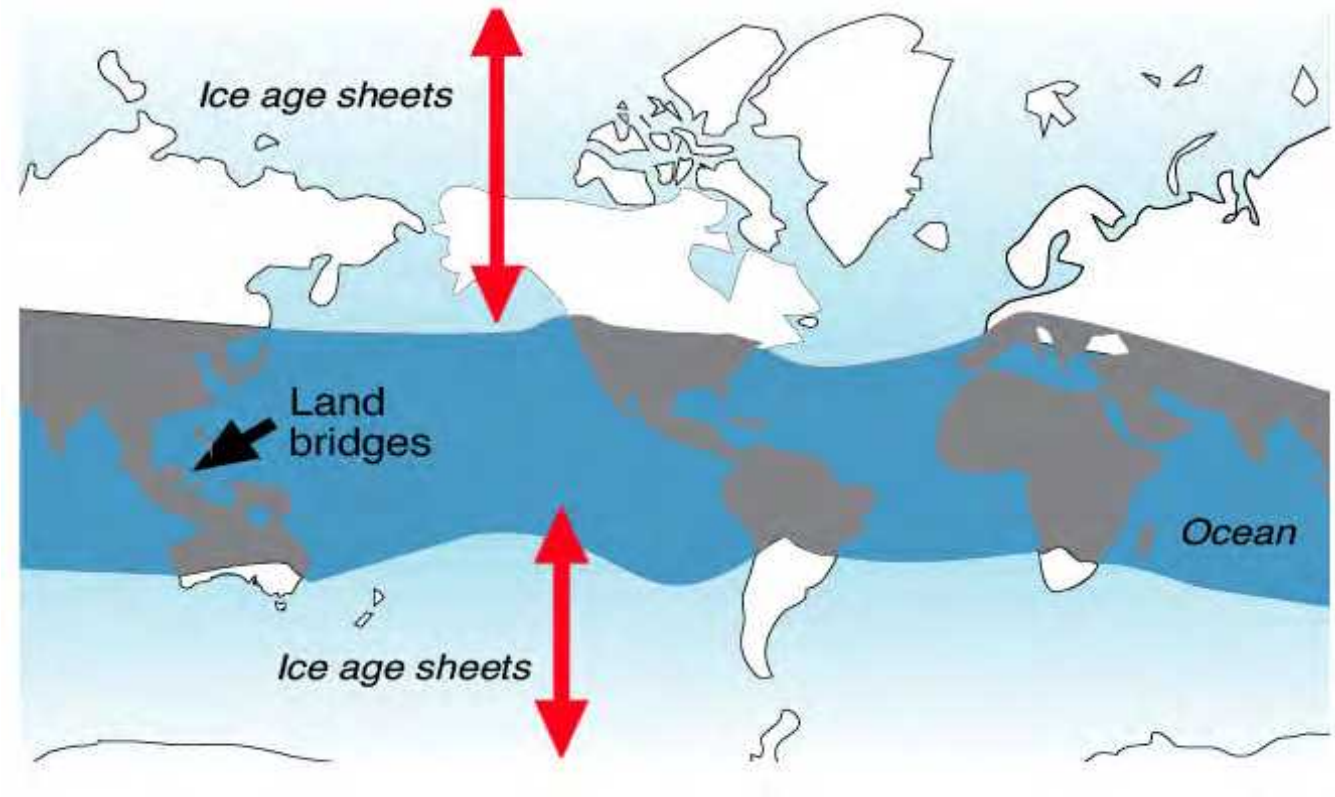
From 50 mya to present a series of ice ages engulfed the earth during this period.

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

NASA 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.



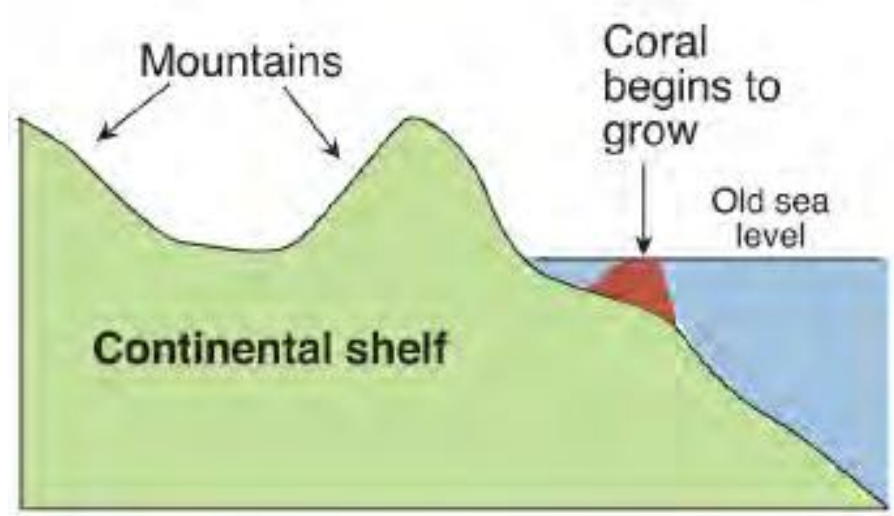
Ice age seas
Illustration Bob Moffatt

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

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.

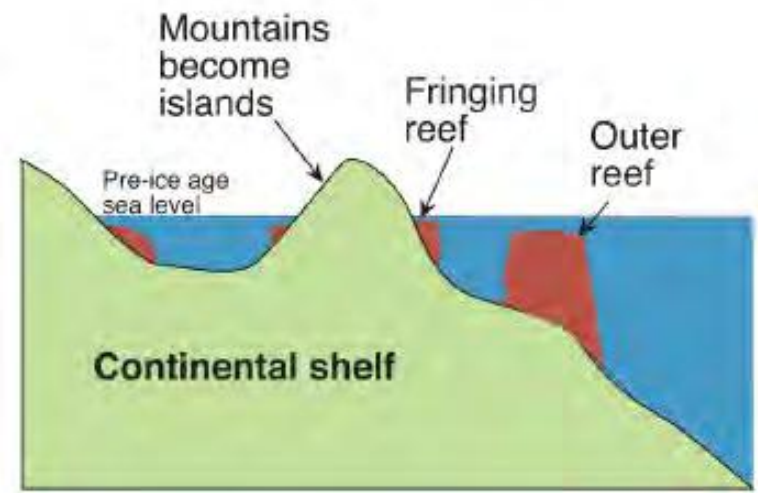


Reef development pre-ice age A

Illustration Bob Moffatt

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

Then followed a series of ice ages.

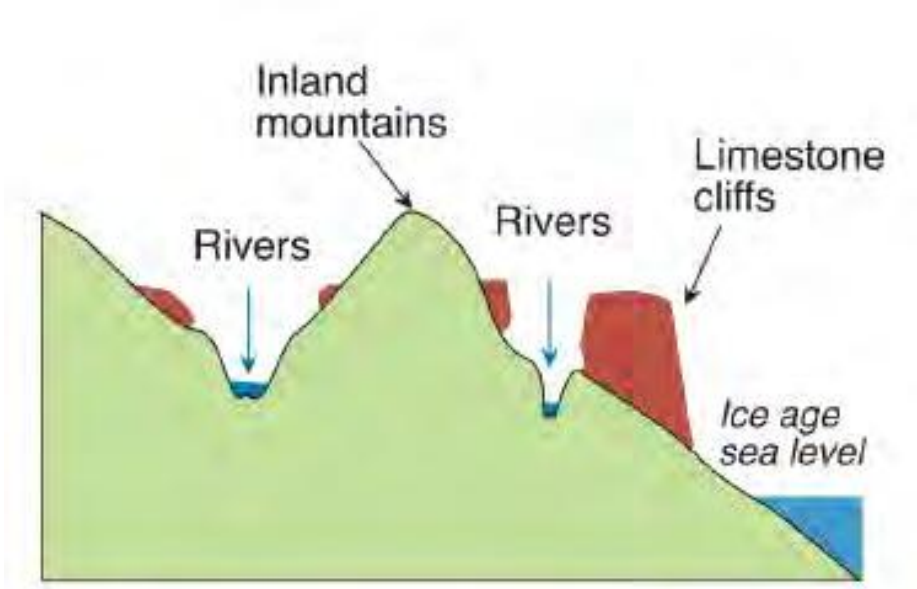
The sea level fell about 150 metres as ice formed at the poles.

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

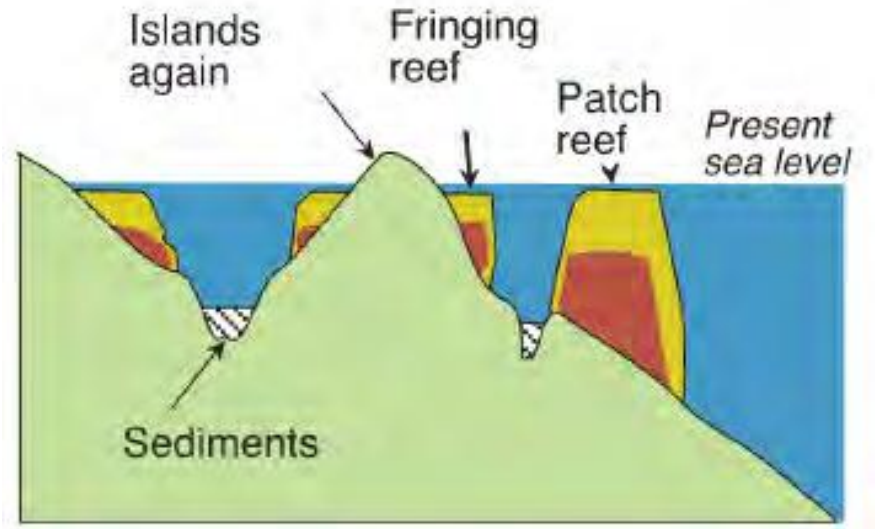
Illustration Bob Moffatt

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

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)

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

Magnetic Island

Photo Tourism Queensland

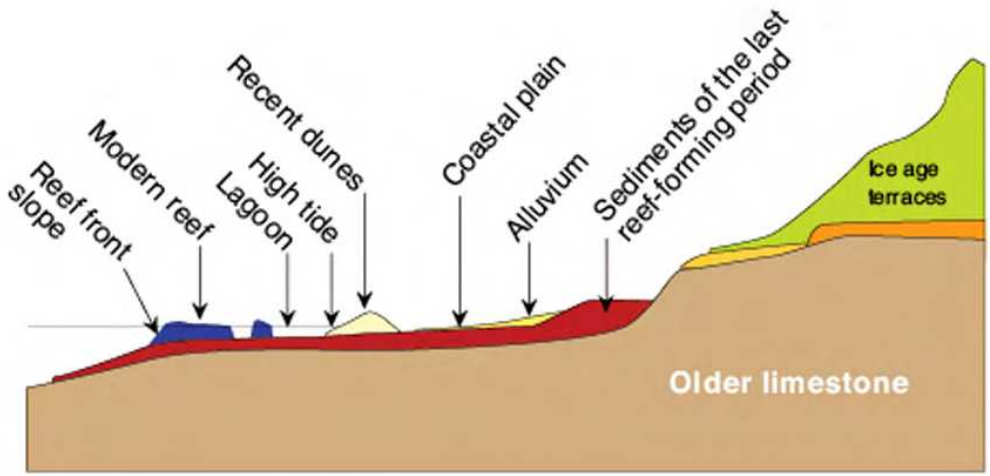
West coast islands and reefs

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



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

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 indicatIng that the beds have been folded and pushed around.

Rocky shore tectonics

Photo Bob Moffatt

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

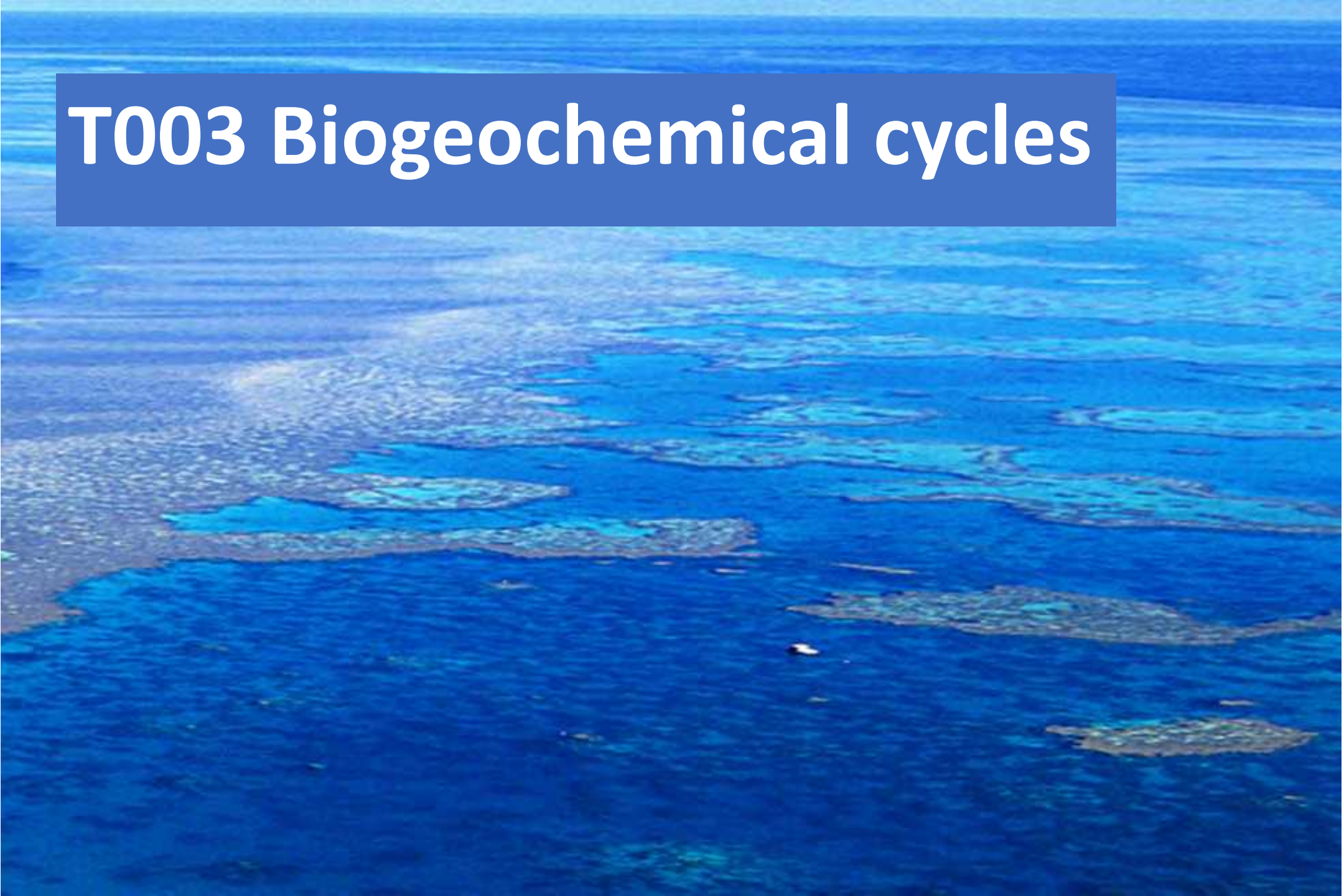
Table 1:

Earth's features	Model used to explain feature
Continental drift	
Atoll formation	
Volcanoes	
Mountain building	
Earthquakes	
Island chains	

Table 2.

Australian feature	Model used to explain feature
Ancient NT limestone reefs	
Great Dividing Range	
Qld coal deposits and marine dinosaurs	
Fringing reefs, patch reefs and coral cays	
Coastline stratifications	

T003 Biogeochemical cycles



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.

Question

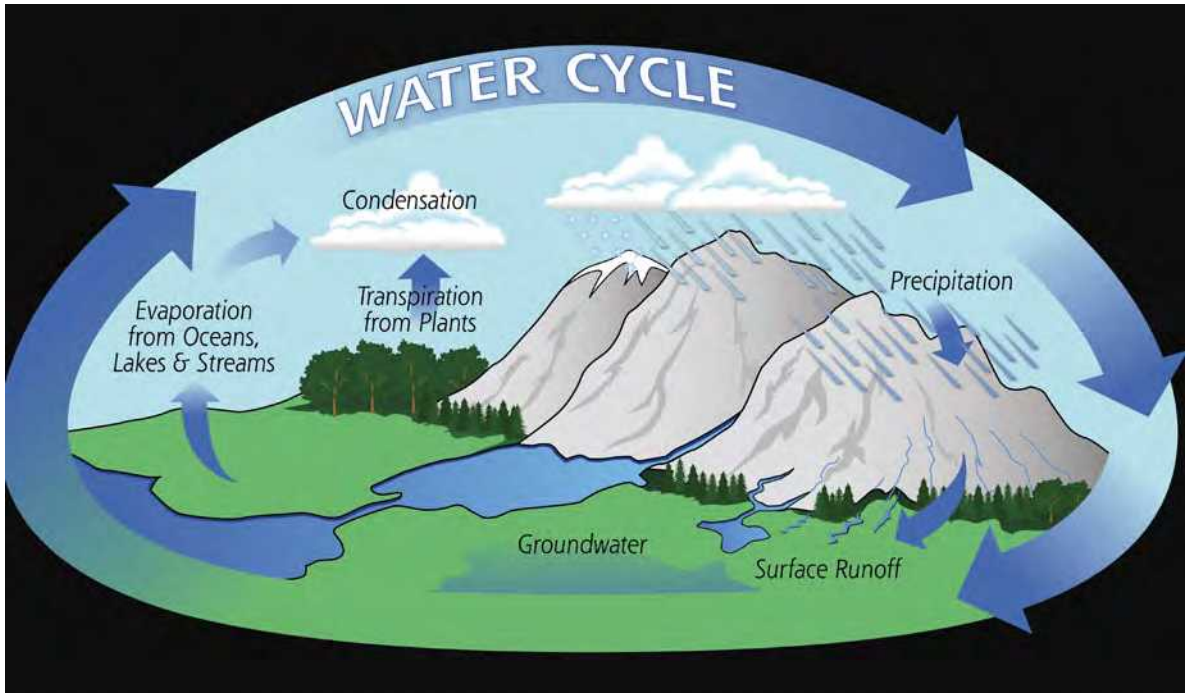
Explain the term cycle and give a written account of the **processes** involved in the

water, carbon and oxygen cycles.

Definition

A **biogeochemical cycle** is the cycle in which chemical elements and simple substances are transferred between living systems and the environment.

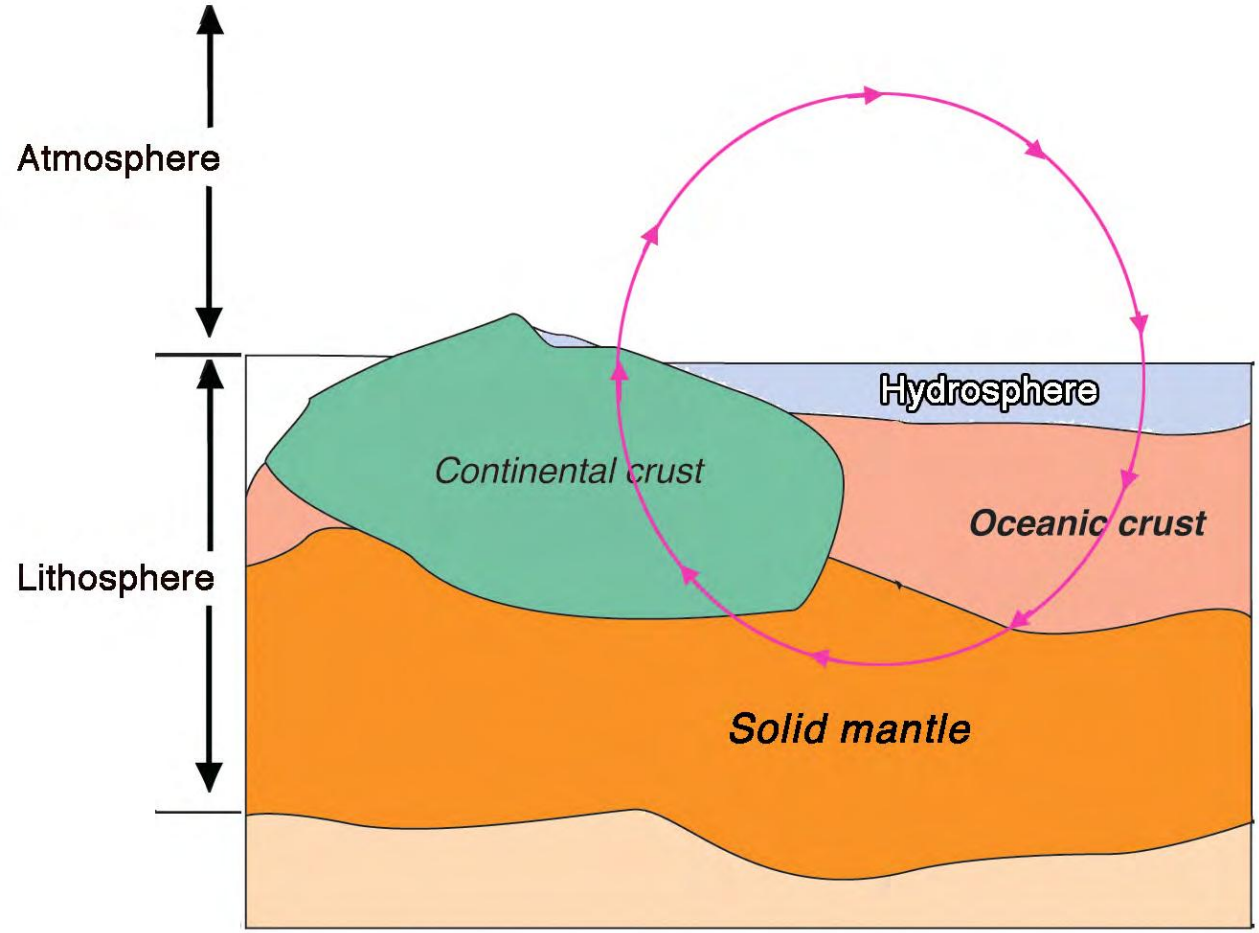
Water, for example, is always recycled through the water cycle, which undergoes evaporation, condensation and precipitation, before falling back to Earth.



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 (where organisms exist) to another through biogeochemical cycles.



Cycle - lithoshpere atmosphere hydrosphere

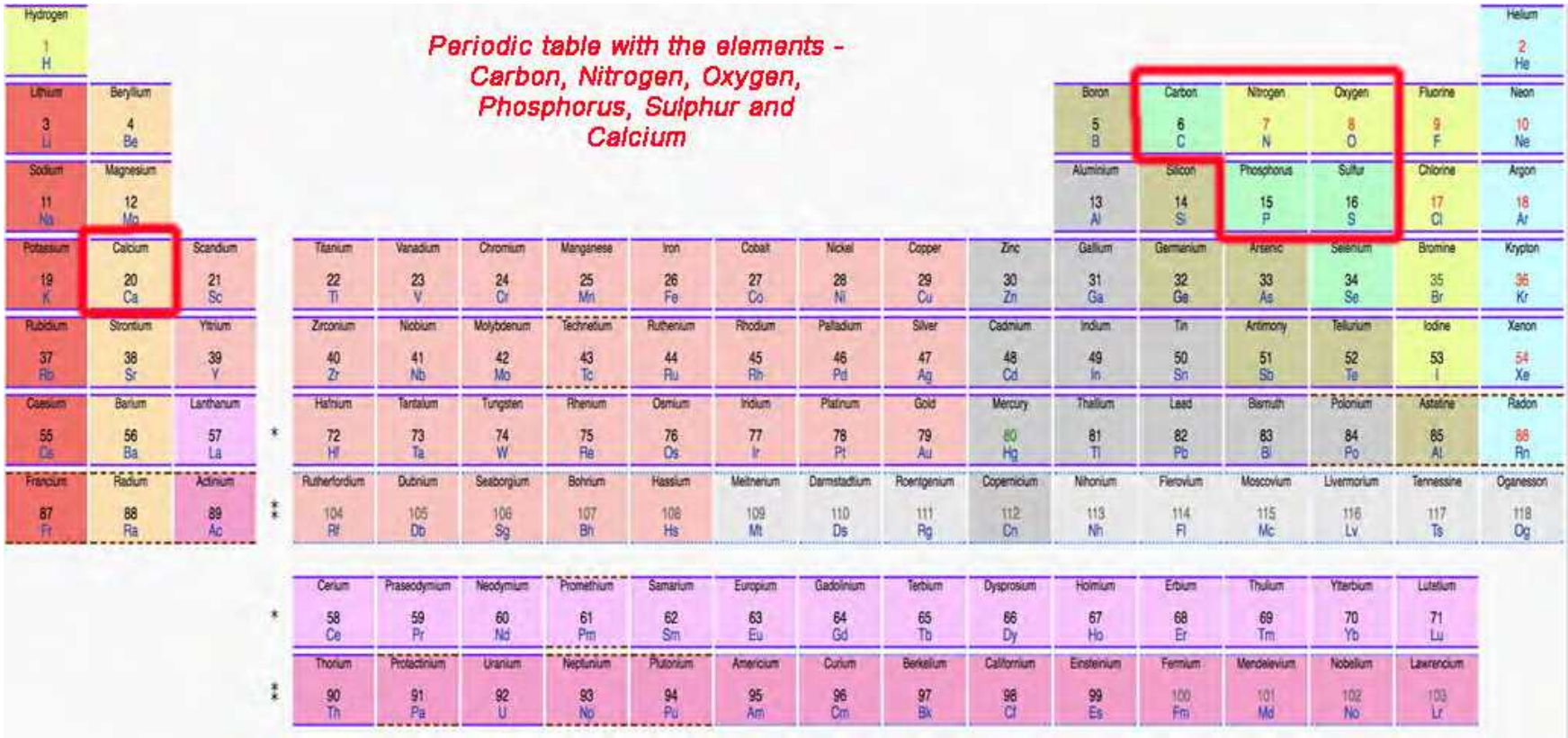
Illustration Bob Moffatt

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

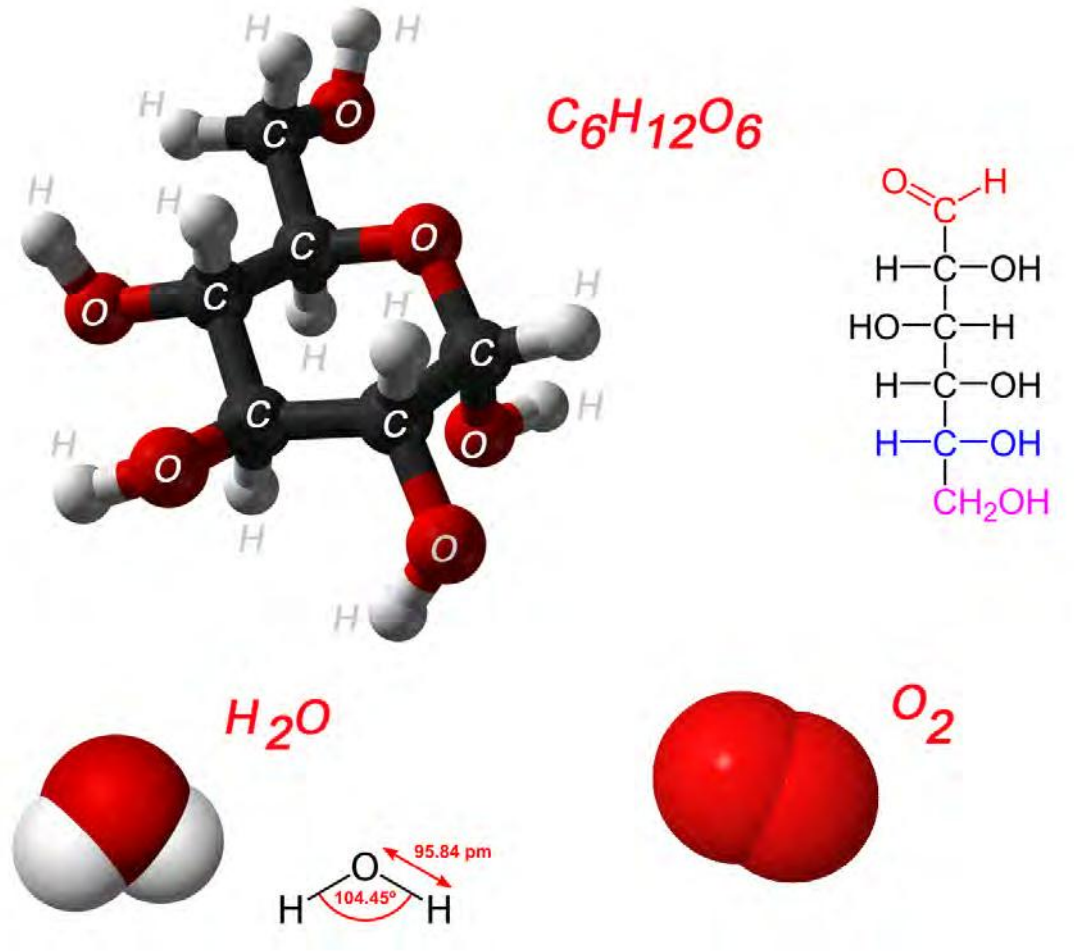
Cycles involve the elements and compounds.
Important elements are nitrogen, oxygen, phosphorus, sulphur and hydrogen.



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

Cycles also involve molecules.

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



Sugar, water and oxygen molecules

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.

There are also human-induced cycles such as those for the toxic substances of DDT and mercury.

DDT Nature article

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

nature International weekly journal of science

comments on this story

Stories by subject
- Earth and Environment

Stories by keywords
- DDT
- pesticides
- atmospheric fate and transport
- oceans
- pollution
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Published online 7 January 2010 | Nature | doi:10.1038/news.2010.4

News

Oceans release DDT from decades ago

Emissions of controversial pesticide are heading northwards.

Richard A. Lovett

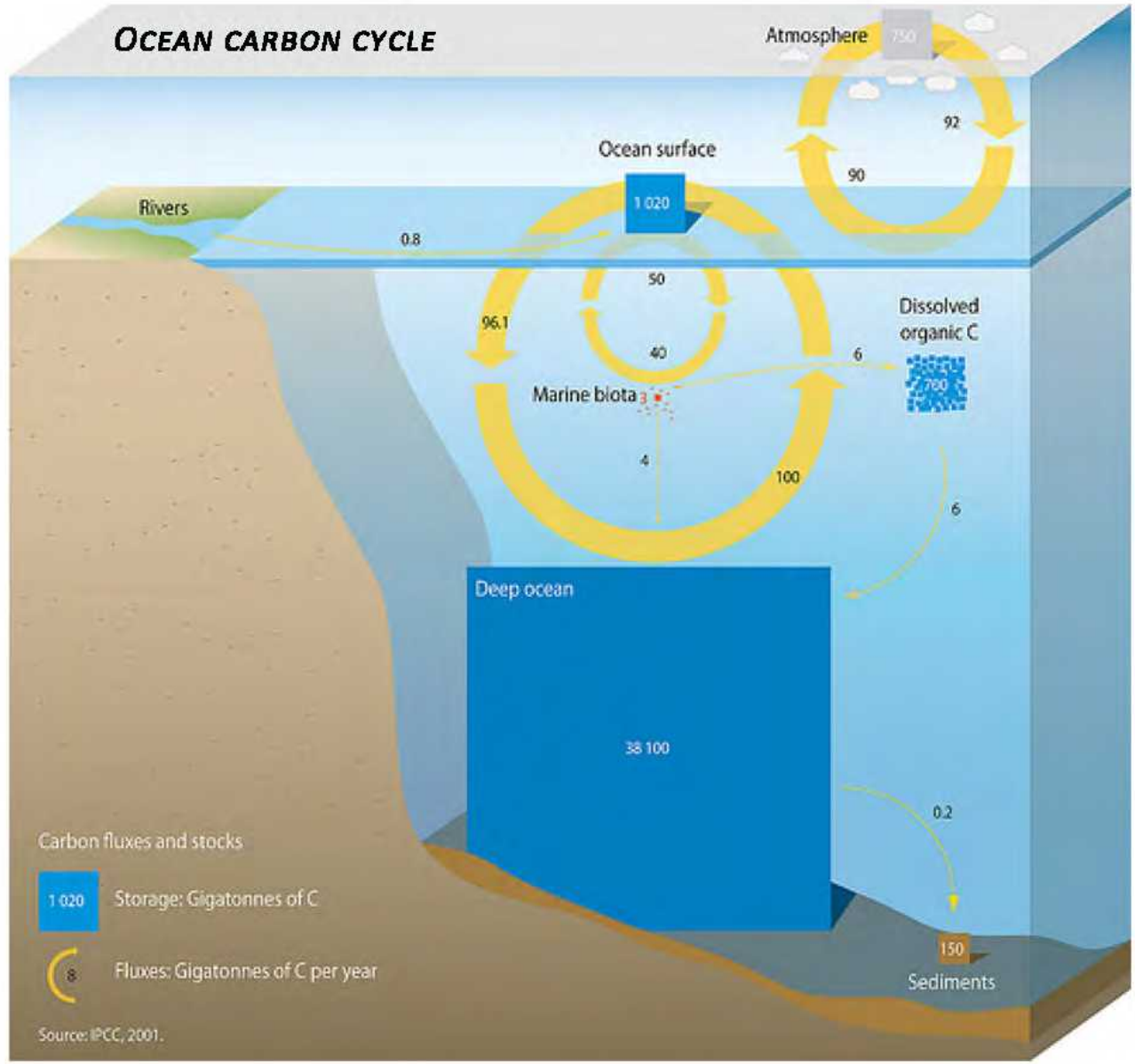
A computer simulation of the environmental fate of DDT (dichlorodiphenyltrichloroethane) has revealed that substantial quantities of the pesticide are still being released from the world's oceans, despite widespread restrictions on its use during the 1970s.

The calculations show that although remaining DDT use today tends to be in the southern hemisphere, its concentrations are actually growing in the northern hemisphere as it moves through the world's oceans and atmosphere.

Residues of the pesticide DDT may be heading northwards. *Corbis*

An estimated 1.5 million tonnes of DDT were used worldwide between the 1940s and 1970s, both as an agricultural insecticide and to control disease-carrying insects such as mosquitoes – the chemical was a key weapon in the war against malaria, for example. But DDT is toxic to a wide range of aquatic life, and its eggshell-thinning effects also had a drastic impact on many bird species. Concerns about its environmental toxicity led to a series of countries banning the agricultural use of DDT through the 1970s.

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



Ocean carbon cycle

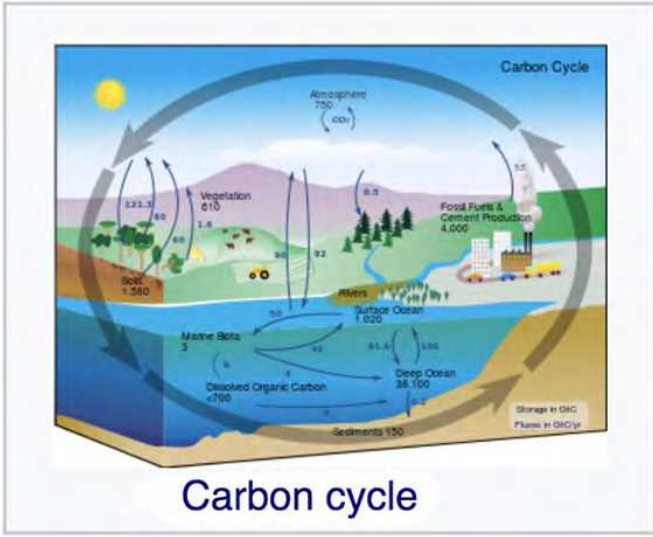
By Offnfopt (Own work) [Public domain or CC0], via \
Commons

Common biogeochemical cycles are

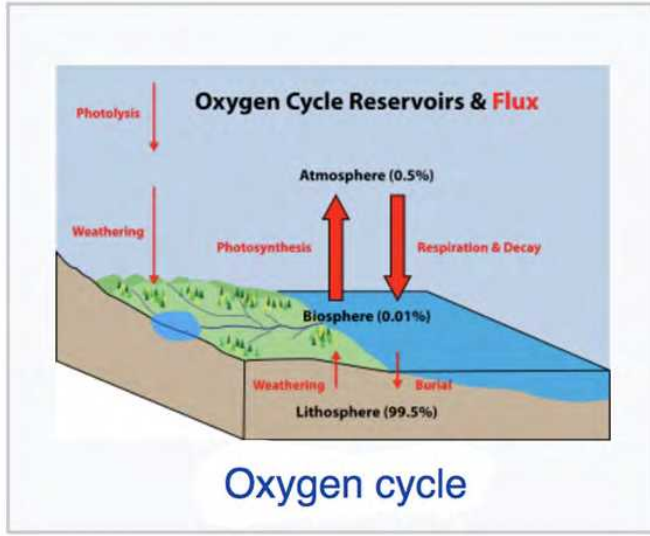
Carbon

Oxygen

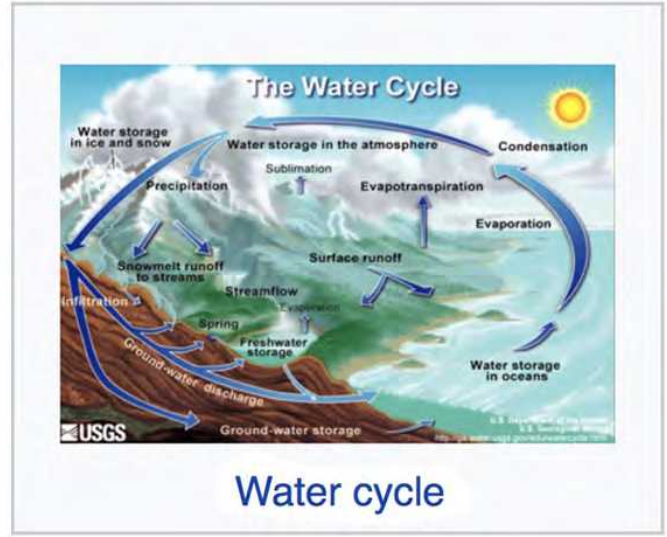
Water



Carbon cycle



Oxygen cycle



Water cycle

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 Commons
Oxygen - 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=9842362
Water - By John M. Even / USGS [Public domain or Public domain], via Wikimedia Commons

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

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.

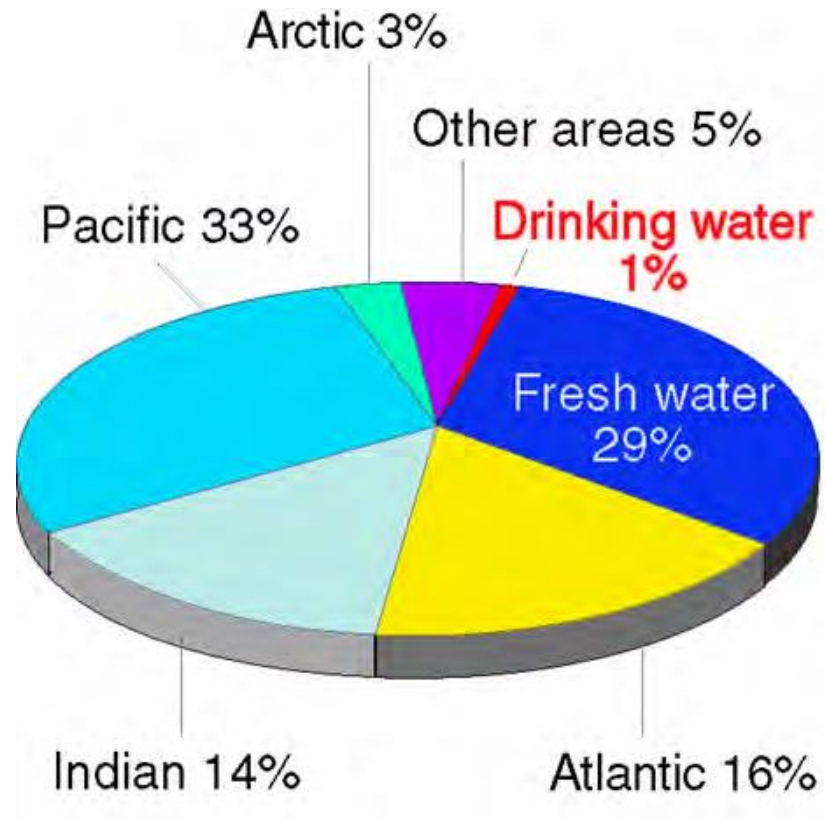
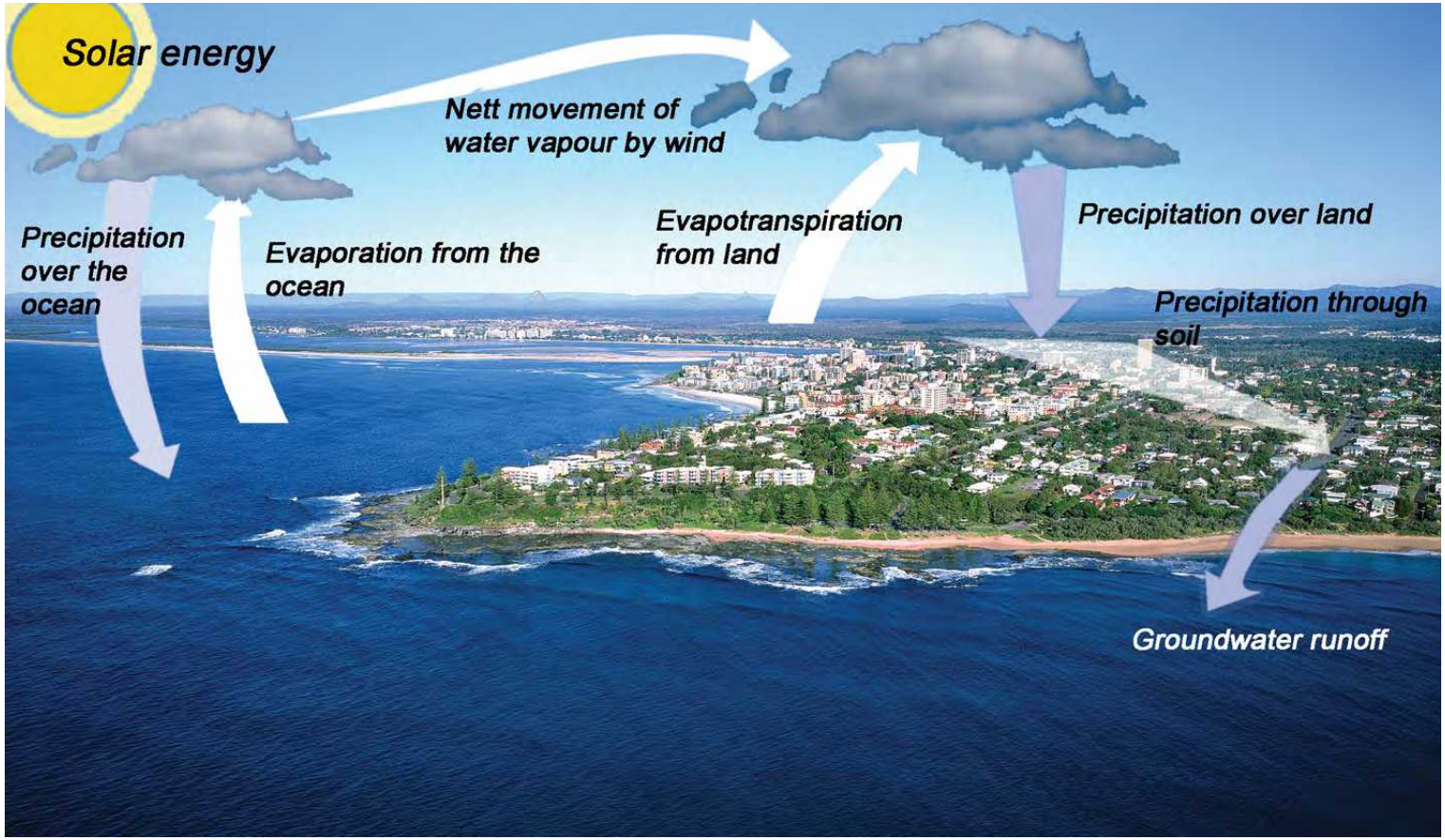


Illustration Bob Moffatt

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

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

Cyclone Debbie

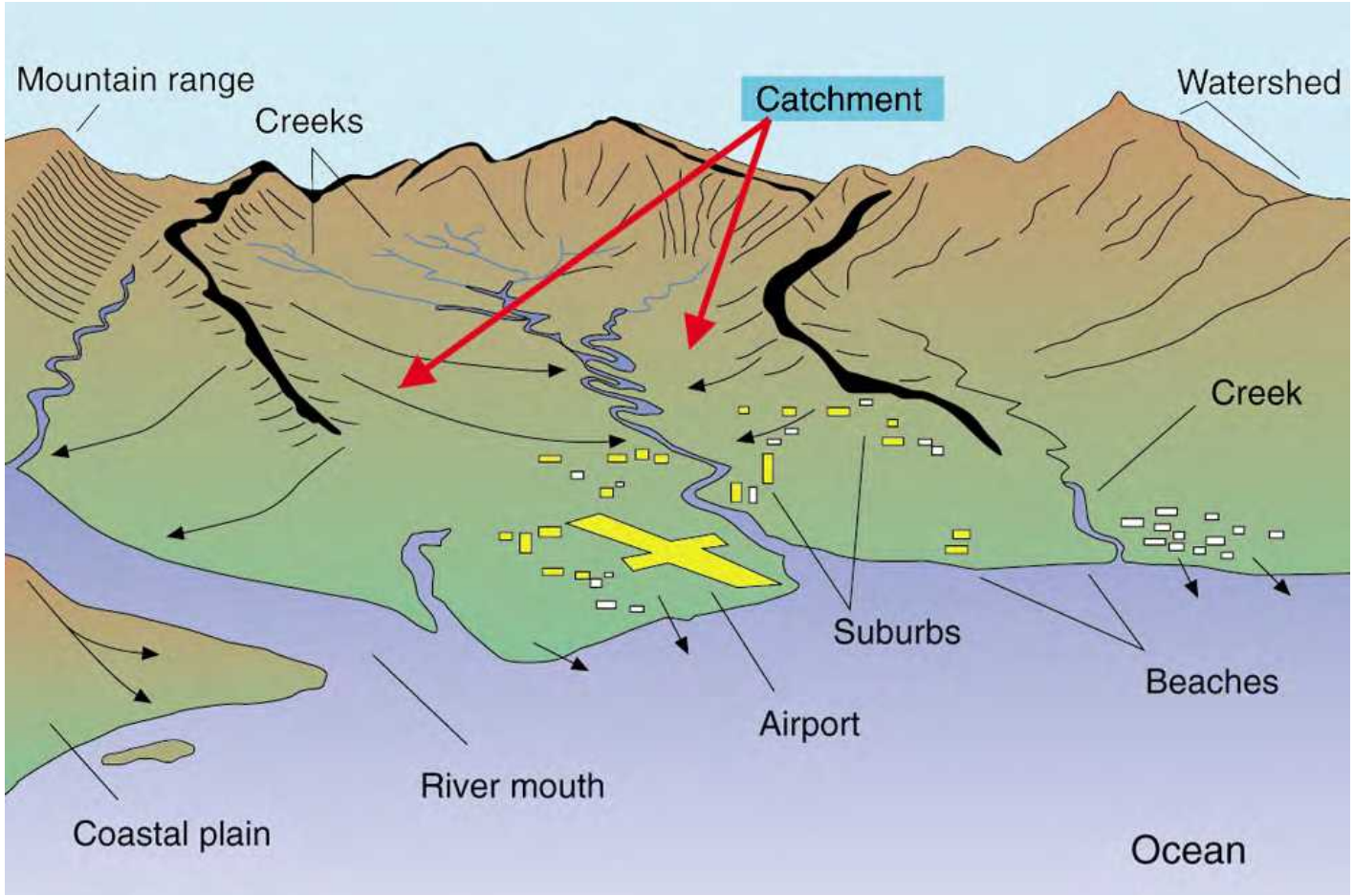
During these events, large volumes of water runoff can carry nutrients and sediments onto the Great Barrier Reef.

A flood plume containing sediments, nutrients and pesticides flowing onto the Great Barrier Reef from Bundaberg. AAP Image/James Cook University

Cyclone flood plume

AAP Image/James Cook University

Water in the cycle erodes rocks in mountains, which travel down rivers to form sand, which ends up on our beaches and is blown onto the beach to form sand dunes, allowing plants to grow.



Water catchment

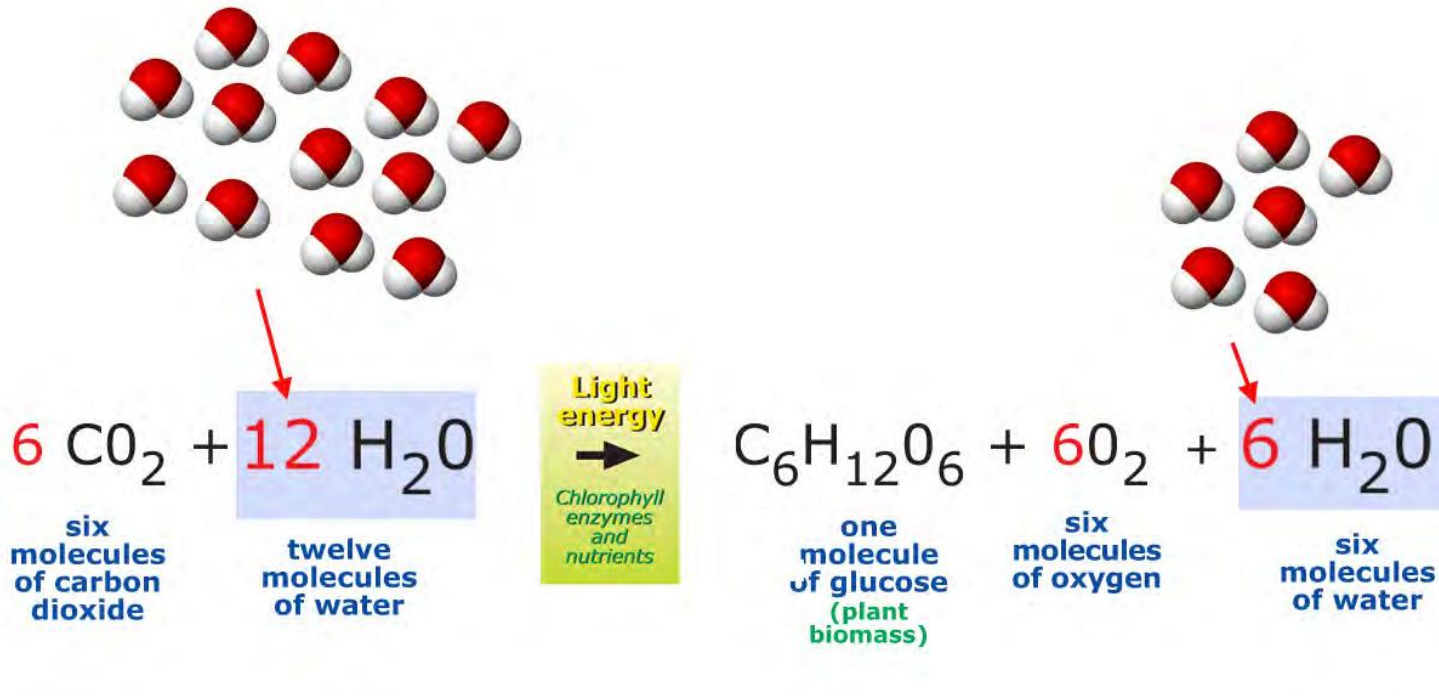
Illustration Bob Moffatt

Water also cycles off the land into storm water pipes that can greatly affect the water quality of local waterways.

Storm water drain

Photo Bob Moffatt

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



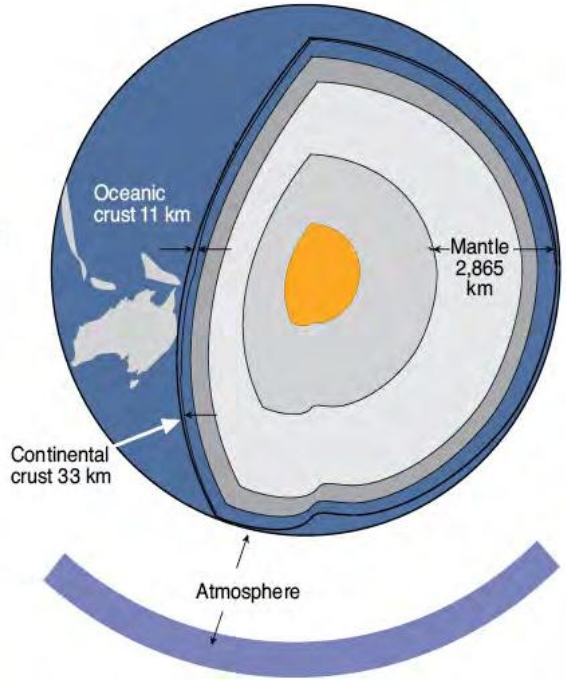
Photosynthesis equation involves water

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

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%).

99.5% crust and mantle
0.01% biosphere
0.36% atmosphere

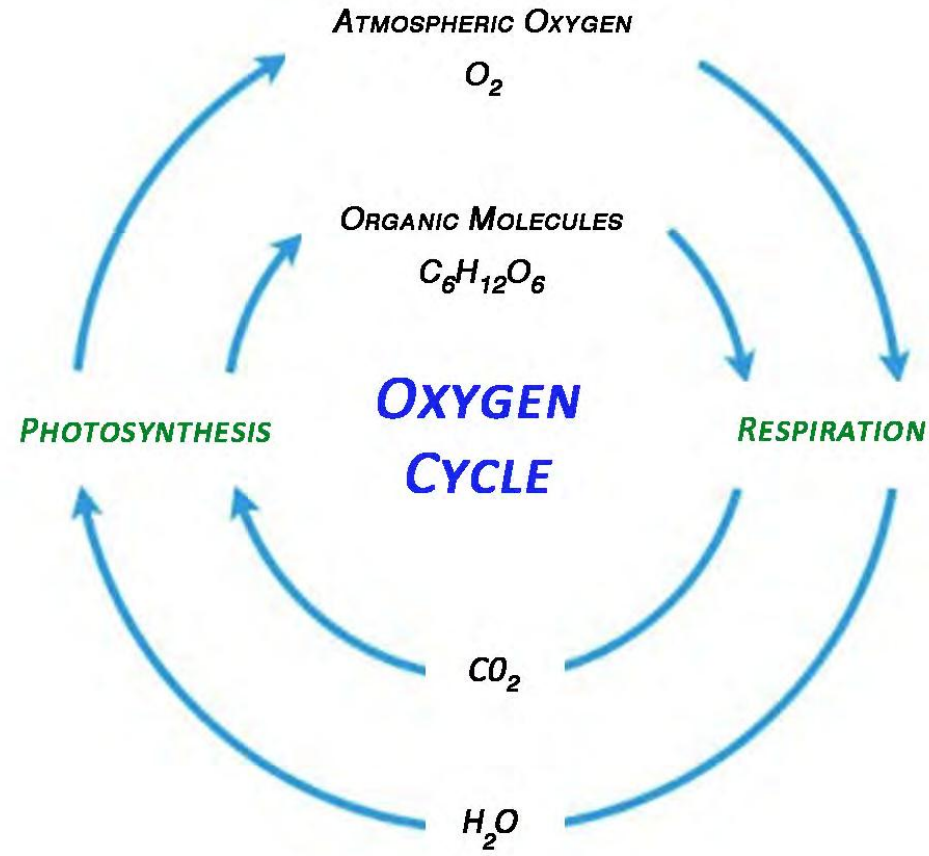


Available oxygen to planet Earth

Illustration Bob Moffatt

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.

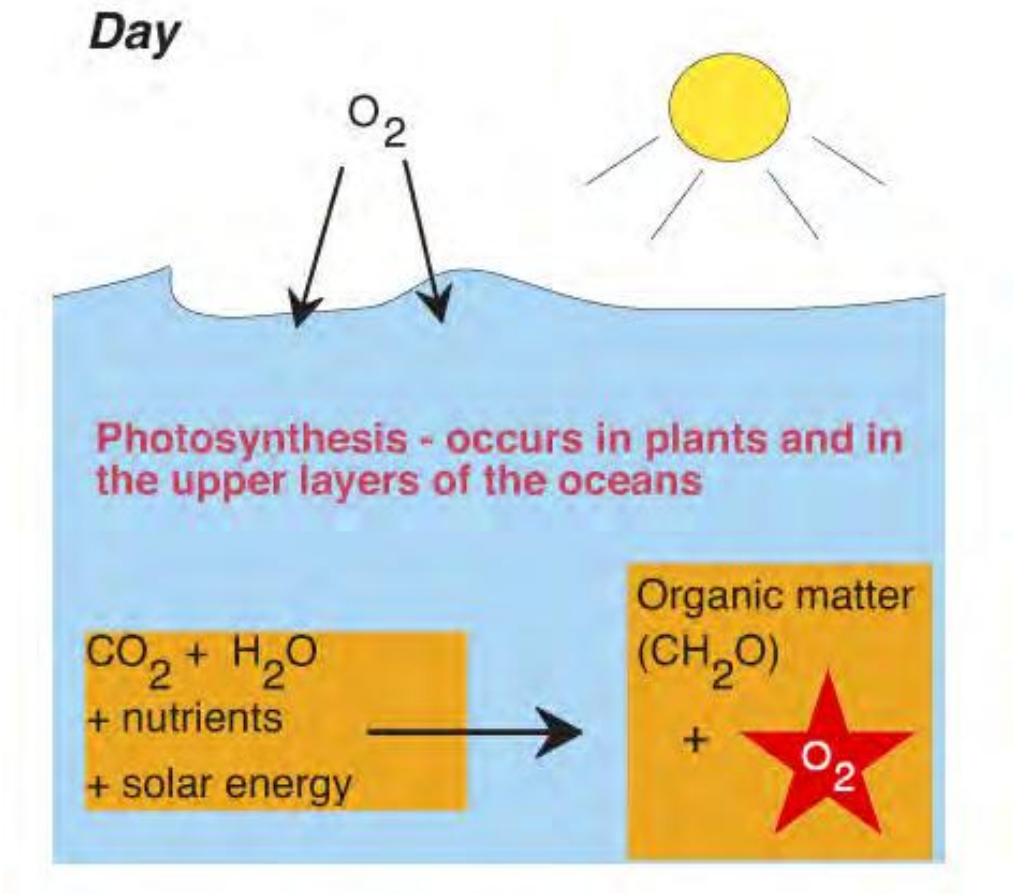
Photosynthesis and respiration are the two main processes of this cycle.



Oxygen cycle

Illustration Bob Moffatt

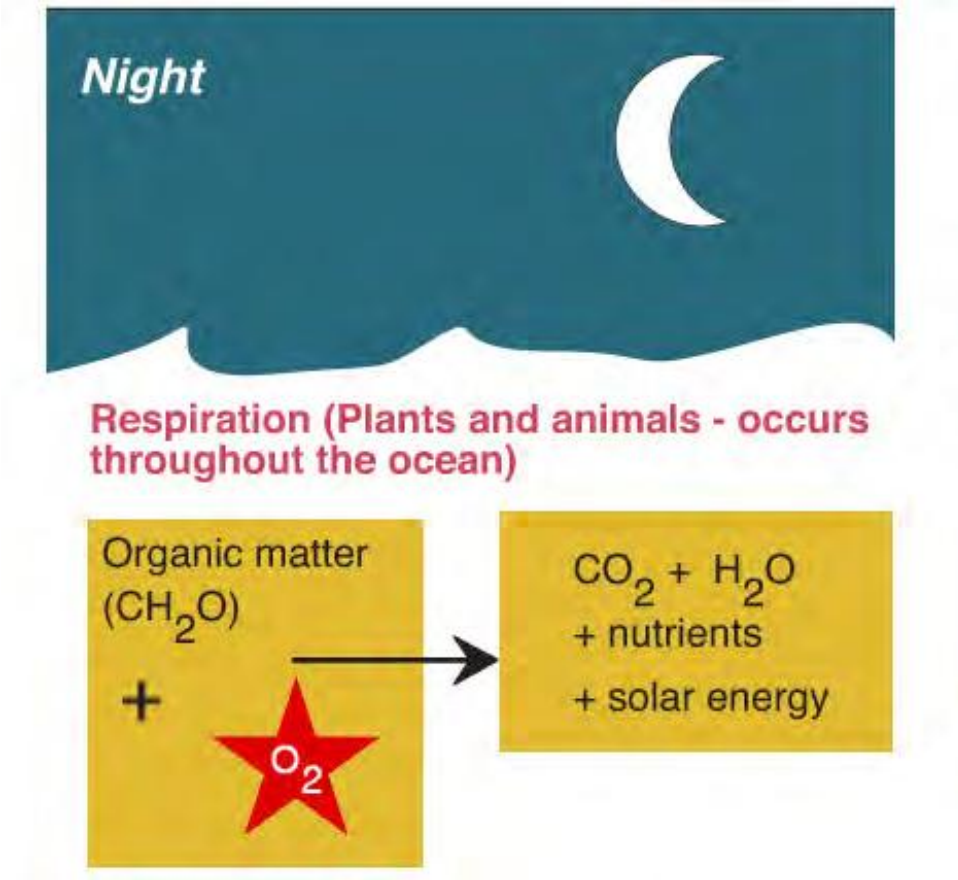
The processes involved in photosynthesis in daylight involve water combining with carbon dioxide to make sugar and oxygen and released into the atmosphere.



Photosynthesis day

Illustration Bob Moffatt

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

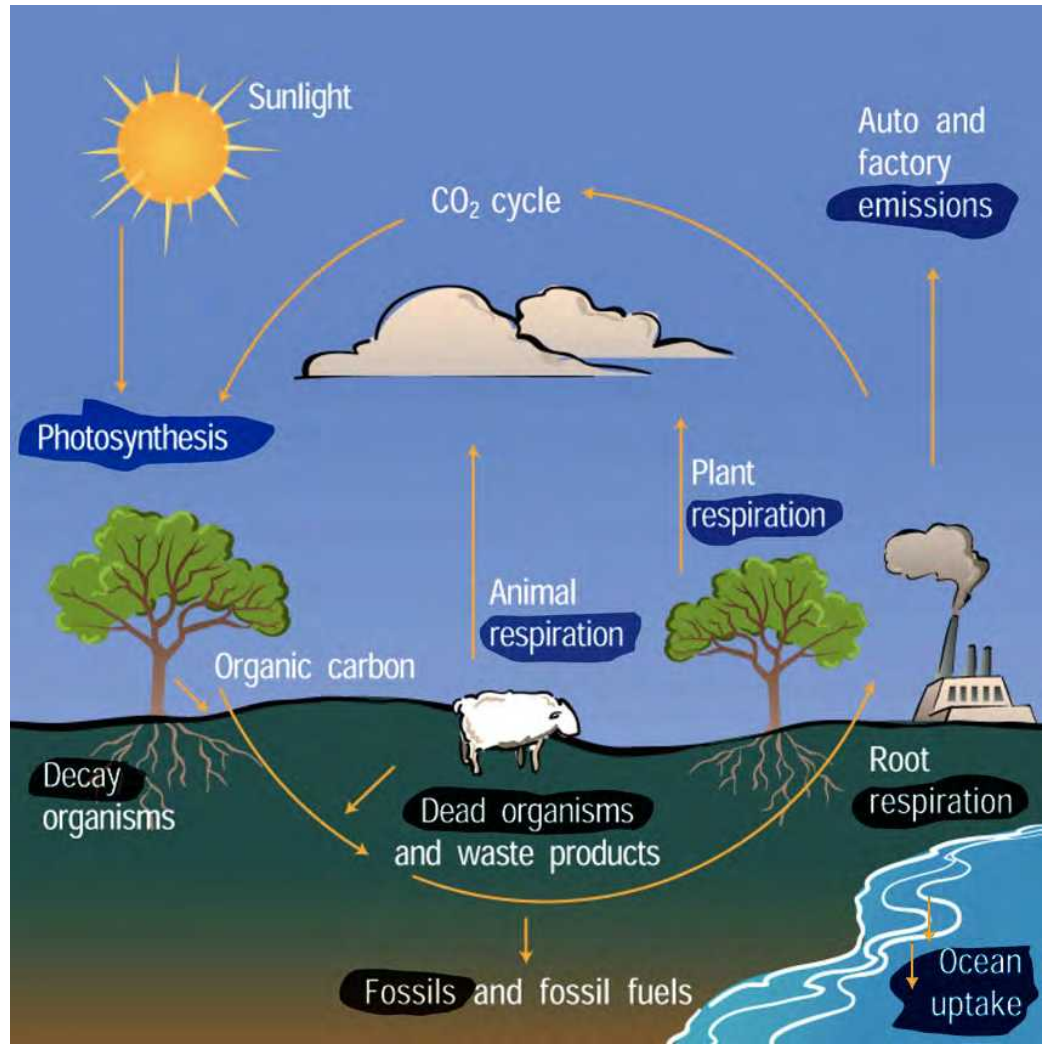
Carbon cycle

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

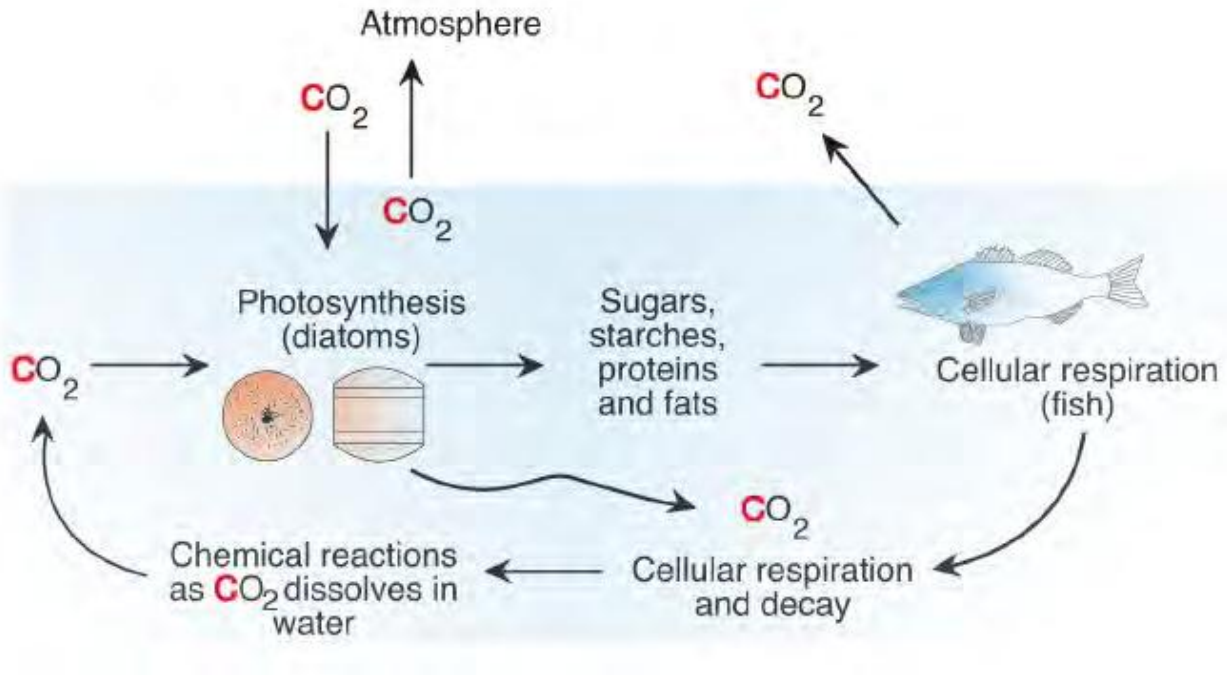
Some processes include

- 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



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.



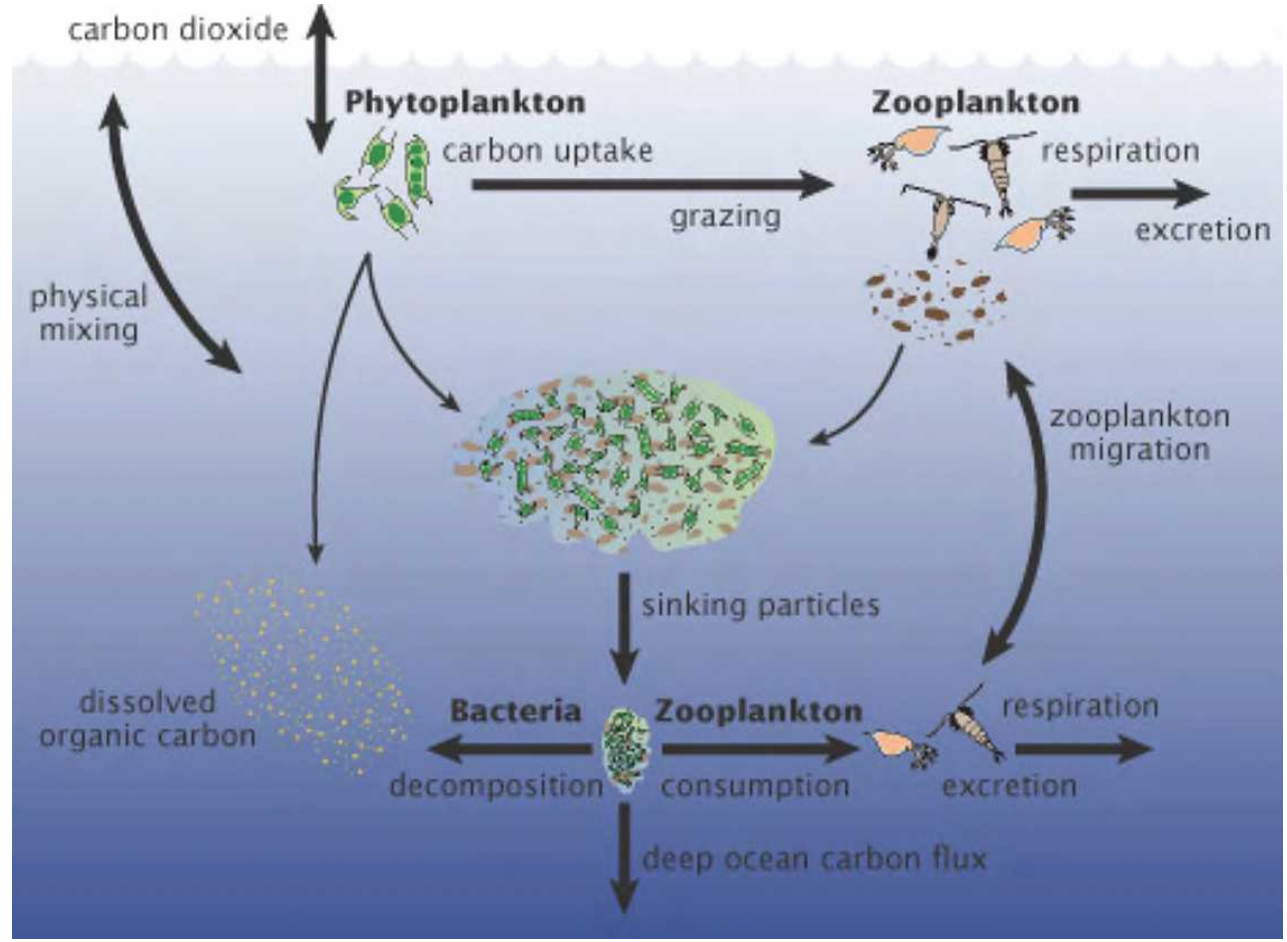
Carbon cycle photosynthesis and respiration elements

Illustration Bob Moffatt

Marine organisms (such as phytoplankton) 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.

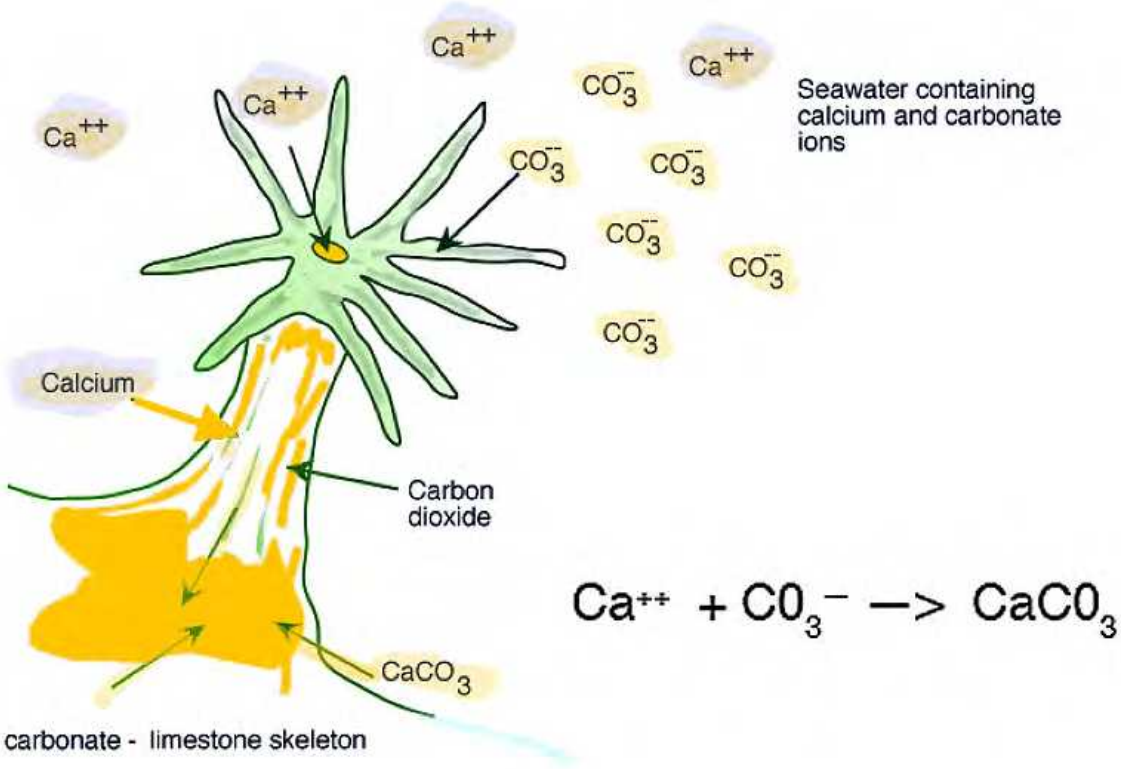
It is estimated oceans contain 50 times more carbon dioxide than the atmosphere as it diffuses into the ocean's surface.



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

Carbon dioxide dissolves in rain and diffuses into seawater when the pressure of CO_2 is greater in the atmosphere than the ocean's surface waters.

This dissolved carbon dioxide forms bicarbonate ions in seawater that can combine with calcium ions to form calcium carbonate. Many marine animals especially ones with shells and limestone skeletons (corals) absorb carbon in this form.



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

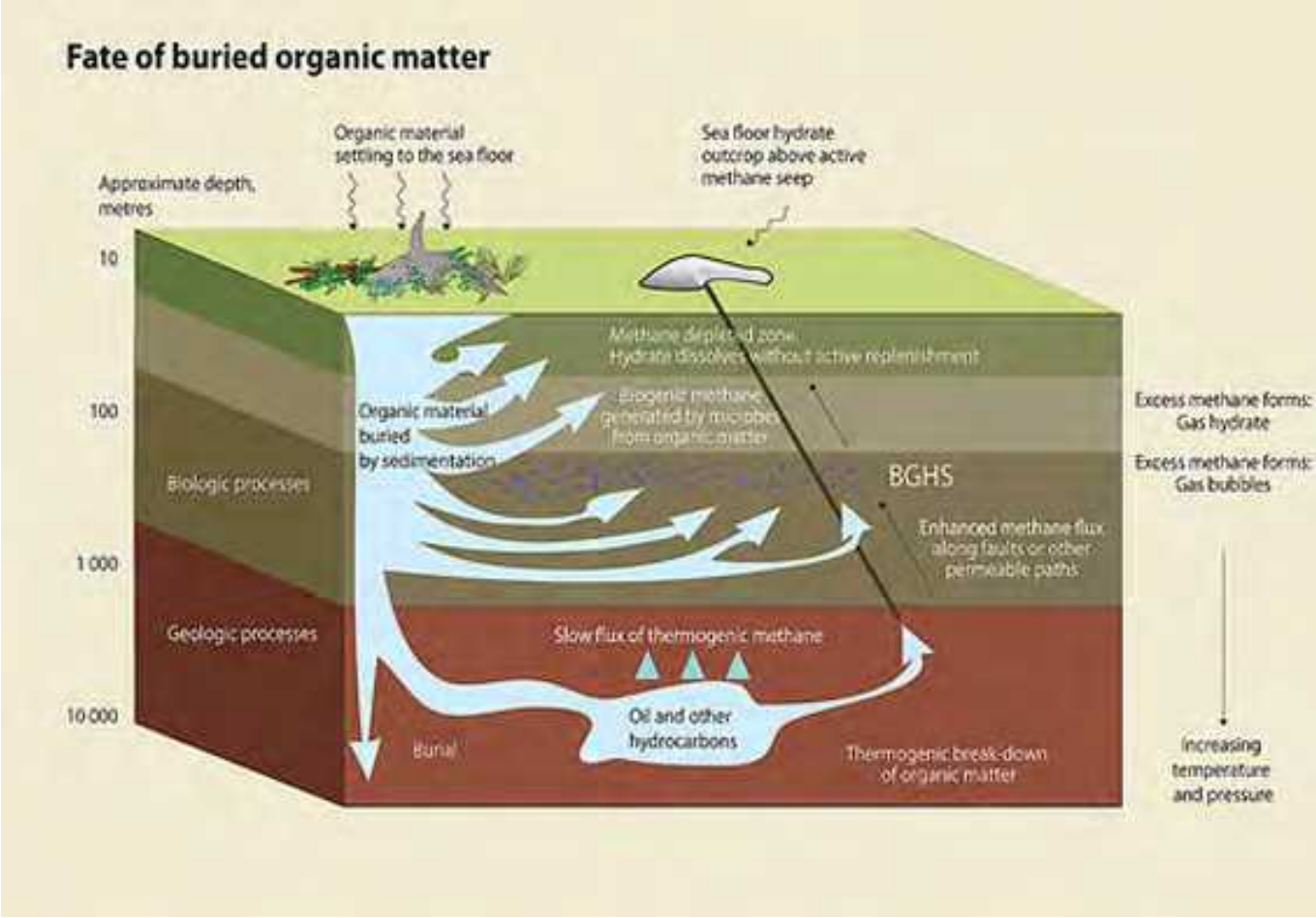
Illustration Bob Moffatt

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 forming hydrocarbon stores and methane gas.



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

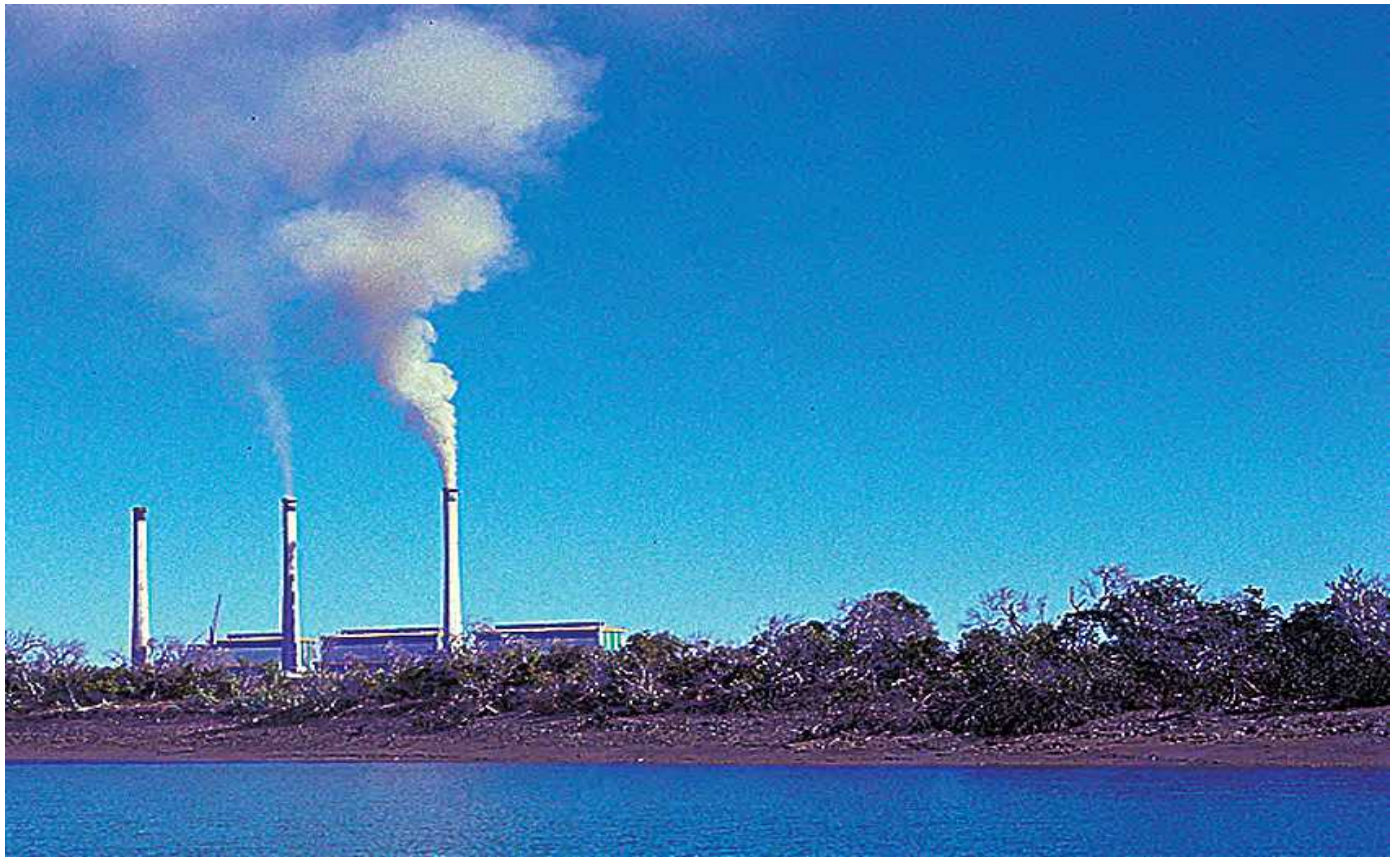
Fate of organic buried matter
By GRID-Arendal - GRID-Arendal, Public Domain, https://en.wikipedia.org/w/index.php?curid=55925857

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

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

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

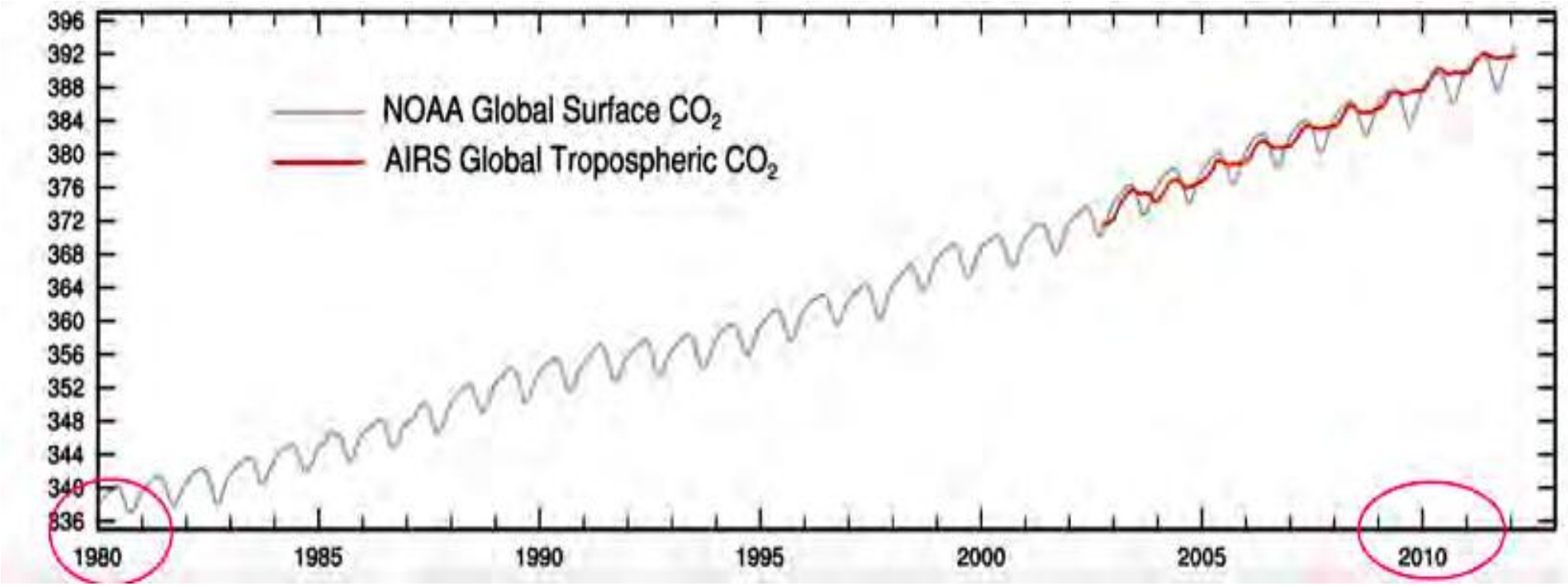
Cars in a city

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.

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

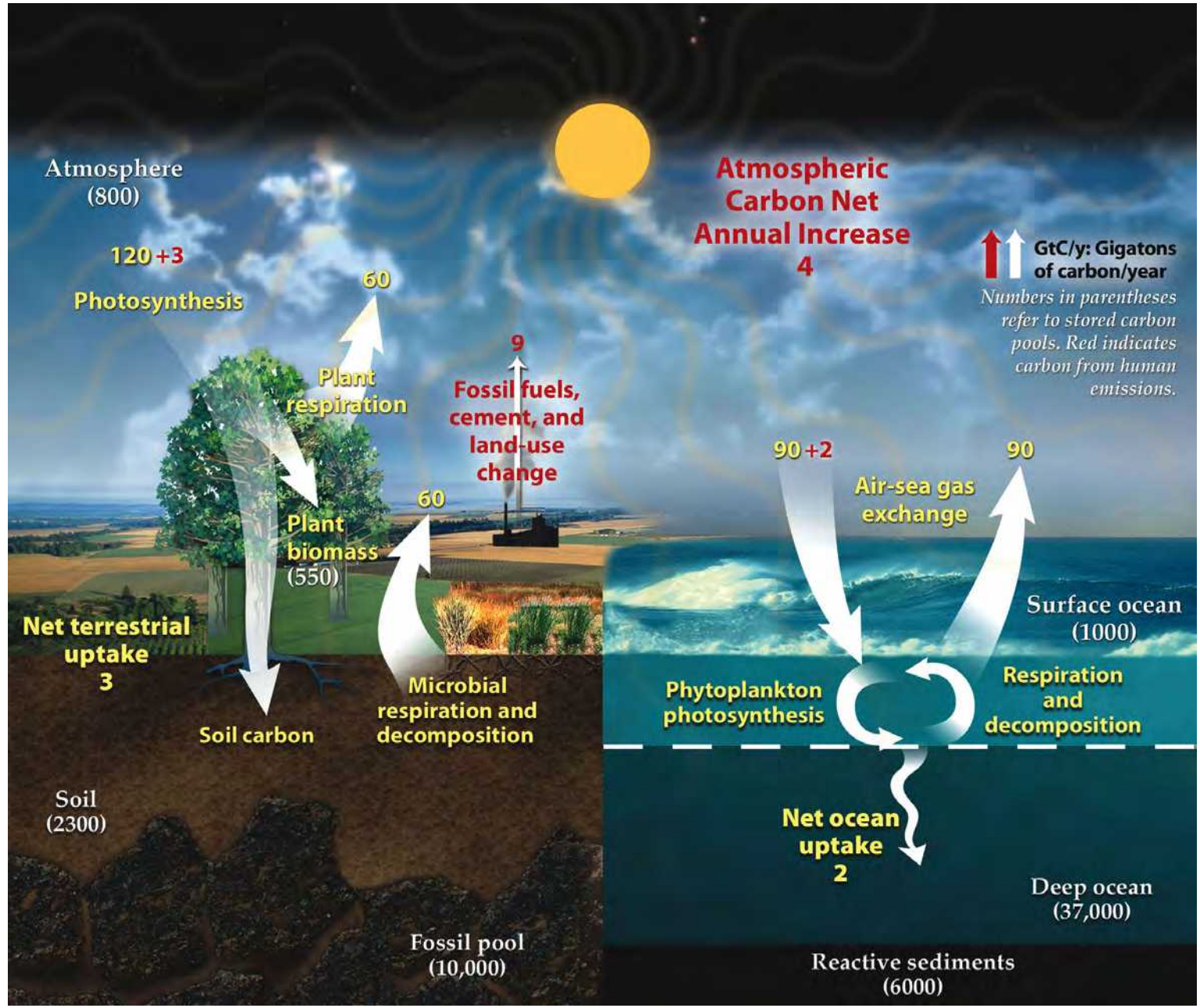


AIRS 2011 annual mean carbon dioxide concentration in the free troposphere

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

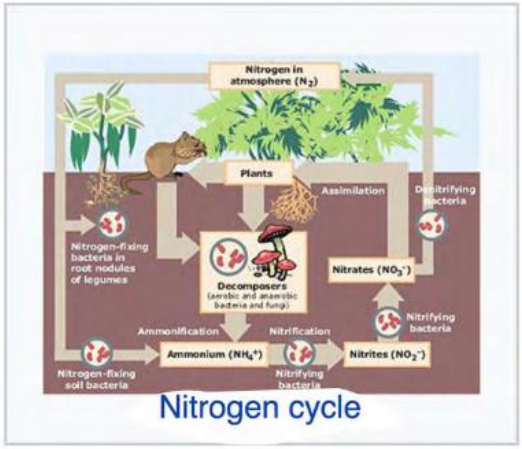
You can read more at wiki:

Search carbon cycle.

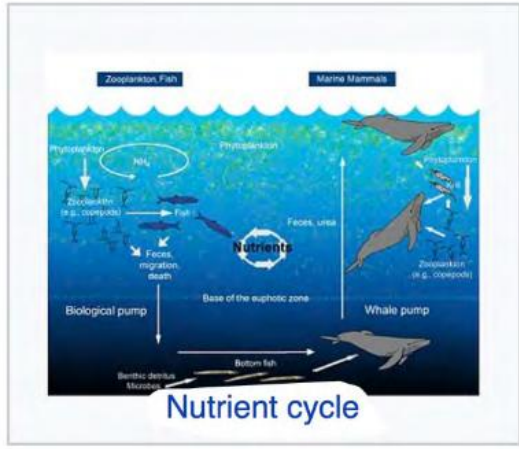


By Diagram adapted from U.S. DOE, Biological and Environmental Research Information System. [Public domain], via Wikimedia Commons

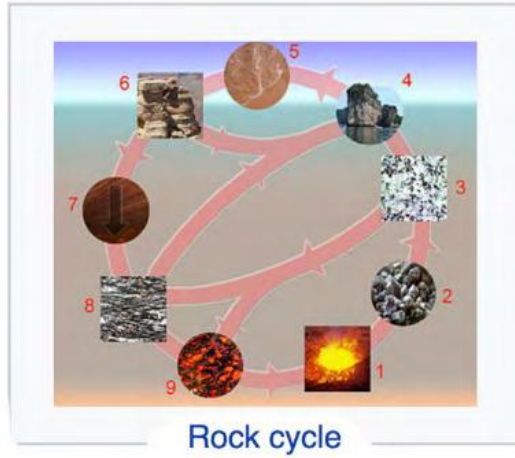
Other cycles are – Nitrogen, nutrient, phosphorus, sulfur and rock



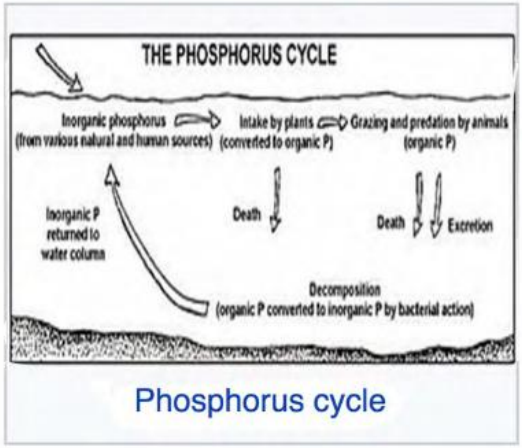
Nitrogen cycle



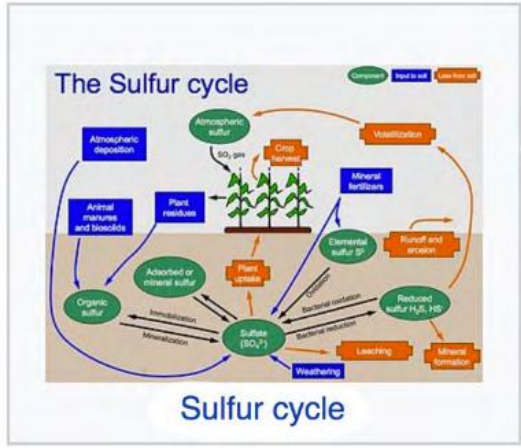
Nutrient cycle



Rock cycle



Phosphorus cycle



Sulfur cycle

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)

Write a summary statement for the processes involved in the following cycles	
Water	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.
Carbon	Carbon passes through the air, water, plankton, fish, decomposer organisms and mud. Some processes include Respiration Photosynthesis Diffusion Dissolving Death Decomposition Fossilization Burning (Wood, petrol in cars etc) Sedimentation
Oxygen	In daylight involve water combining with carbon dioxide to make sugar and oxygen and released into the atmosphere. At night respiration then takes this oxygen out of the air, combines it with sugar making water and carbon dioxide and releasing energy.

Write a summary statement for the **processes** involved in the following cycles	
Water	
Carbon	
Oxygen	

Ch 2 Ocean currents

T004 Current driving forces

T005 Ocean water, heat and nutrient distribution

T006 Seawater properties

T007 Effects of temperature, density and salinity

T008 Oxygen minimum zone

T009 Deep ocean circulation

T004 Current driving forces

Syllabus statement

The syllabus says ... you should be able to

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

Describe

- give an account (written or spoken) of a situation, event, pattern or process,

or

- of the characteristics or features of something.

Questions

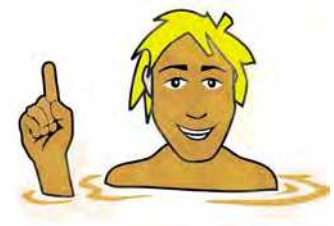
1. Describe how the following drive ocean surface currents

A. Wind

B. Temperature

C. Gravity (tides)

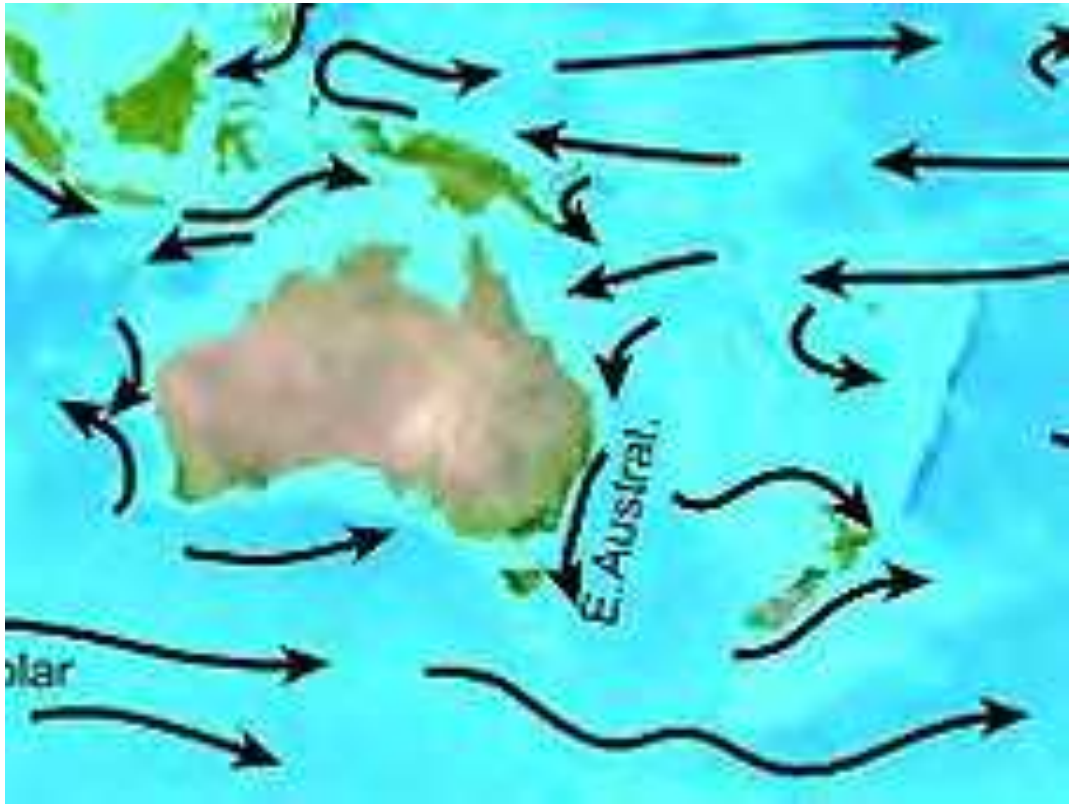
2. List important Australian surface currents



Describe how the following drive ocean surface currents	
Wind	
Temperature	
Gravity (tides)	

Definition

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



Ocean currents

Key ideas

•Ocean water circulates in currents.

•Surface currents are caused mainly by wind and affect the uppermost 10% of the ocean.

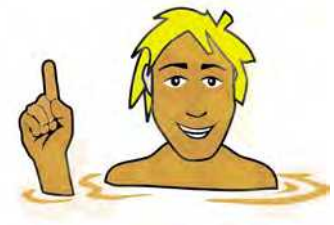
•Circulation of the other 90% of the ocean is driven by gravity, as dense water sinks and less dense water rises.

•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.

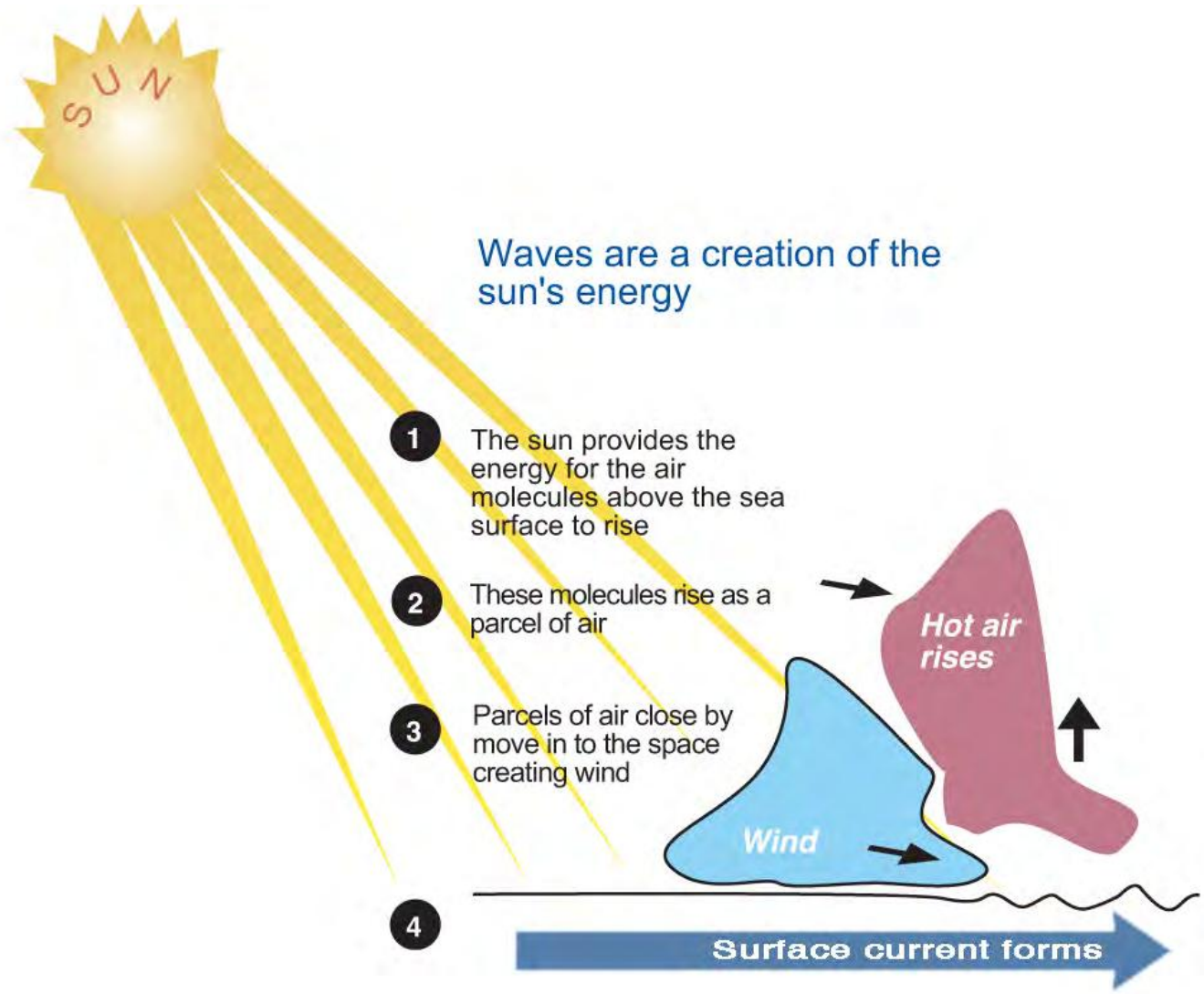


Wind

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.

The length of water where the wind blows (transferring its energy) is called the fetch length.



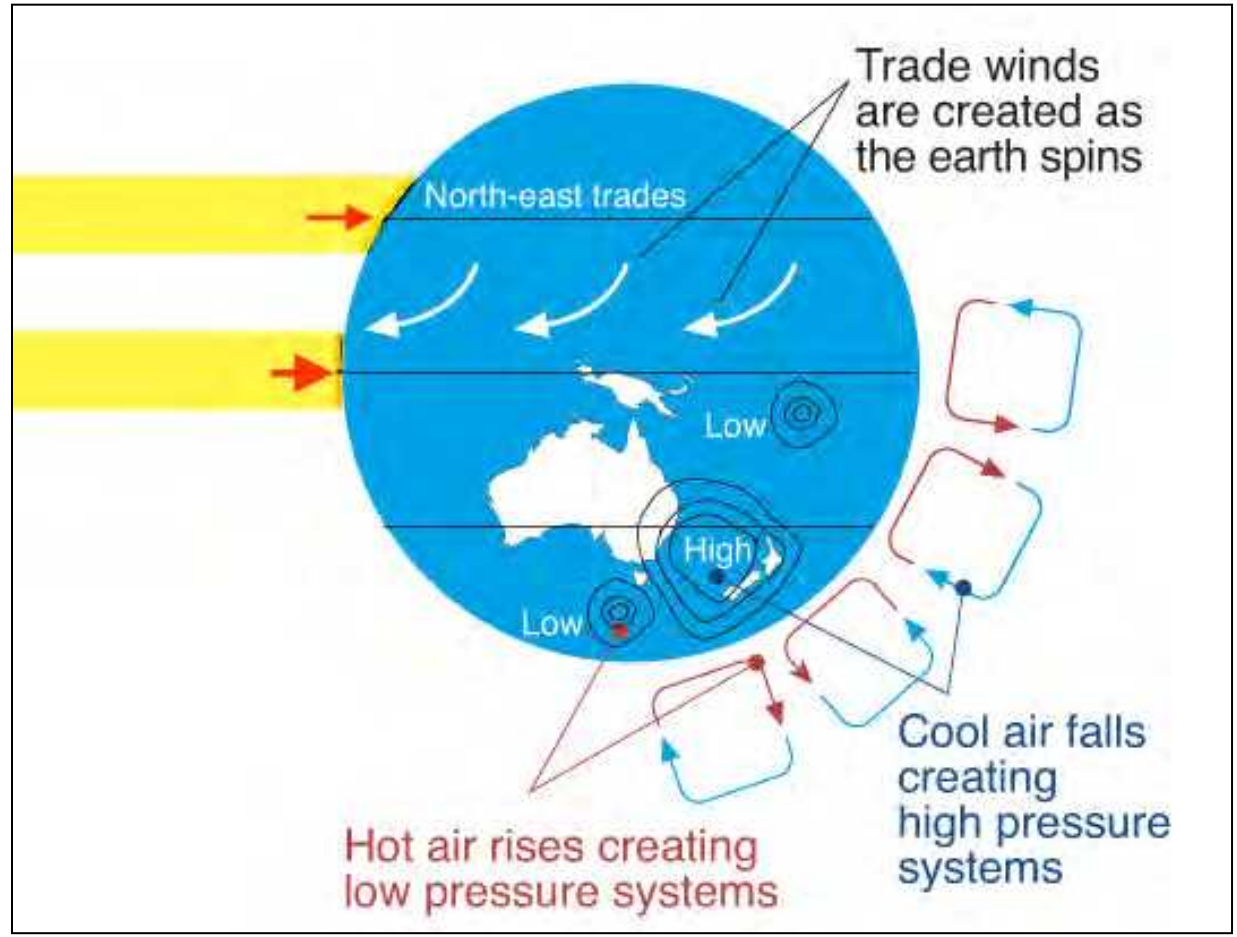
Wind and surface current principle

Illustration Bob Moffatt

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.

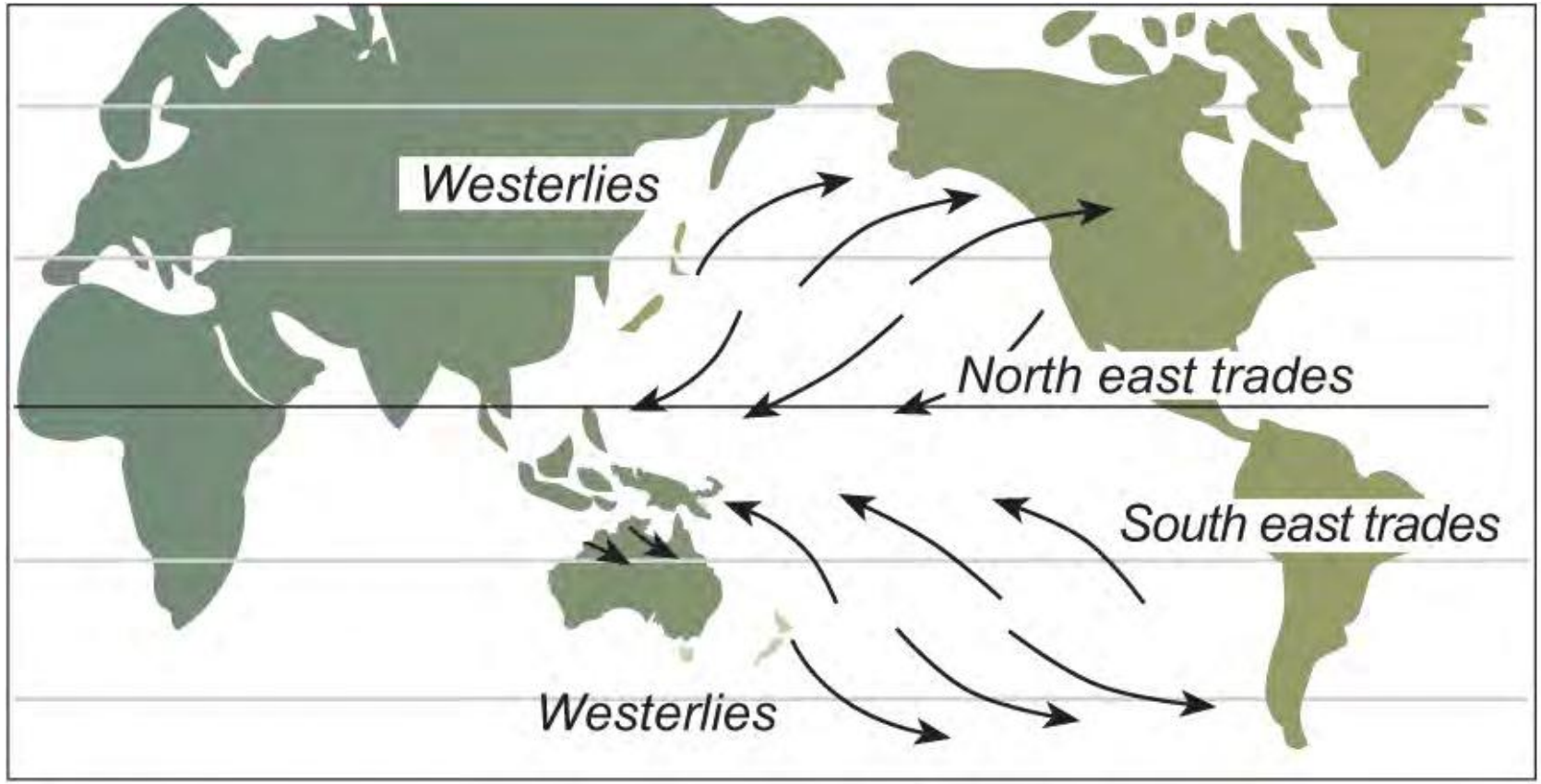
When this rising hot air cools it falls, creating areas of high pressure.



Hadley cells and wind

Illustration Bob Moffatt

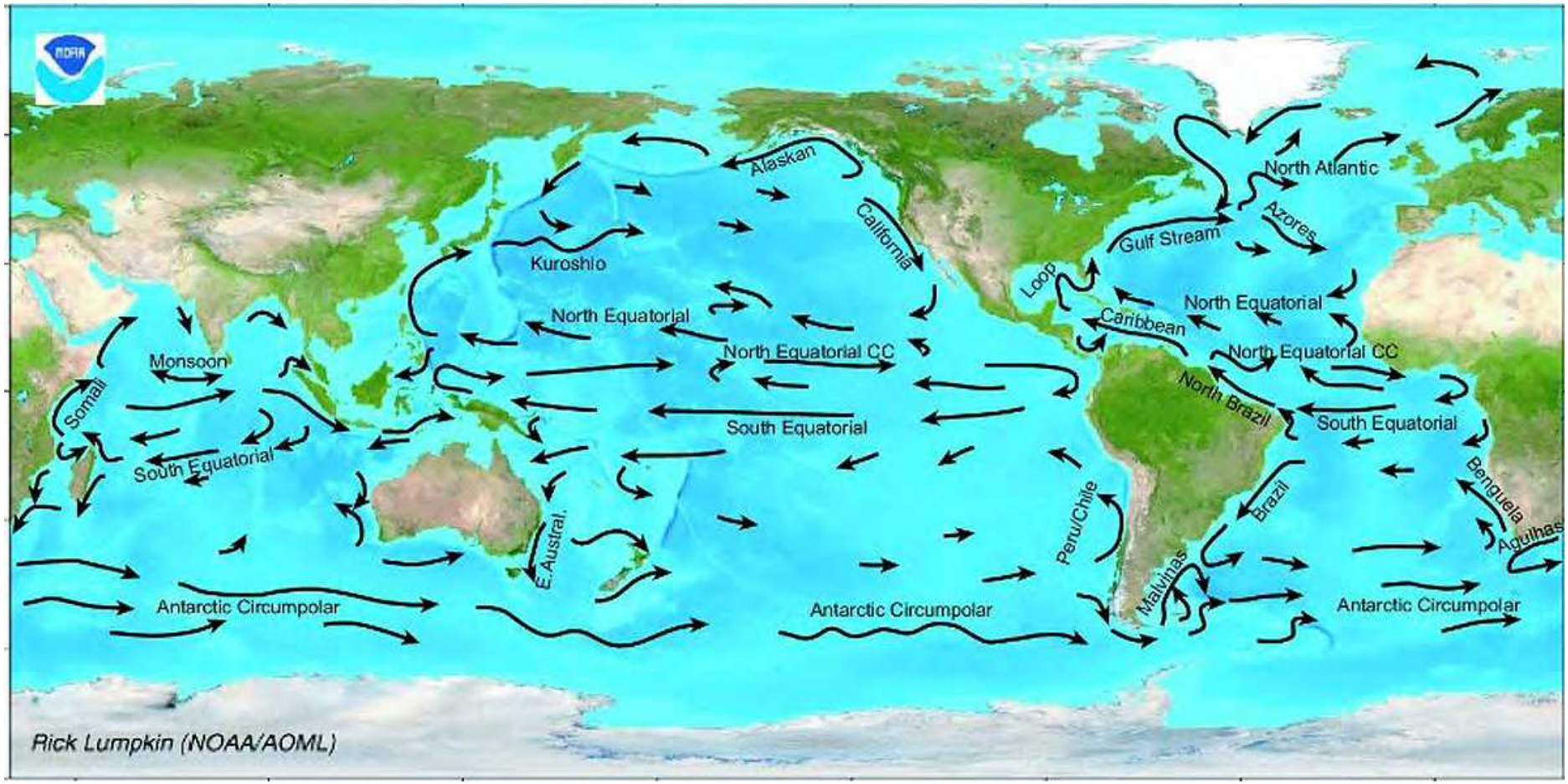
The spinning Earth causes these systems (called trade winds) to move in one prevailing direction, depending on their latitude.



Trade winds

Illustration Bob Moffatt

Trade winds generate the ocean surface currents.

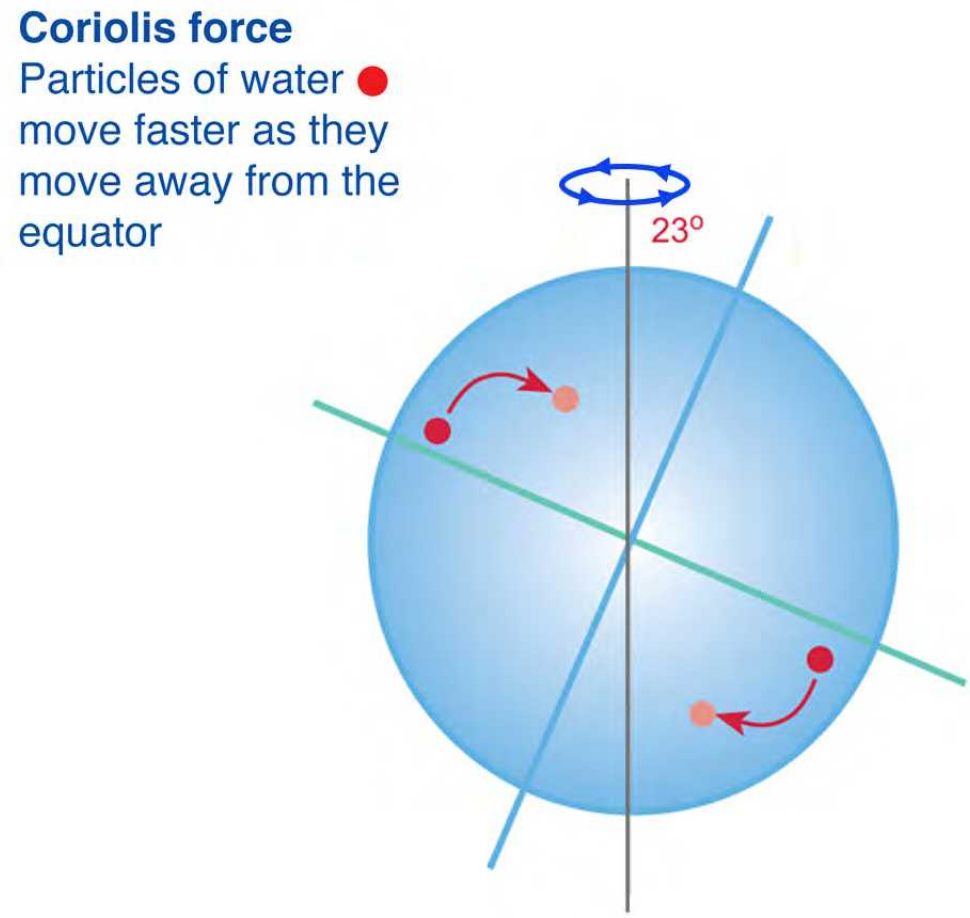


Pacific Ocean currents

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

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

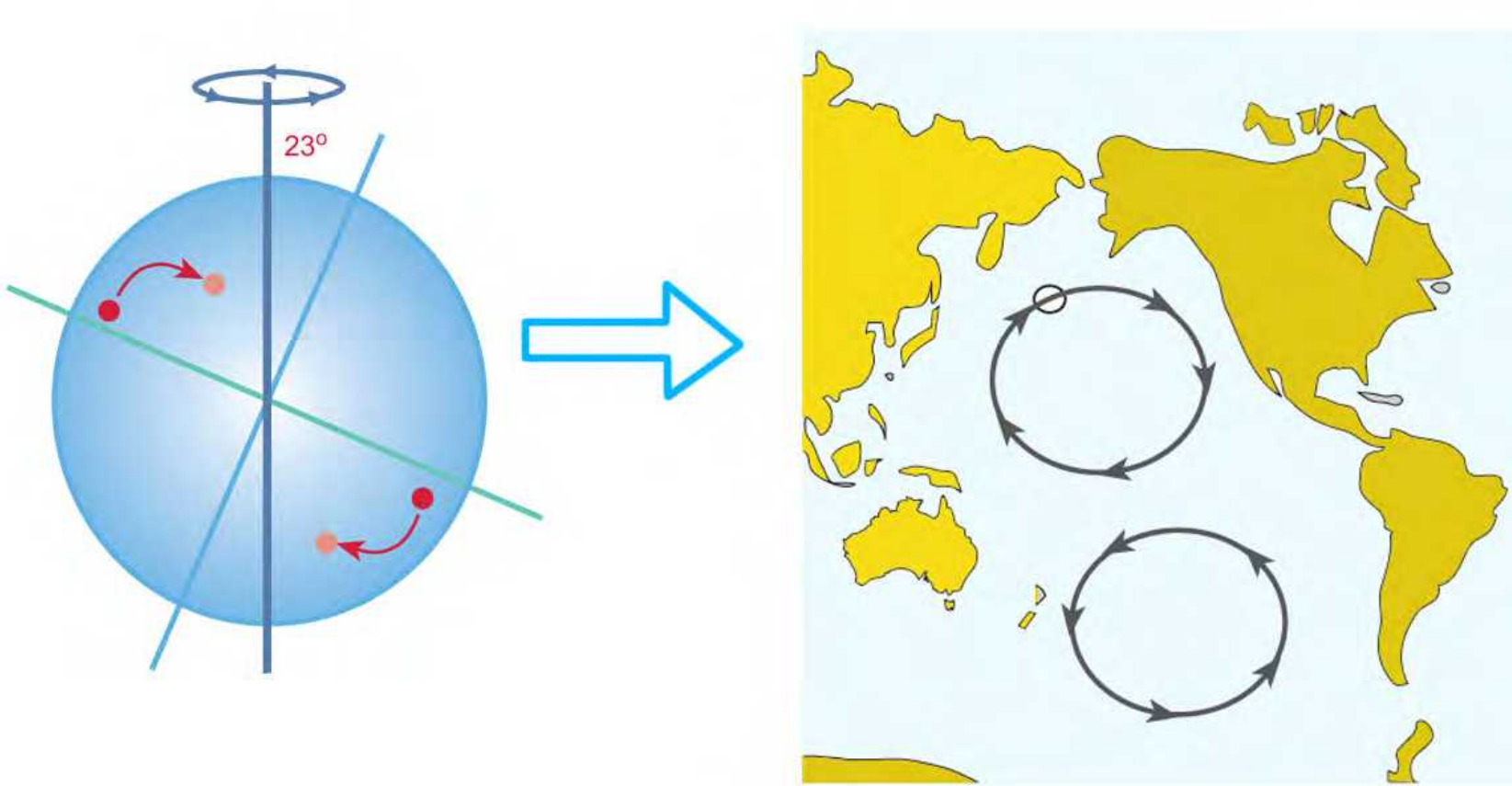
The force driving these particles is called the Coriolis force and is the apparent motion of freely moving objects as earth rotates beneath them.



Coriolis force

Illustration Bob Moffatt

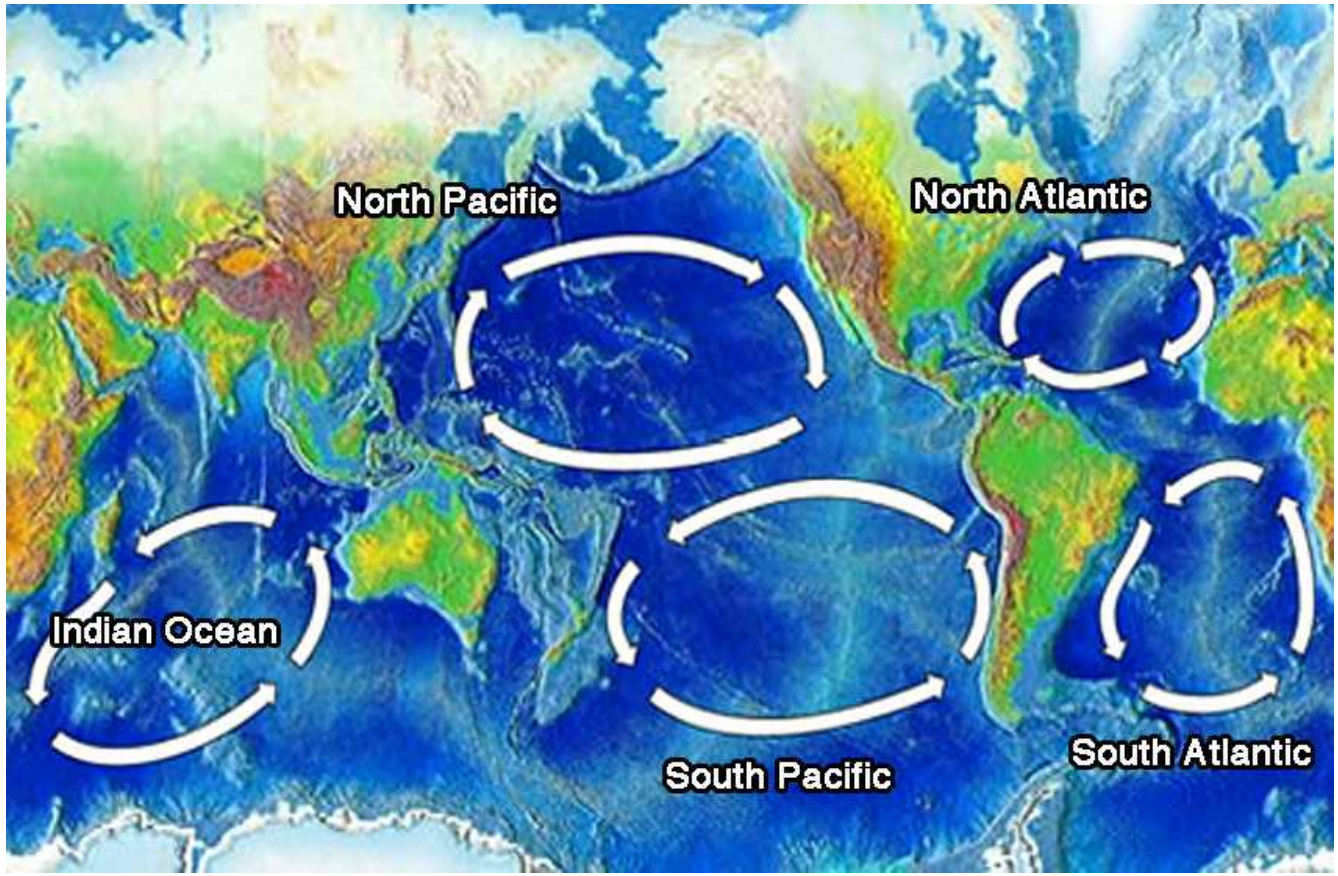
Coriolis forces cause ocean gyres. They are strongest near the poles, zero at the equator and make storms swirl clockwise in the Northern hemisphere and counterclockwise in the Southern Hemisphere.



Coriolis force and effect

Illustration Bob Moffatt

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”.

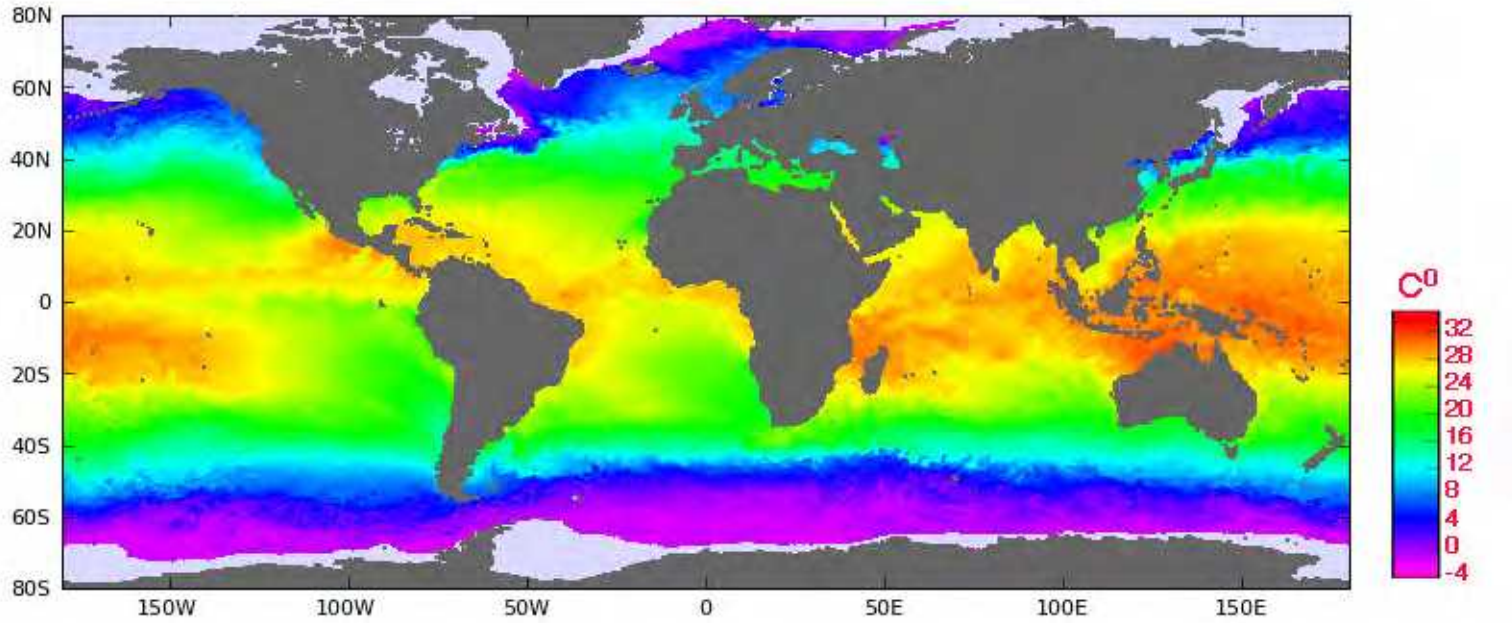


Five major ocean gyres

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

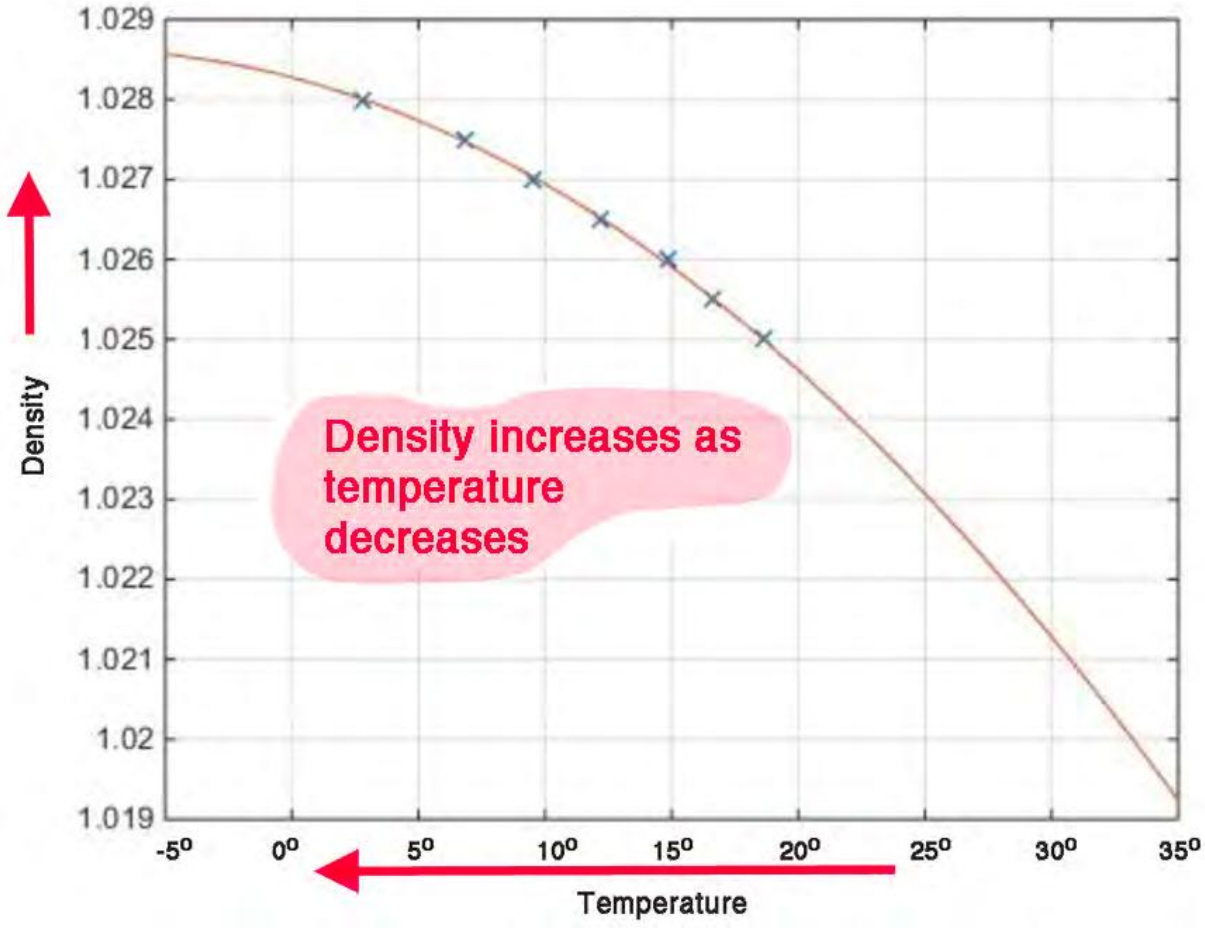
Temperature and gravity

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

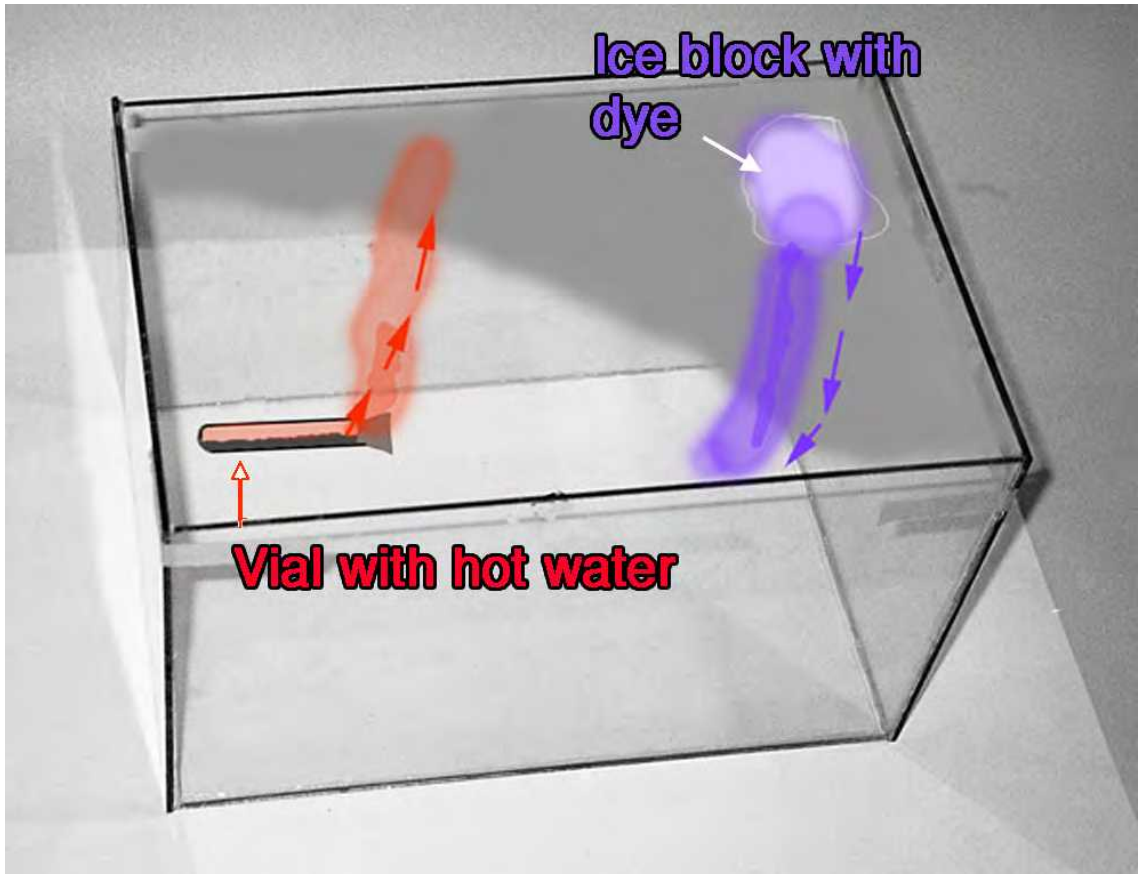
If water is cooled or becomes saltier through evaporation, it becomes denser.



Seawater density graph

Illustration Wet Paper

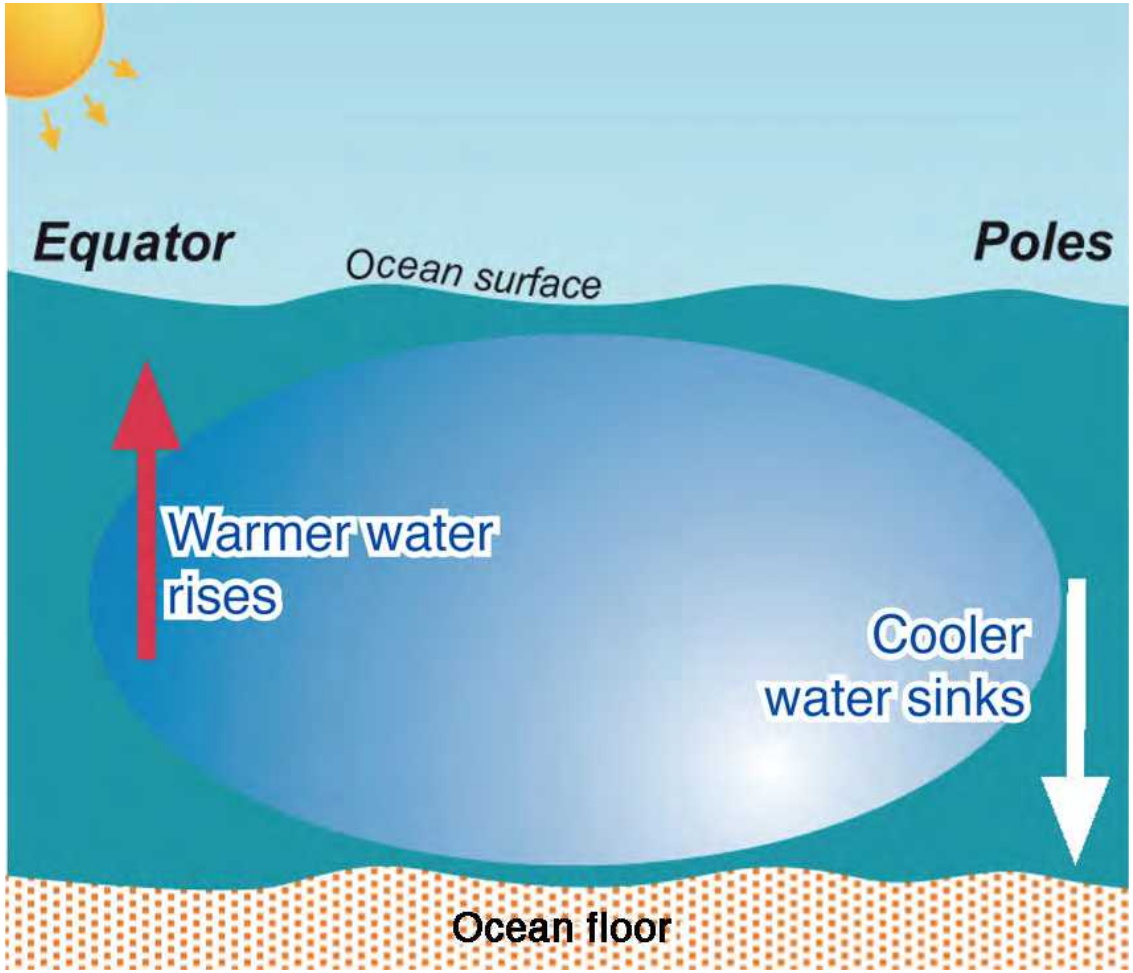
This can be shown in a simple demonstration using an aquarium filled with water, an ice block and a vial with warm water.



Convection experiment

Illustration Wet Paper

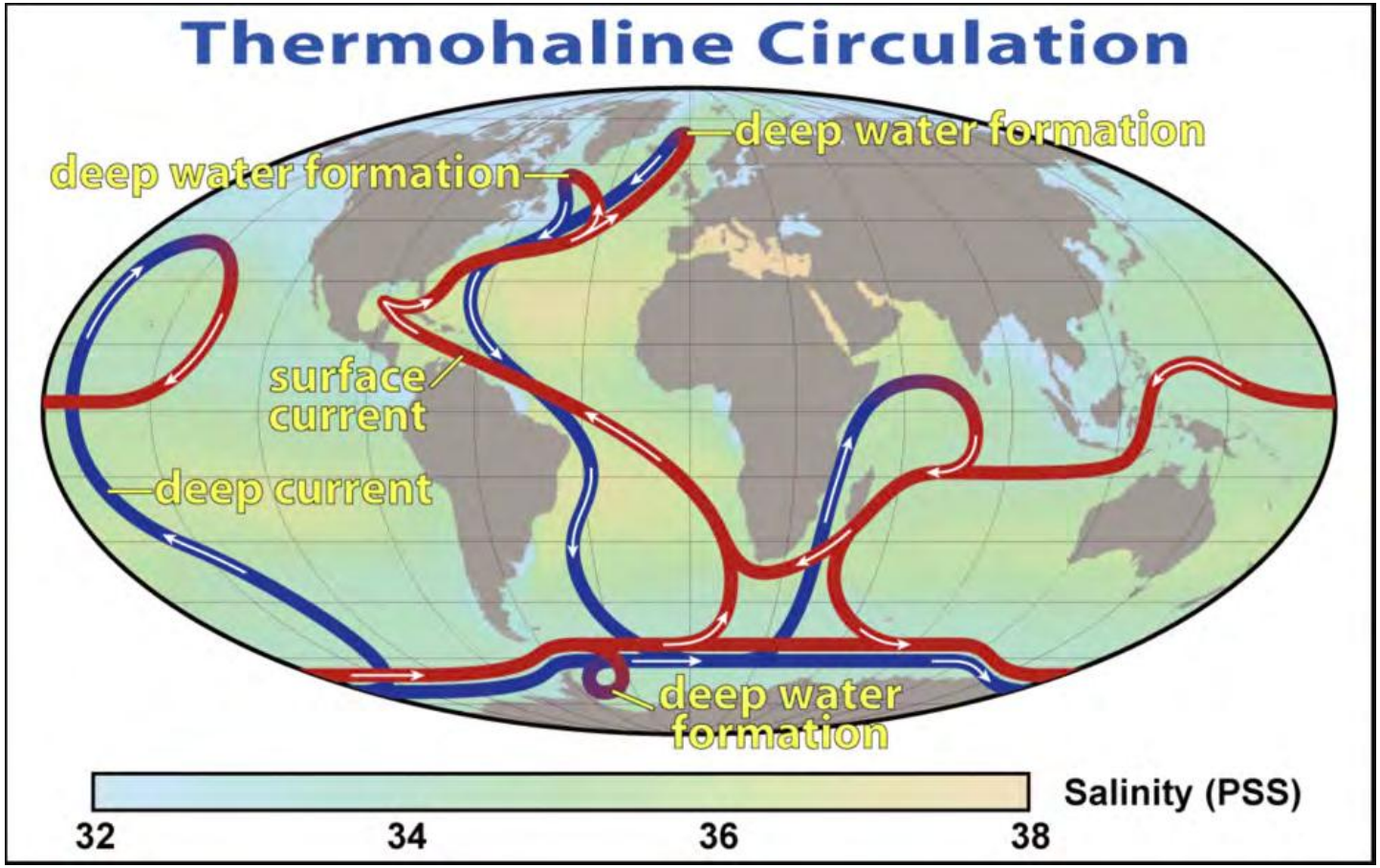
This can result in the water column becoming unstable, setting up density-dependent currents known as the thermohaline circulation.



Thermohaline circulation and gravity

Illustration Bob Moffatt

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.



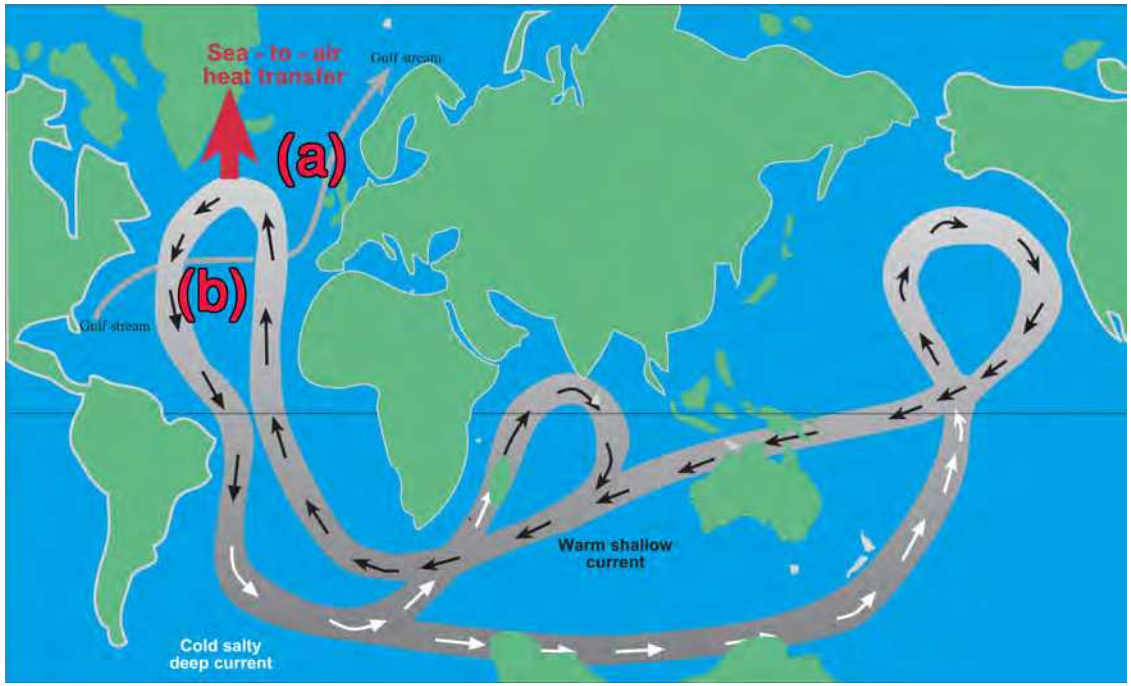
Thermohaline circulation

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

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.

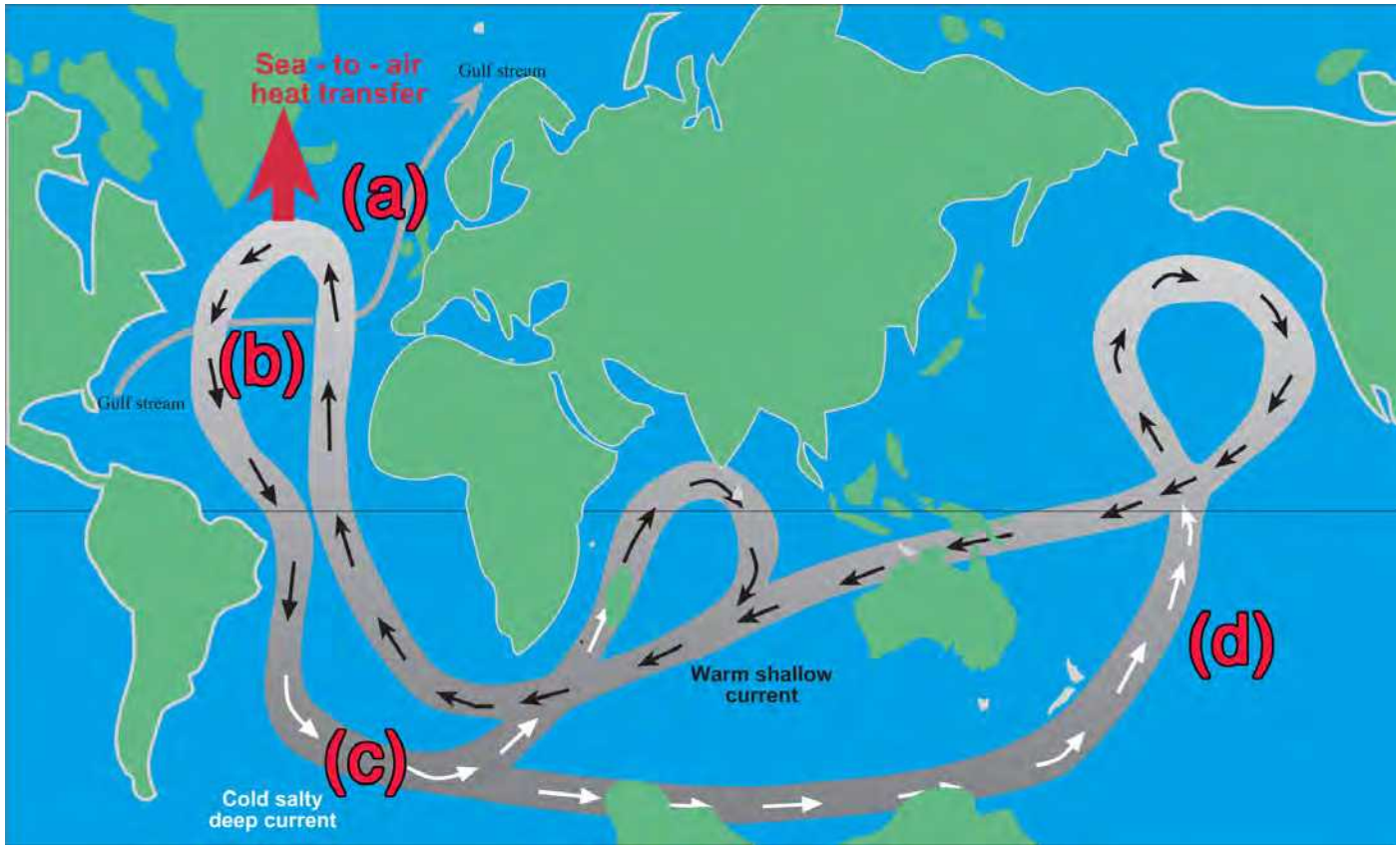
b) Gravity then causes it to sink to the bottom of the ocean. As more warm water is transported north, more cooler water sinks and pushes this water along the ocean floor.



Ocean current conveyor belt a and b

Illustration Bob Moffatt

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.

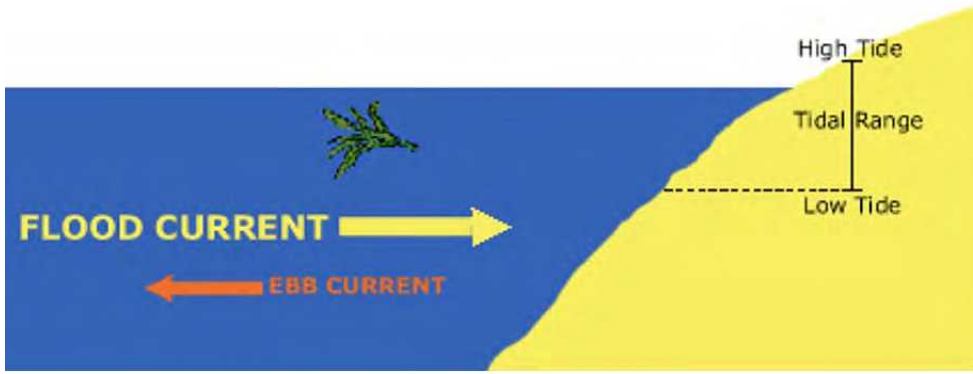


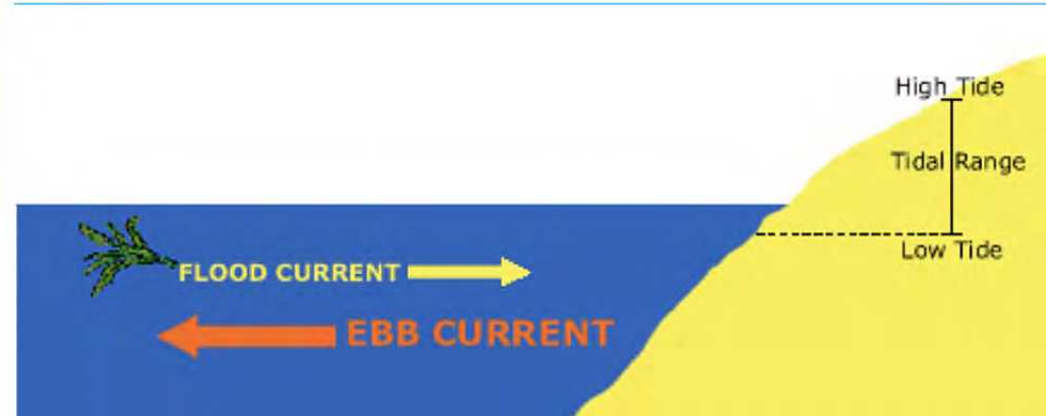
Ocean current conveyor belt

Illustration Bob Moffatt

Tidal currents

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



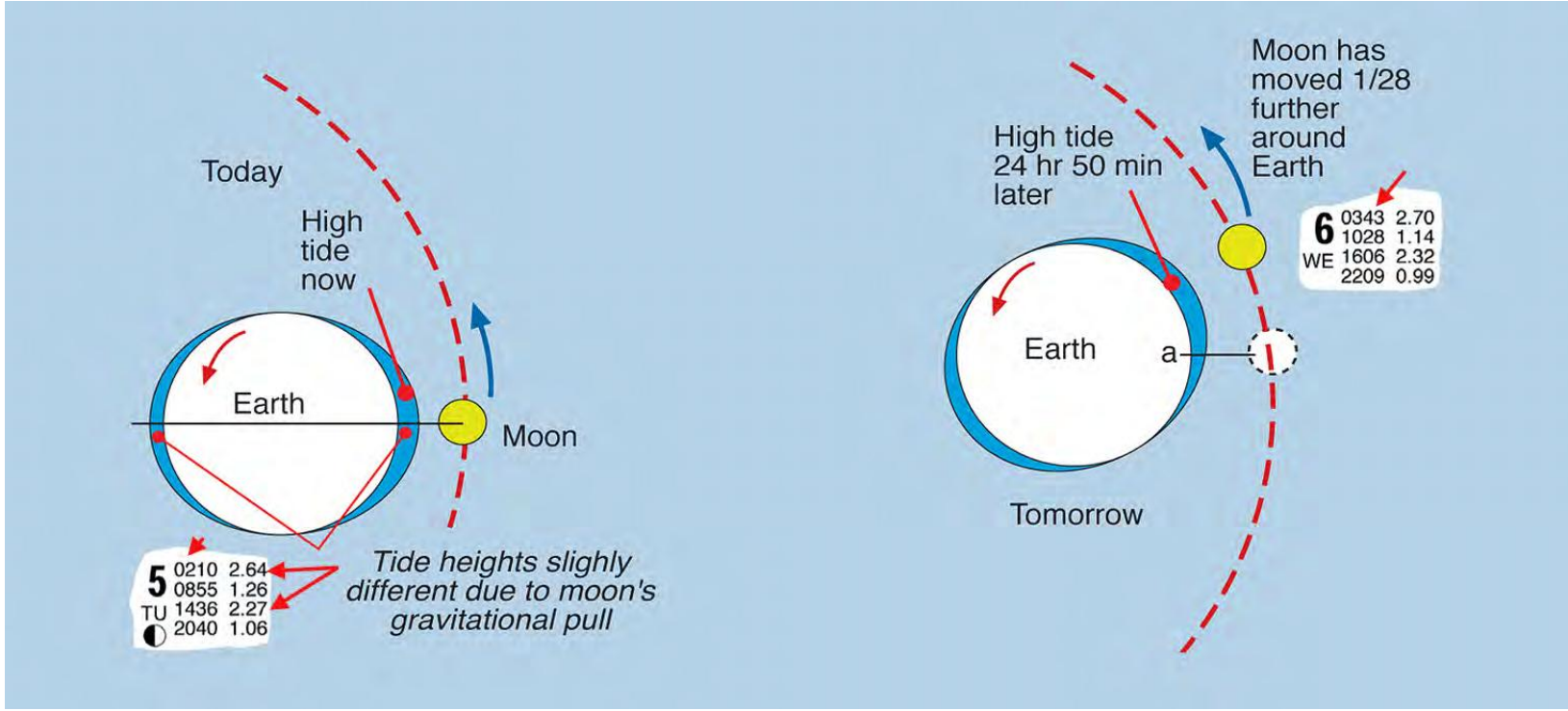


Tidal currents (NOAA)

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

Daily tides

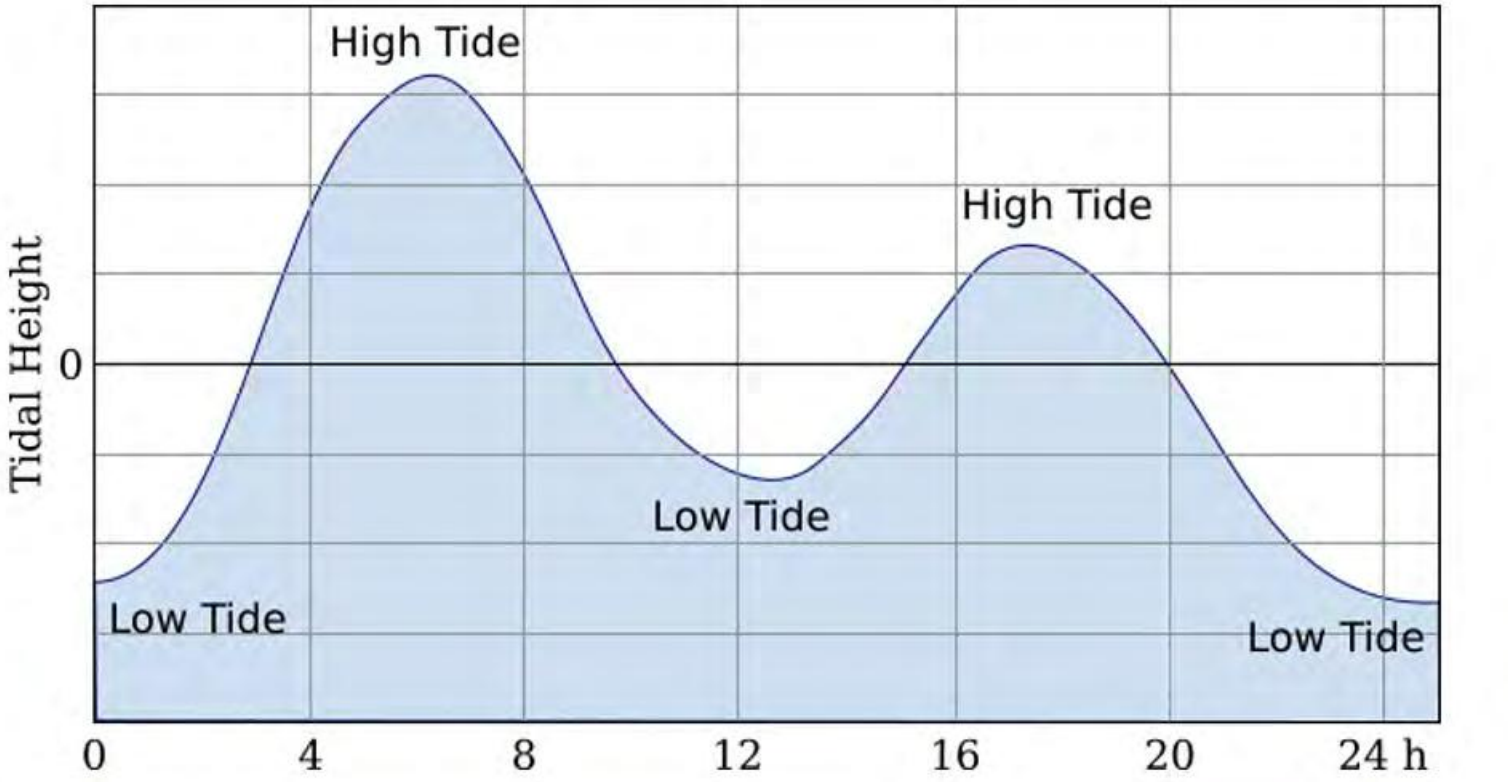
These are caused by the gravitational attraction of the moon to the Earth. One tide is higher than the other because of the difference in attraction.



Daily tides

Illustration Bob Moffatt

These can be shown in a graph.

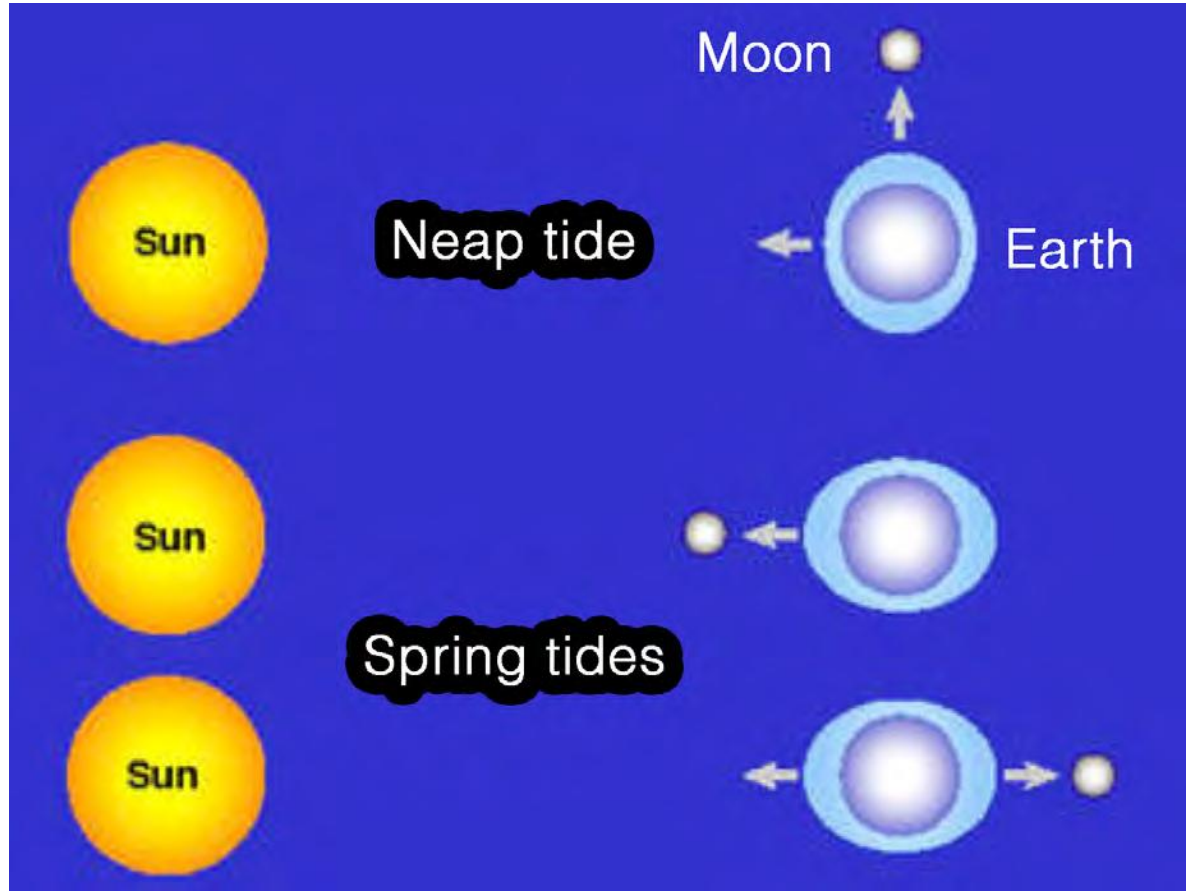


Mixed semidiurnal tide

Graph by Diederik Willemsen

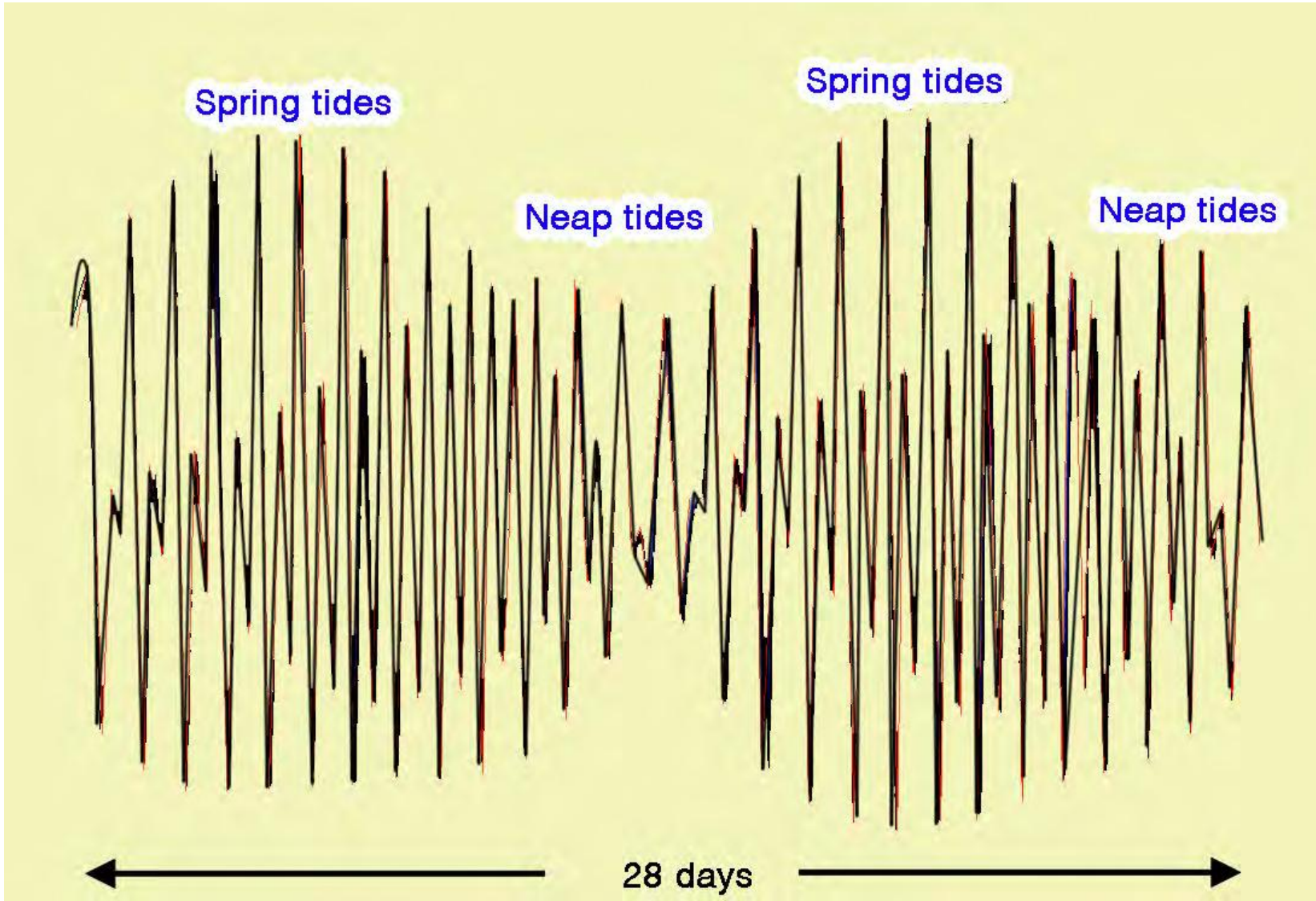
Spring tides occur where the gravitational pull of the Sun and the Moon are combined and the tides are at their highest.

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

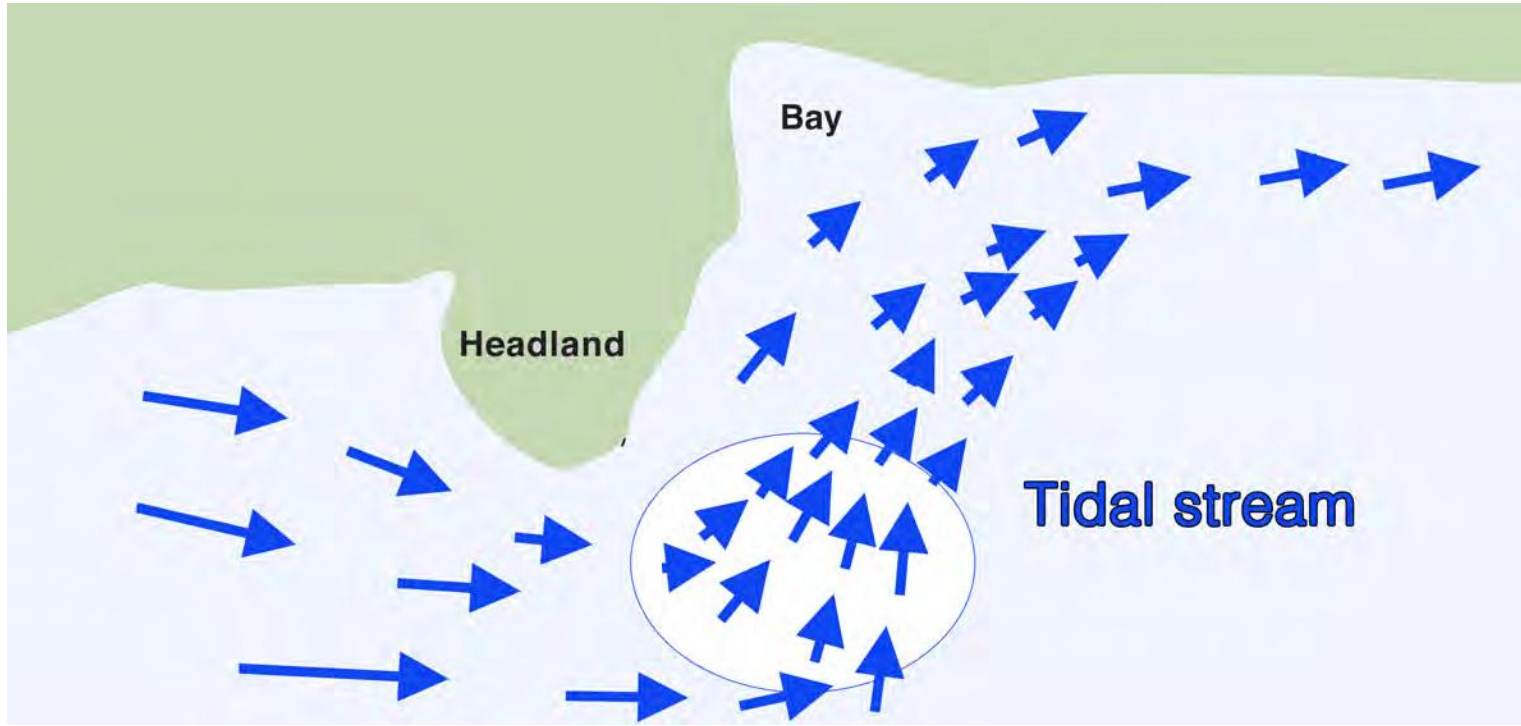


Spring and neap tides

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

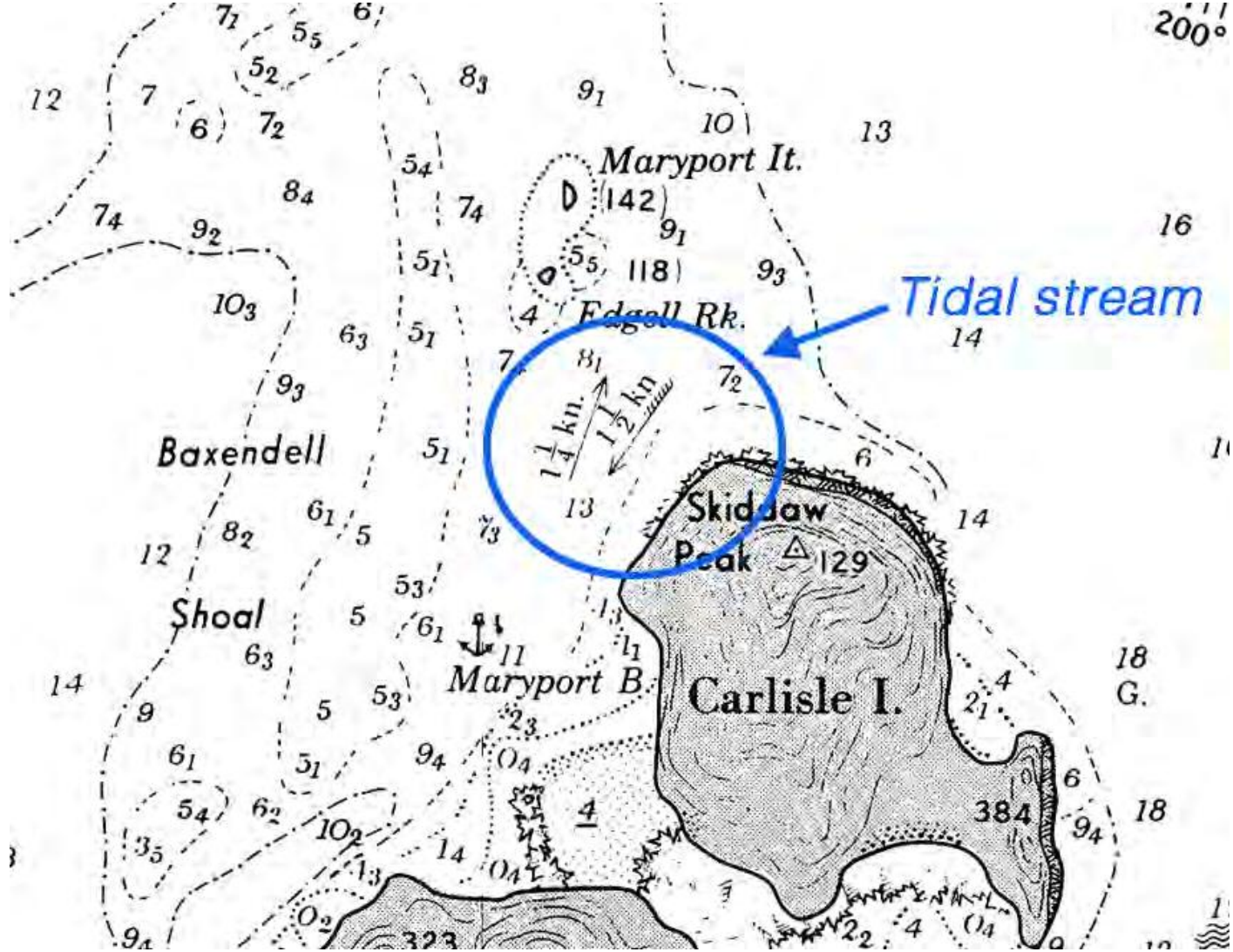
You can study currents with a home made drogue

Bob Moffatt

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

Arrows with feathers represents flooding tide and plain arrows represents ebbing tide.

The arrow indicates the maximum measured flow in that location.

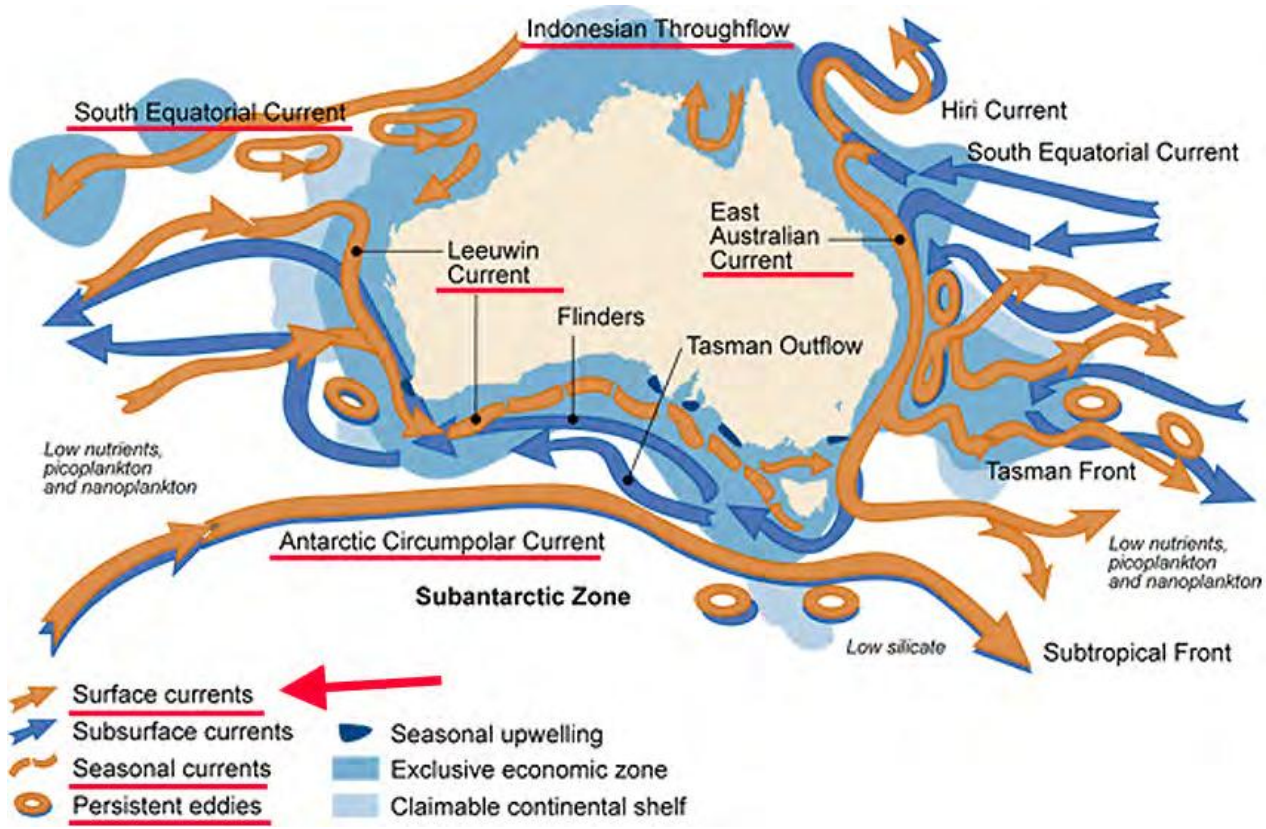


Tidal stream

Illustration Hydrographer for the Navy

Important surface currents around Australia

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

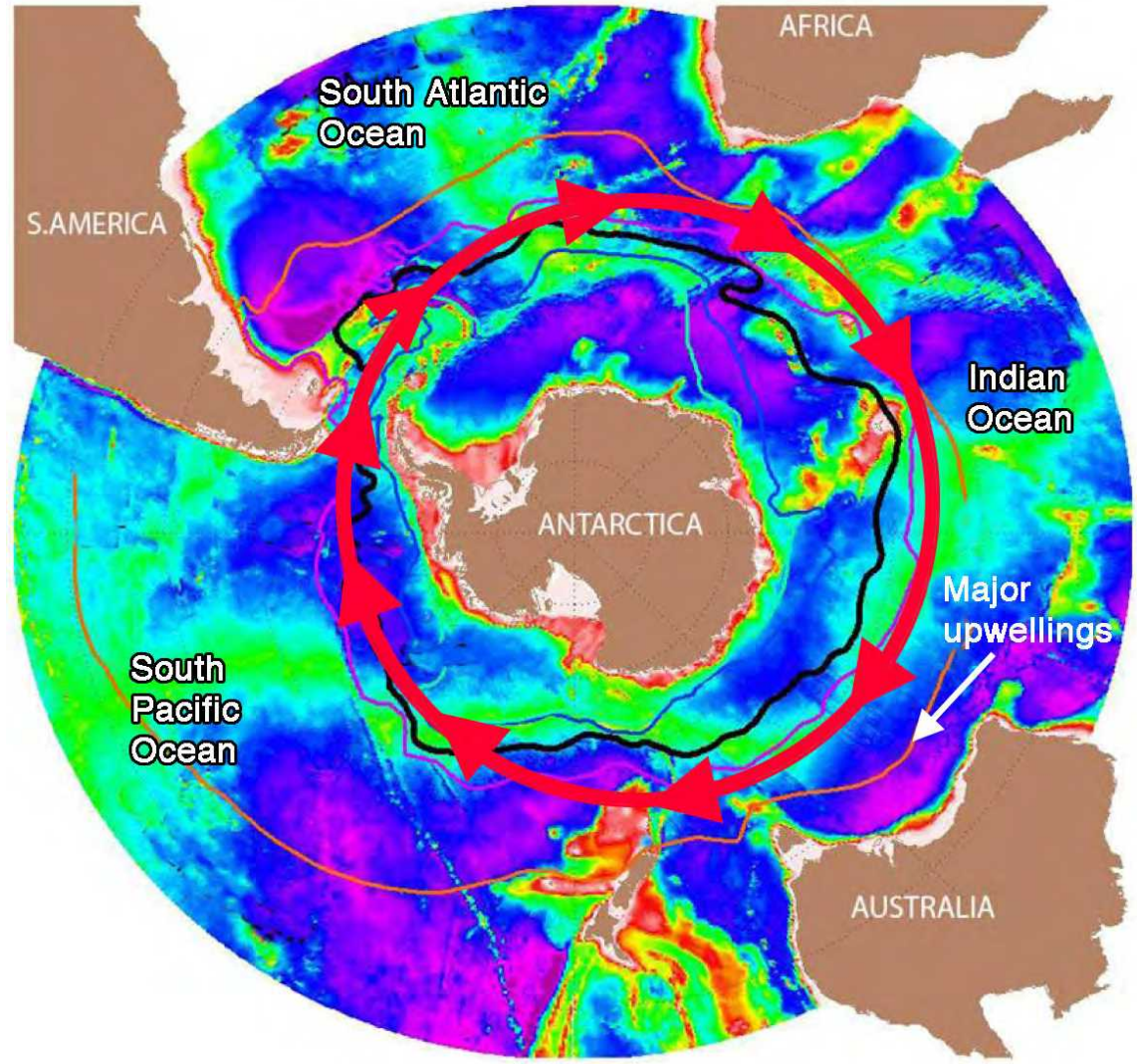


Australian ocean currents

The Antarctic Circumpolar Current

This current is considered the powerhouse for global climate and the 'lungs' of the earth.

It connects the Atlantic, Pacific and Indian Oceans in an eastward flow and features a region of high ocean nutrient production south of Australia



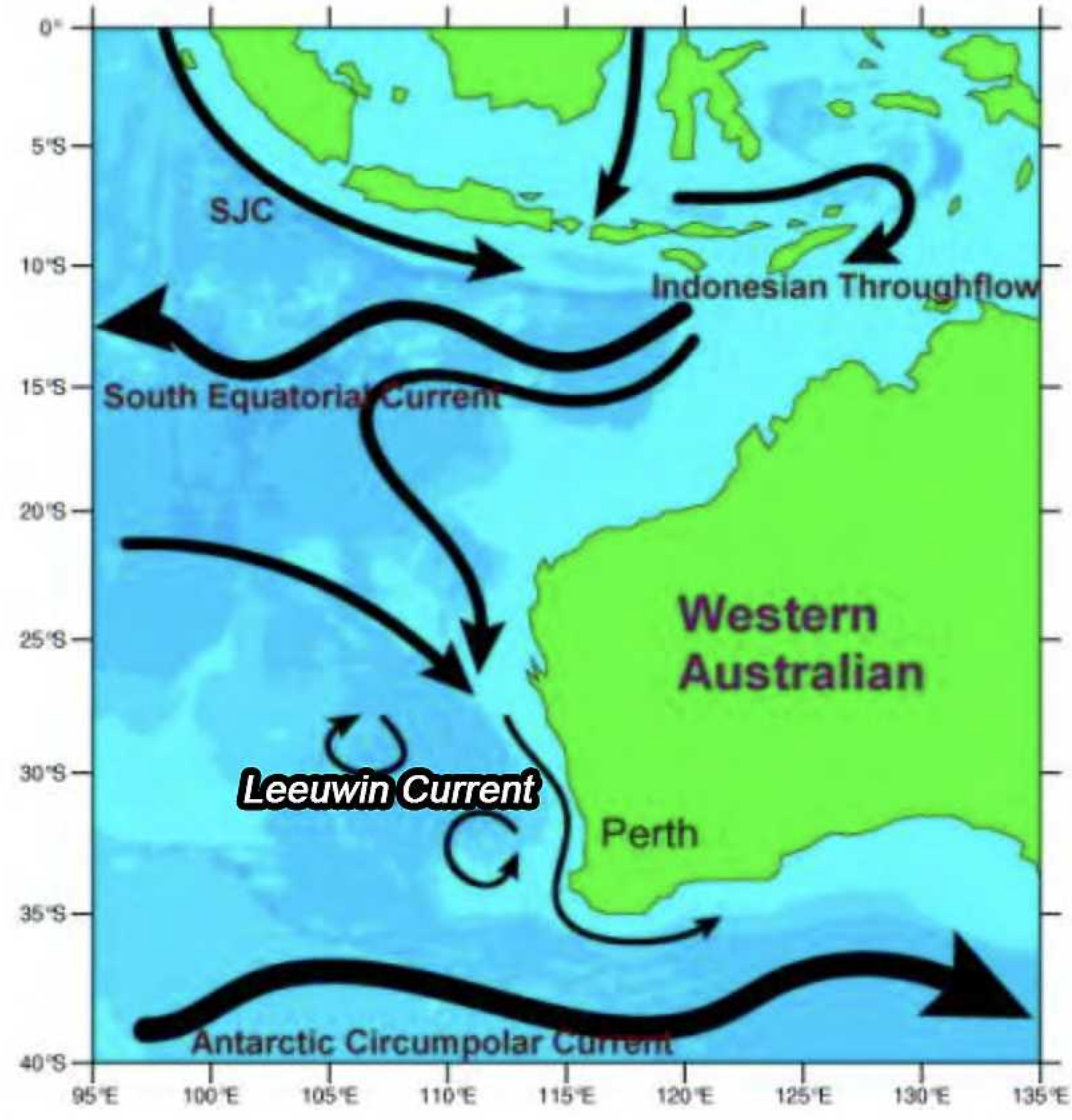
Antarctic Circumpolar Current

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

The Leeuwin Current

This current exerts a major influence on the distribution of marine life and Western Australia's weather.

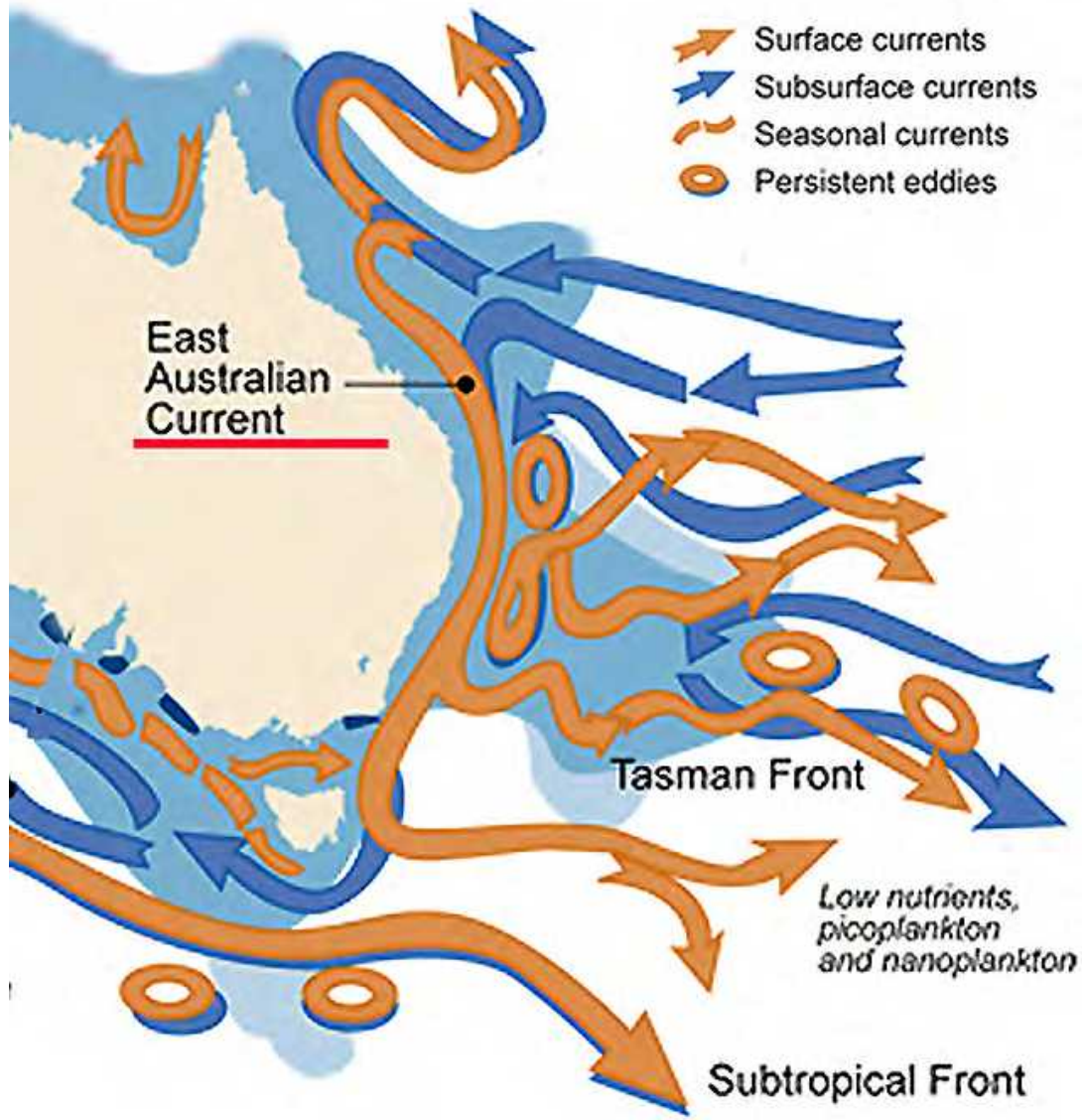
It forms near the North West Shelf on Australia's west coast and travels south into a series of eddies finishing in the Tasman Sea.



Leeuwin Current

The East Australian Current

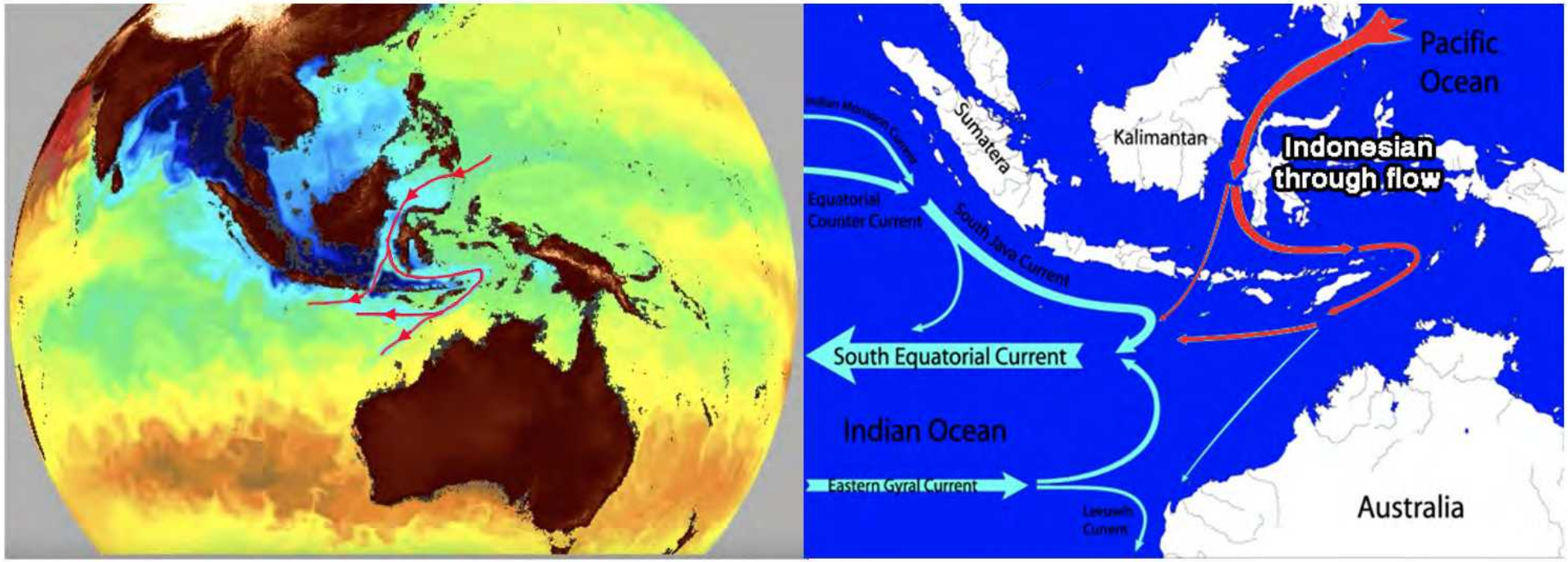
This current flows south along the east coast of Australia from near Queensland's Fraser Island to Tasmania.



East Australian Current

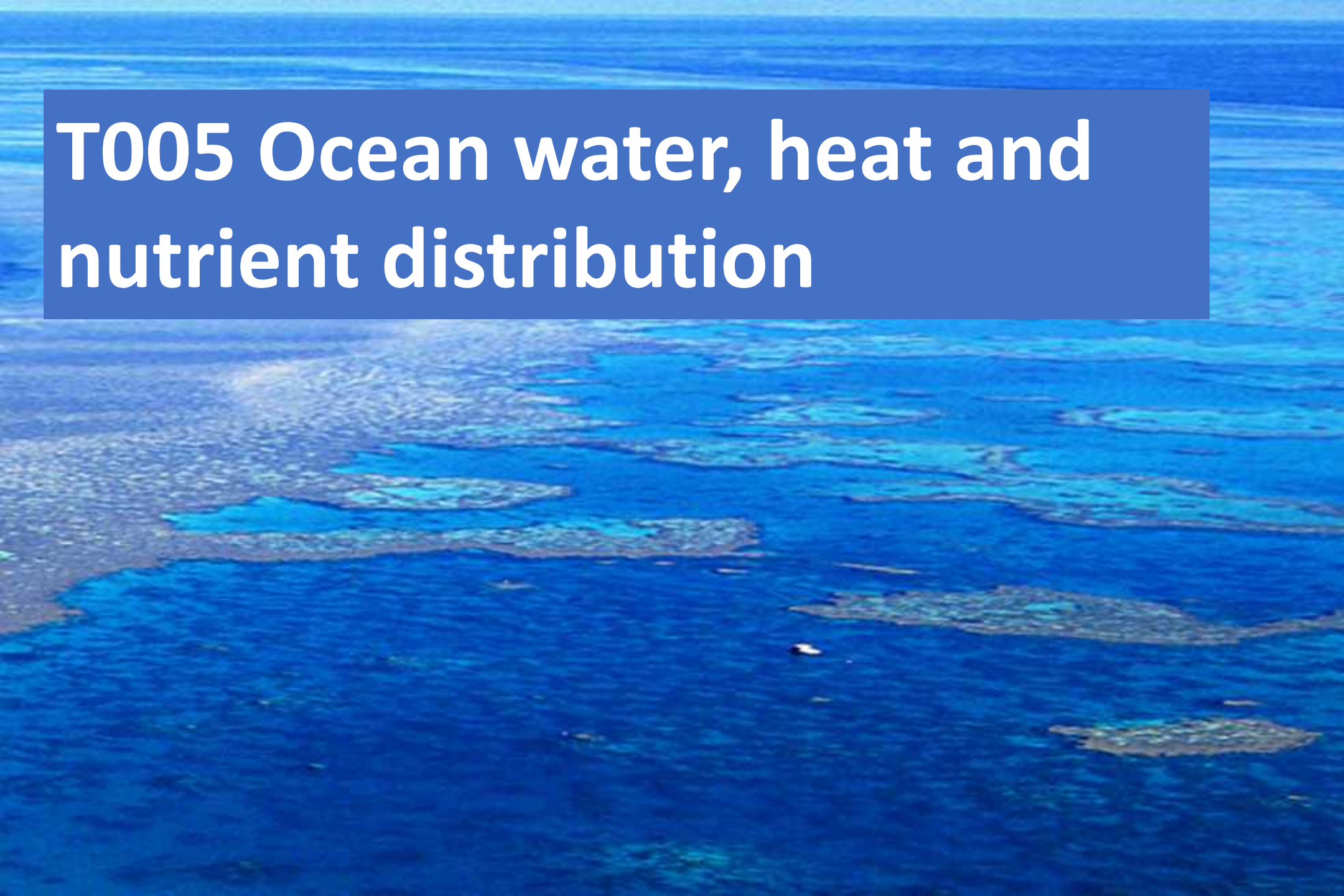
Indonesian throughflow

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 from the Throughflow influences the character of the Leeuwin Current.



Indonesian through flow

Describe how the following drive ocean surface currents	
Wind	
Temperature	
Gravity (tides)	



T005 Ocean water, heat and nutrient distribution

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.

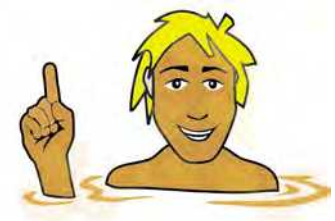
Question

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

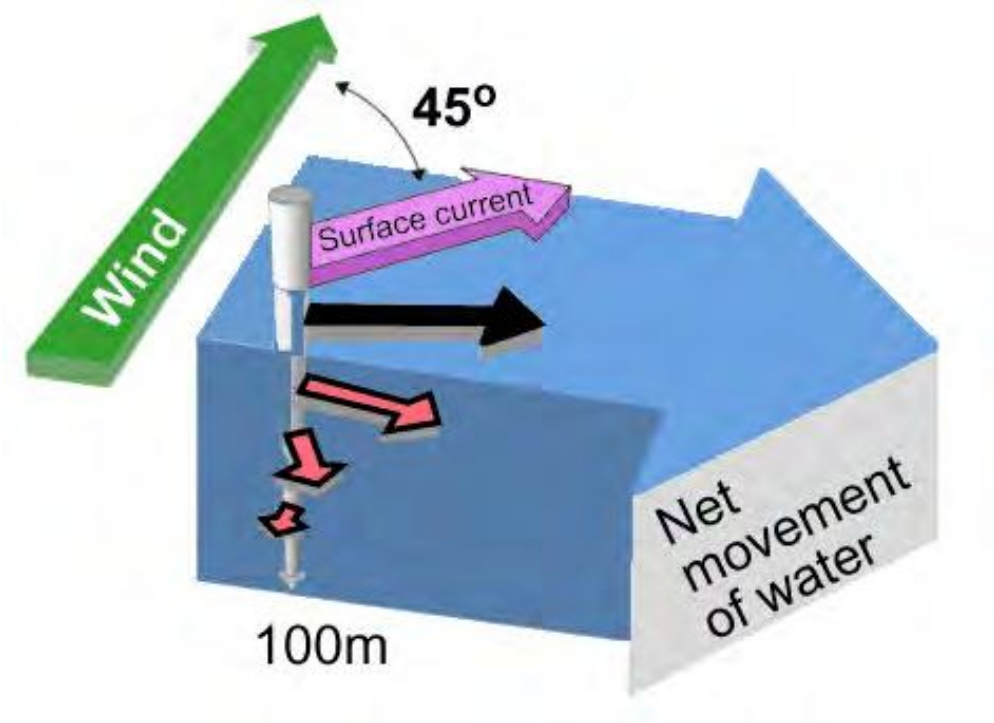


Give an account of how water, heat and nutrients are distributed across coastal and ocean basins with specific reference to	
Ekman spiral	
Upwellings and downwellings	
El Niño and La Nina events	
Langmuir circulation	

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

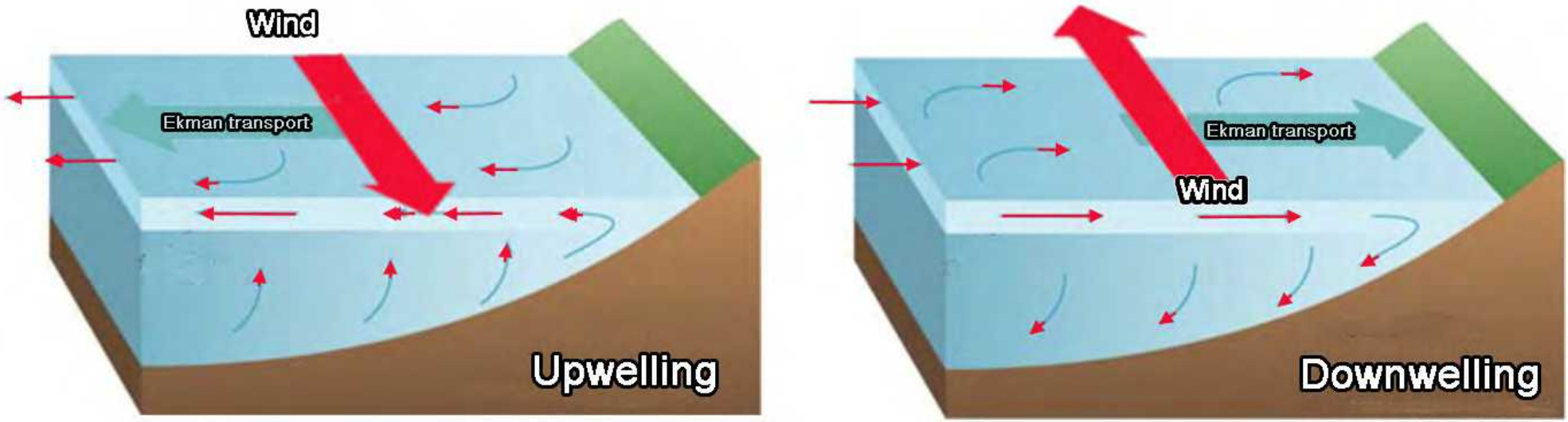
Illustration Bob Moffatt

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.

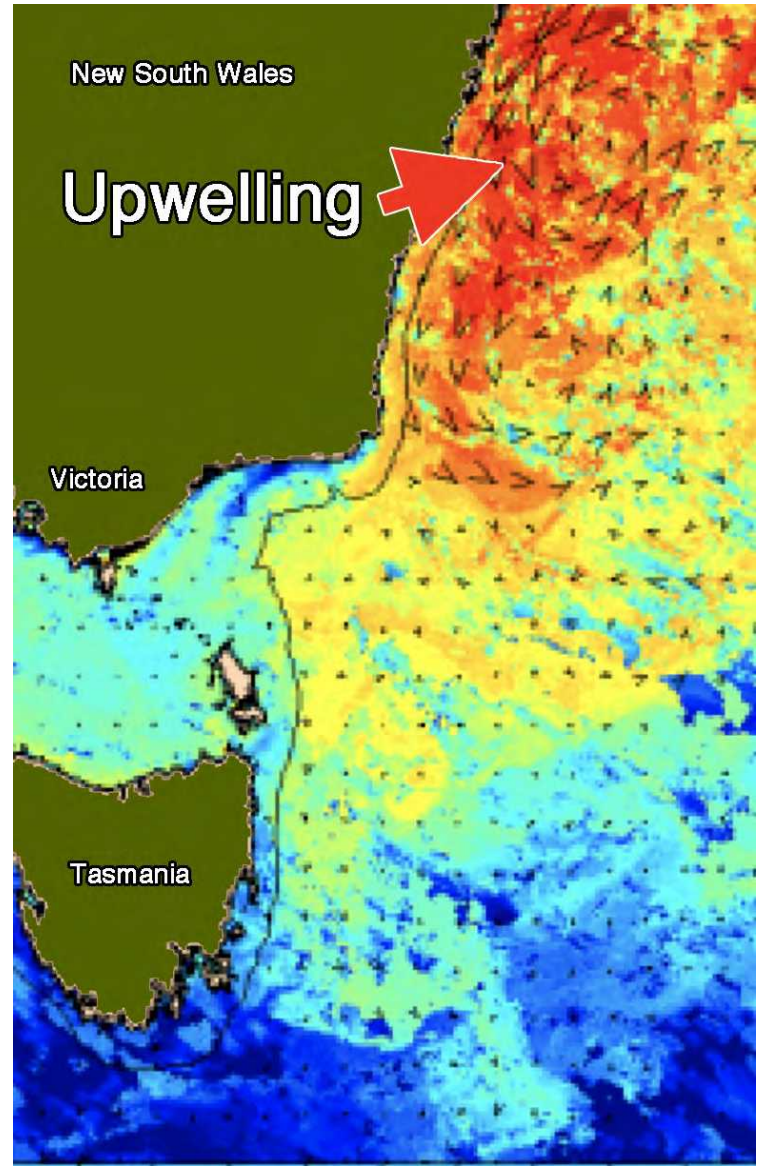


Ekman transport, upwelling and downwellings

After NASA and American Geography Society, modified Bob Moffatt

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.

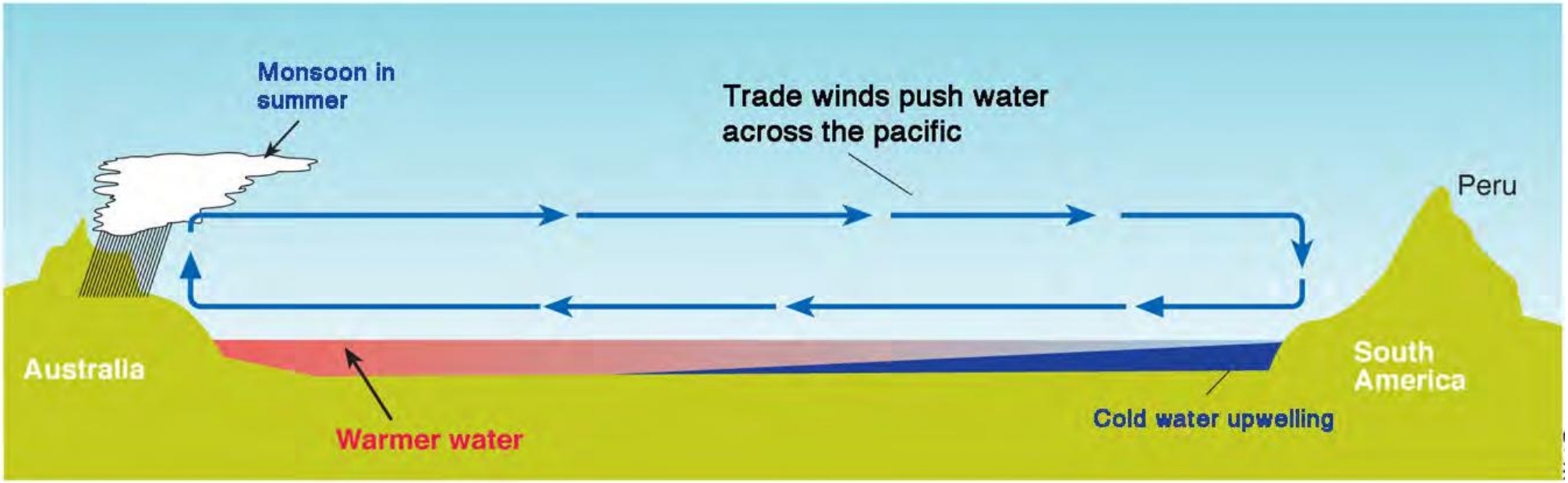


Bonney upwelling

By CSIRO Marine division, modified Bob Moffatt

Easterly trade winds push large amounts of warm water across the Pacific causing upwellings in Peru and creating monsoons (rain) in Australia. The South Pacific gyre moves strongly.

This is called La Nina.



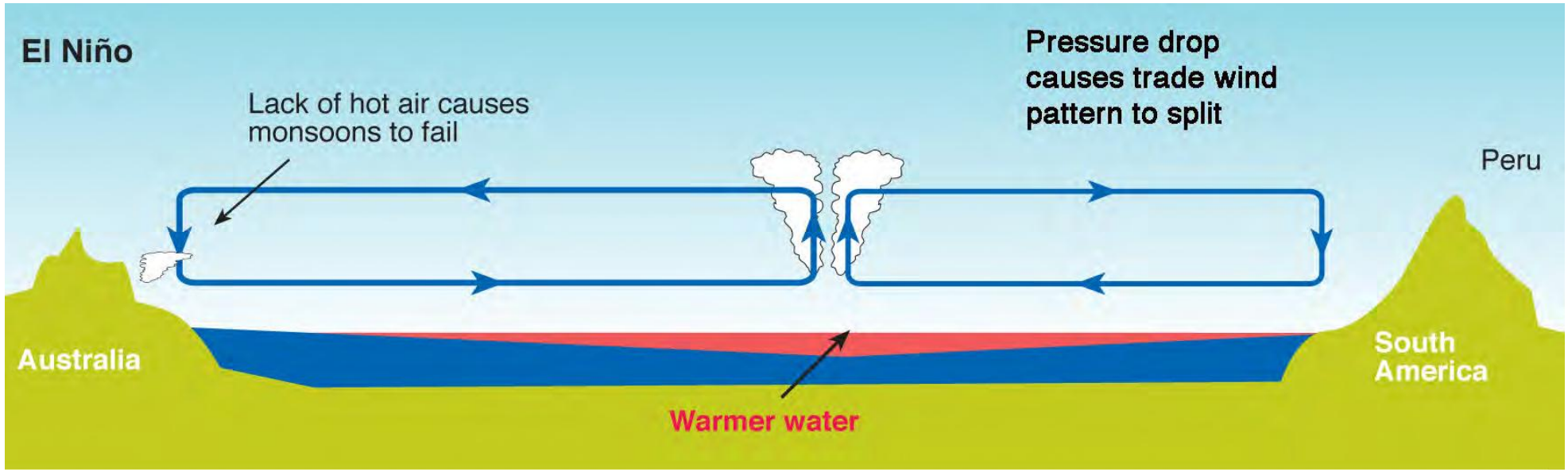
La Nina

Illustration Bob Moffatt

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.

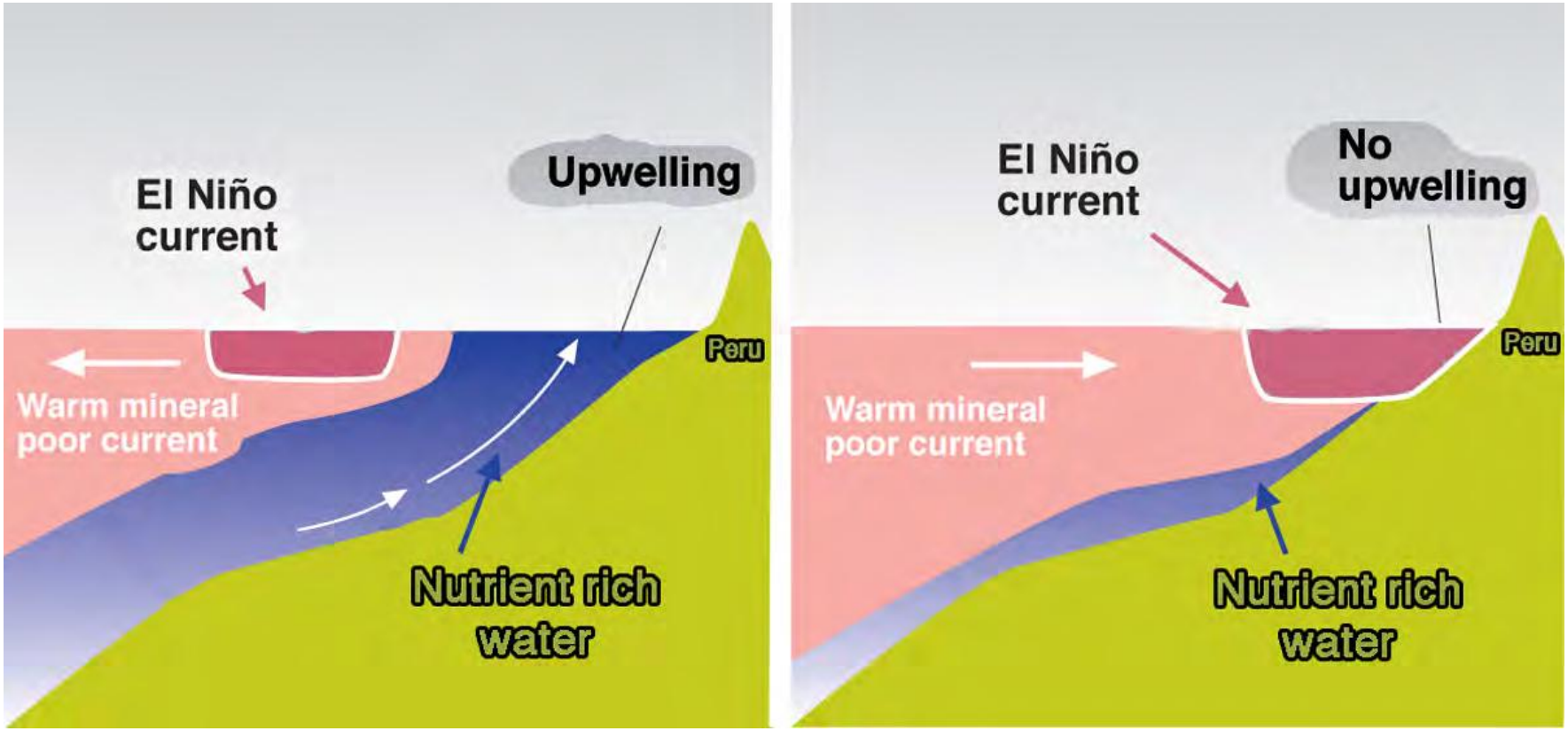


El Nino

Illustration Bob Moffatt

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 and consequently disrupts the fishing industry.



El Nino currents and Peru

Illustration Bob Moffatt

In Australia, hot and dry conditions from El Nino can cause bushfires.

Bushfires
Photo Simone Baker

Cyclones from El Nino conditions also bring large amounts of devastation due to flash flooding to coastal Queensland.

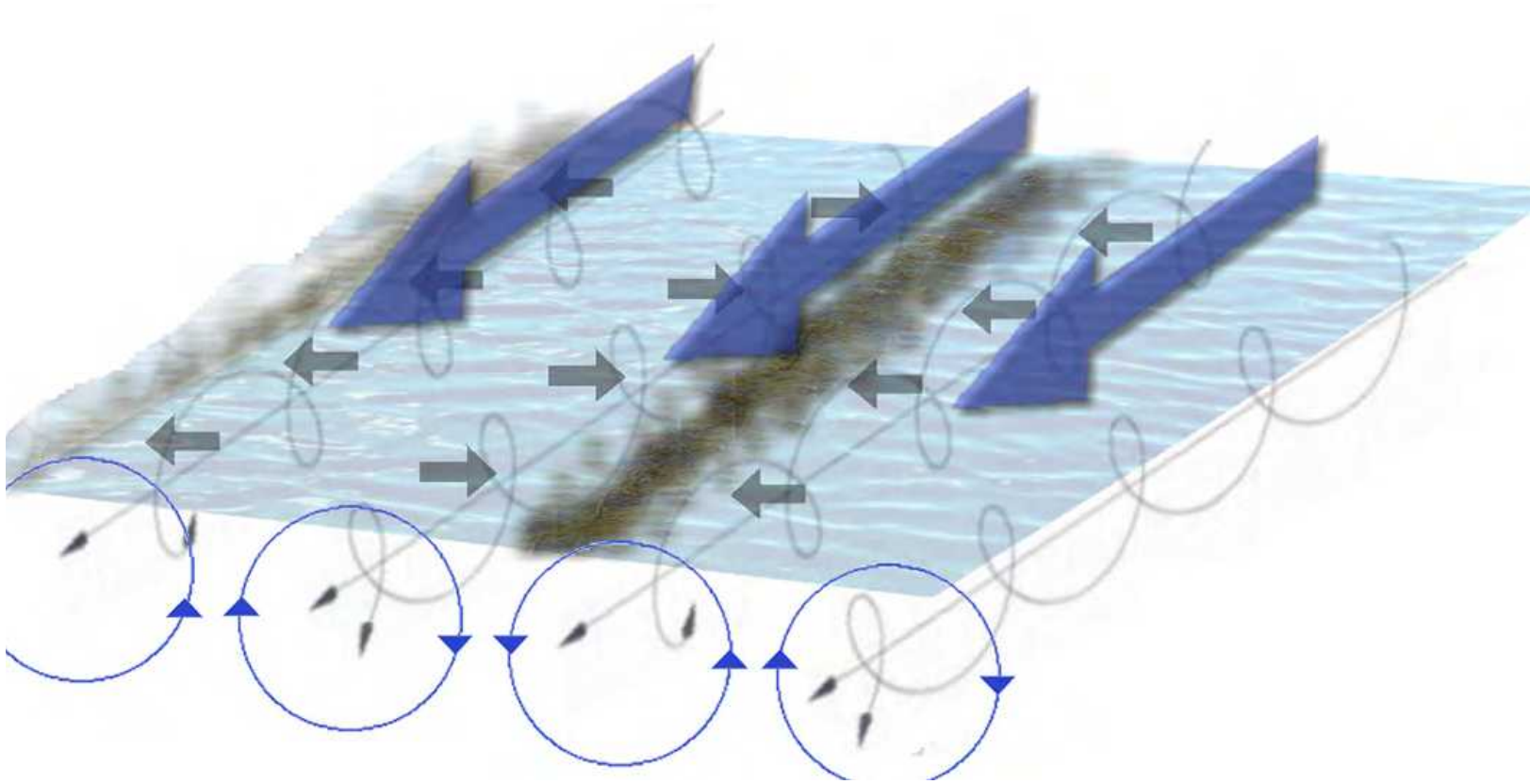
This seriously affects nutrient levels on inshore ecosystems, as nutrients enter the ocean via waterways bringing excess nutrients, sediment and other pollutants. These pollutants can negatively impact ecosystems including seagrass and corals.

Flood plume coastal river

Photo Bob Moffatt

Langmuir circulation

In physical oceanography, Langmuir circulation consists of a series of shallow, slow, counter-rotating vortices at the ocean's surface aligned with the wind.



These circulations are developed when wind blows steadily over the sea surface.

Photo Bob Moffatt

Langmuir circulations circulate within the mixed layer; however, it is not yet so clear how strongly they can cause mixing at the base of the mixed layer.

Reference

https://en.wikipedia.org/wiki/Langmuir_circulation

Offshore currents

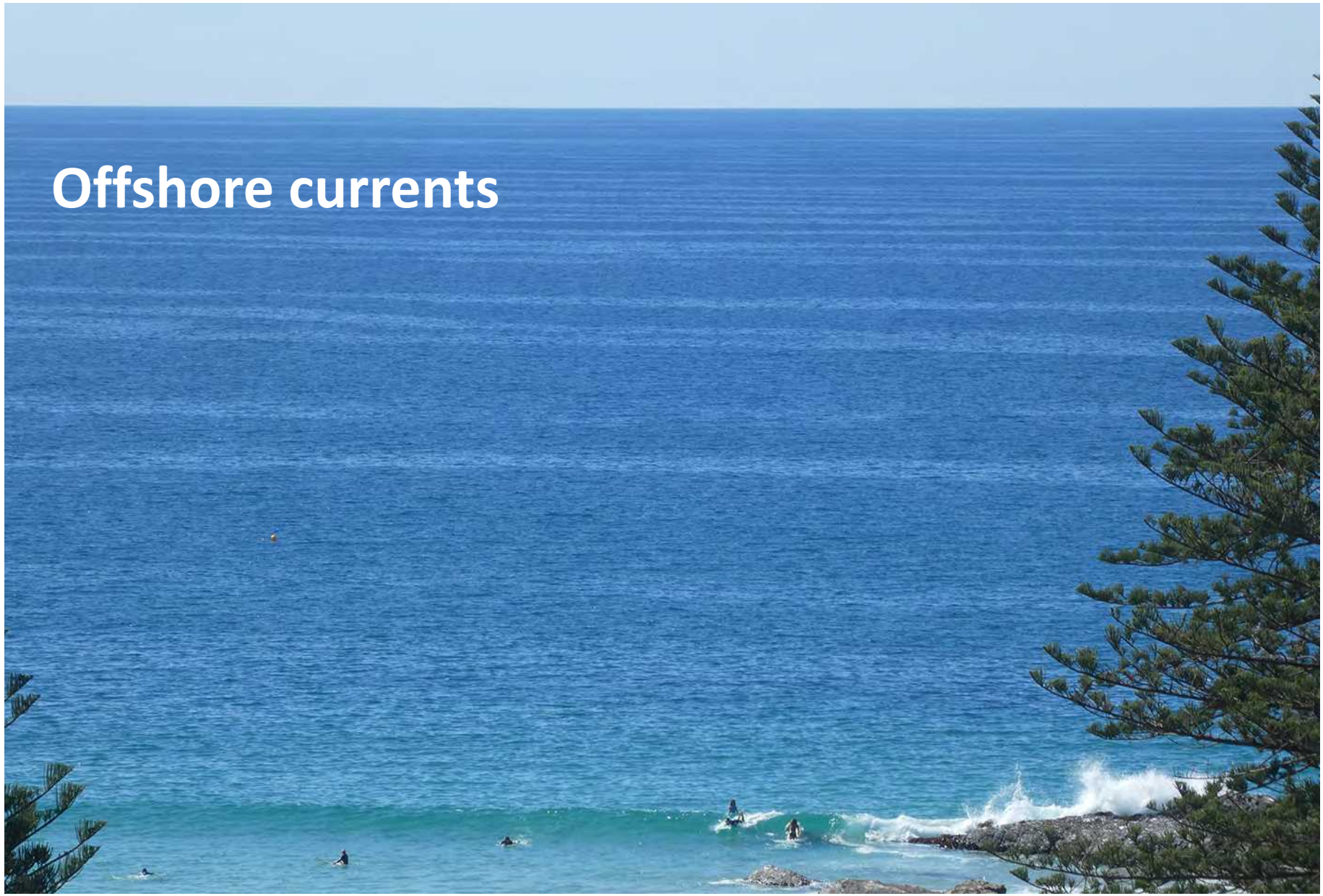
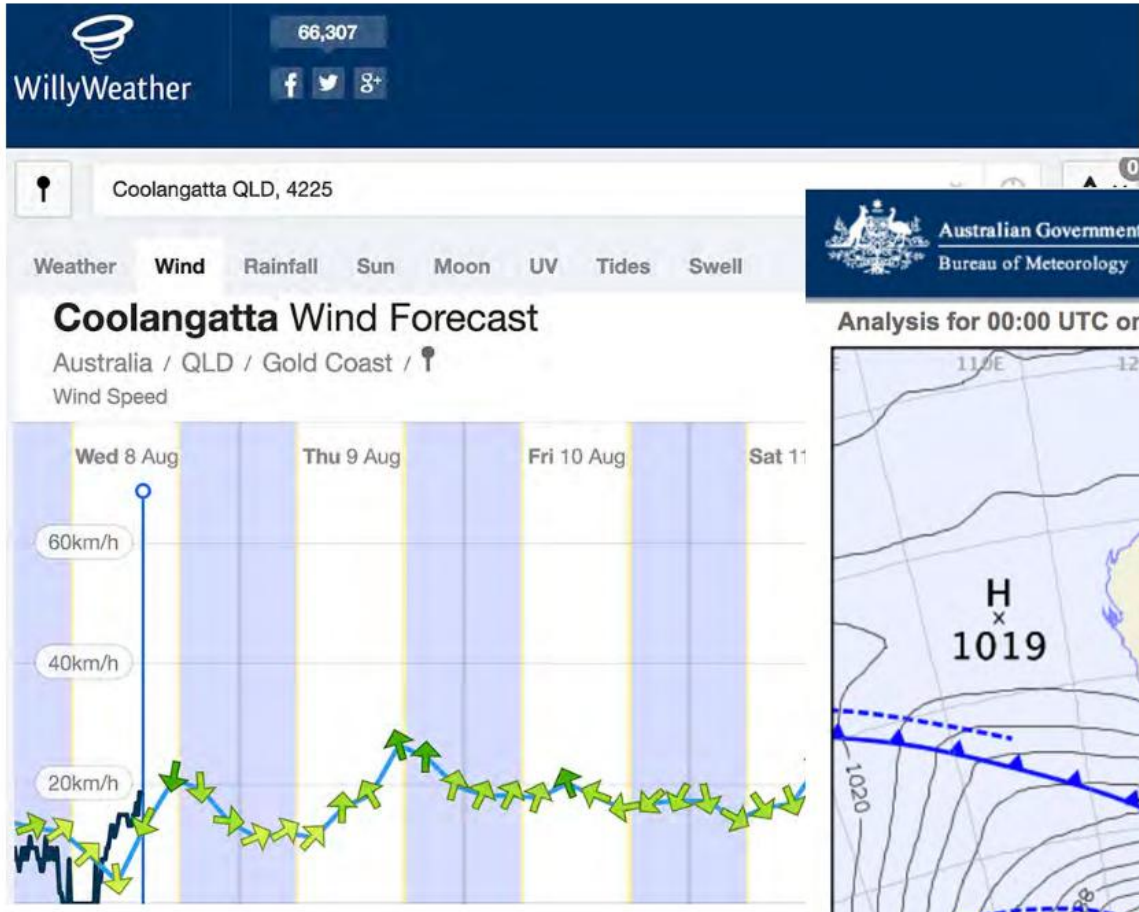
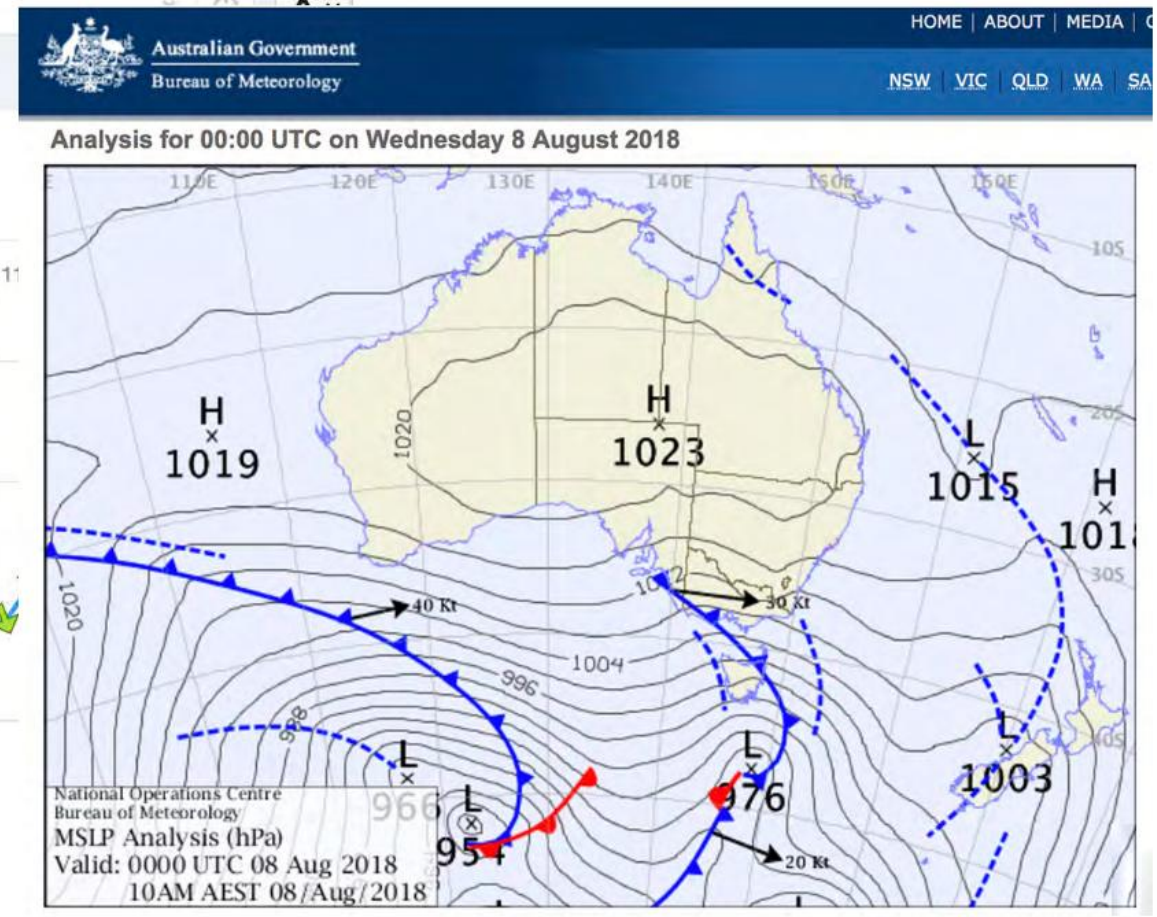


Photo Bob Moffatt

Weather data for last photo shows the slight offshore wind creating the surface current.





Give an account of how water, heat and nutrients are distributed across coastal and ocean basins with specific reference to	
Ekman spiral	
Upwellings and downwellings	
El Niño and La Nina events	
Langmuir circulation	

T006 Seawater properties

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.

Questions

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

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

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

Physical properties of water

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

1. Chemical properties

A. Molecular structure

B. Hydrogen bonding and polarity

C. Ionization

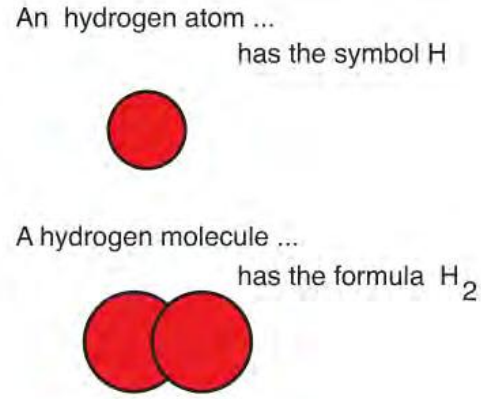
D. Solvent properties and pH

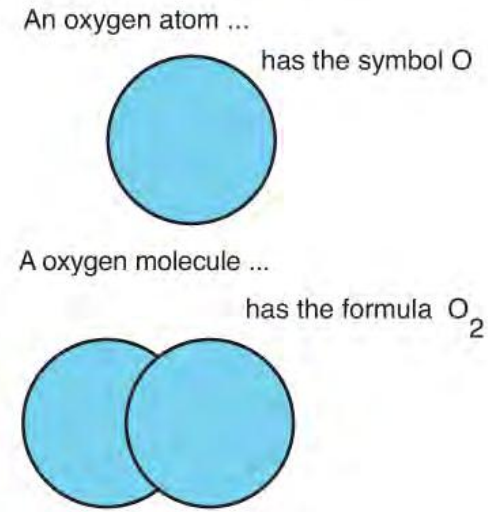
E. Salinity

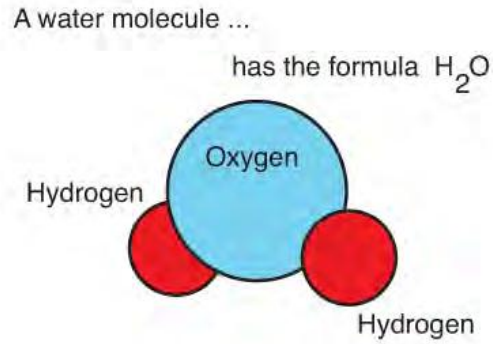
Molecular structure

A water molecule is made of one atom of Oxygen and two atoms of Hydrogen (or one molecule of Hydrogen).

It has the molecular formula of H_2O.







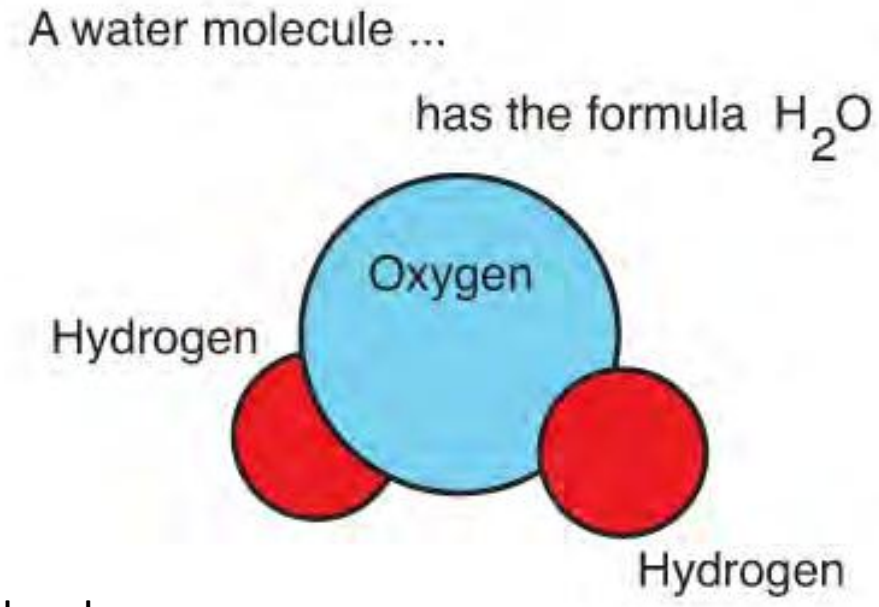
Water molecules

Illustration Bob Moffatt

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 thus giving it a slightly positive charge.

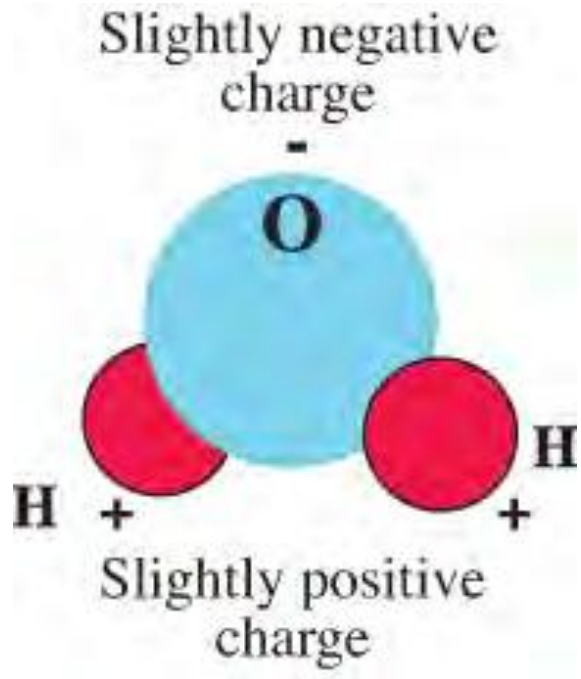


Water molecule

Illustration Bob Moffatt

Hydrogen bonds and polarity

Water is a polar molecule and so is slightly positively charged on the Hydrogen side and slightly negatively charged on the Oxygen side.

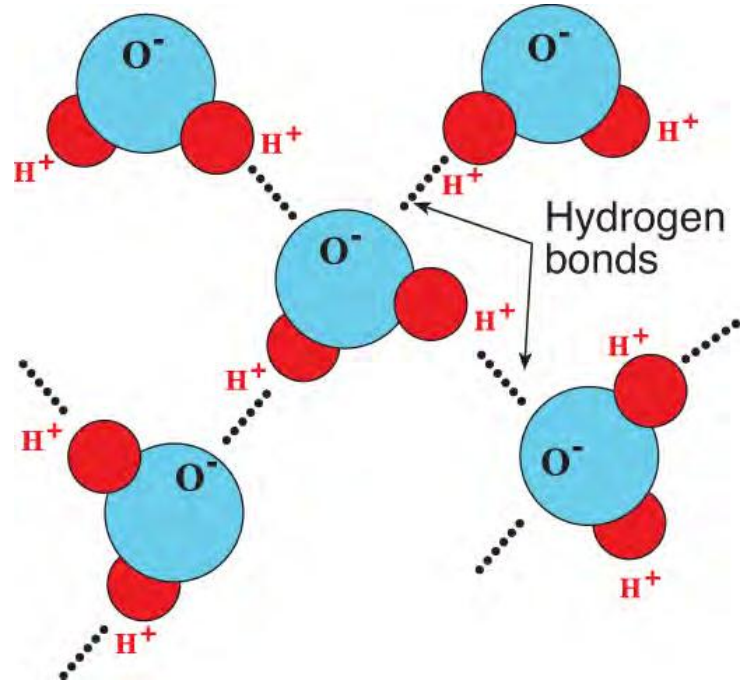


Water molecule showing charges

Illustration Bob Moffatt

A Hydrogen bond forms between the positive Hydrogen sides of this molecule and other negative ions, in this case other water molecules negatively charged Oxygen atoms.

(Remembering an ion is a charged particle)



Water molecules hydrogen bonding

Illustration Bob Moffatt

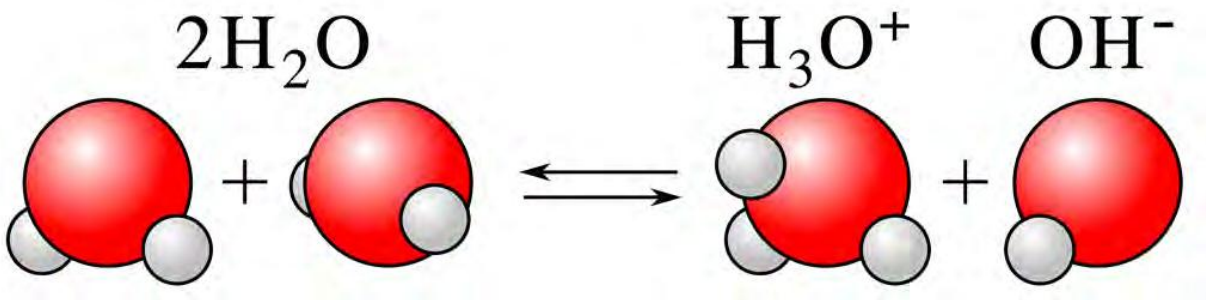
Ionization

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.

Self-ionisation of water occurs when a molecule of water provides a Hydrogen atom to another, forming new products, as seen in this chemical formula:

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

Water self-ionises to produce Hydronium ion ($H_3O^{+)}$ and the Hydroxide ion (OH^-).

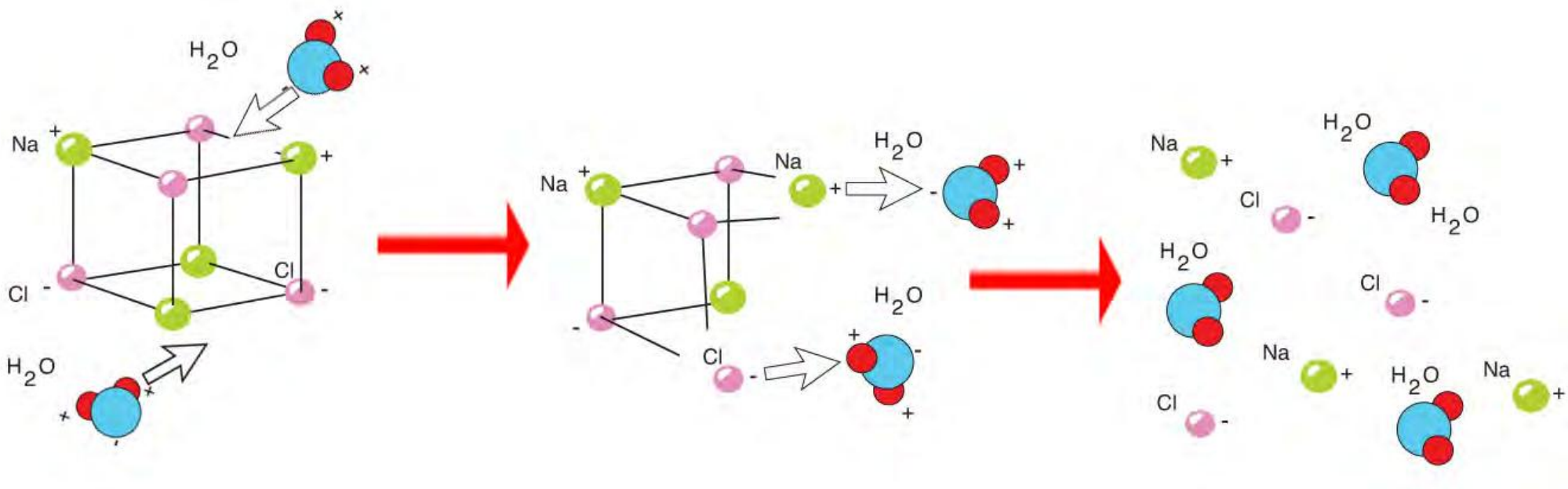


Water ionization

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

Water and salt ionises, salt's crystalline form is broken causing it to dissolve. The negative part of the water molecule (Oxygen) attracts the positive Sodium ion and the positive part of the water molecule (Hydrogen) attracts the negative Chloride ion. The water molecules surround the ion preventing it to form the salt crystal.

Molecules and ions with which water forms Hydrogen bonds (such as Sodium chloride) are called hydrophylic (attracted to water).



Salt and water ions

Illustration Bob Moffatt

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

Mangrove leaf with salt

Photo Bob Moffatt

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

This effect is seen when you put a drop of oil on water, it does not dissolve but is seen to float on the surface, seemingly repelled by the water molecules.

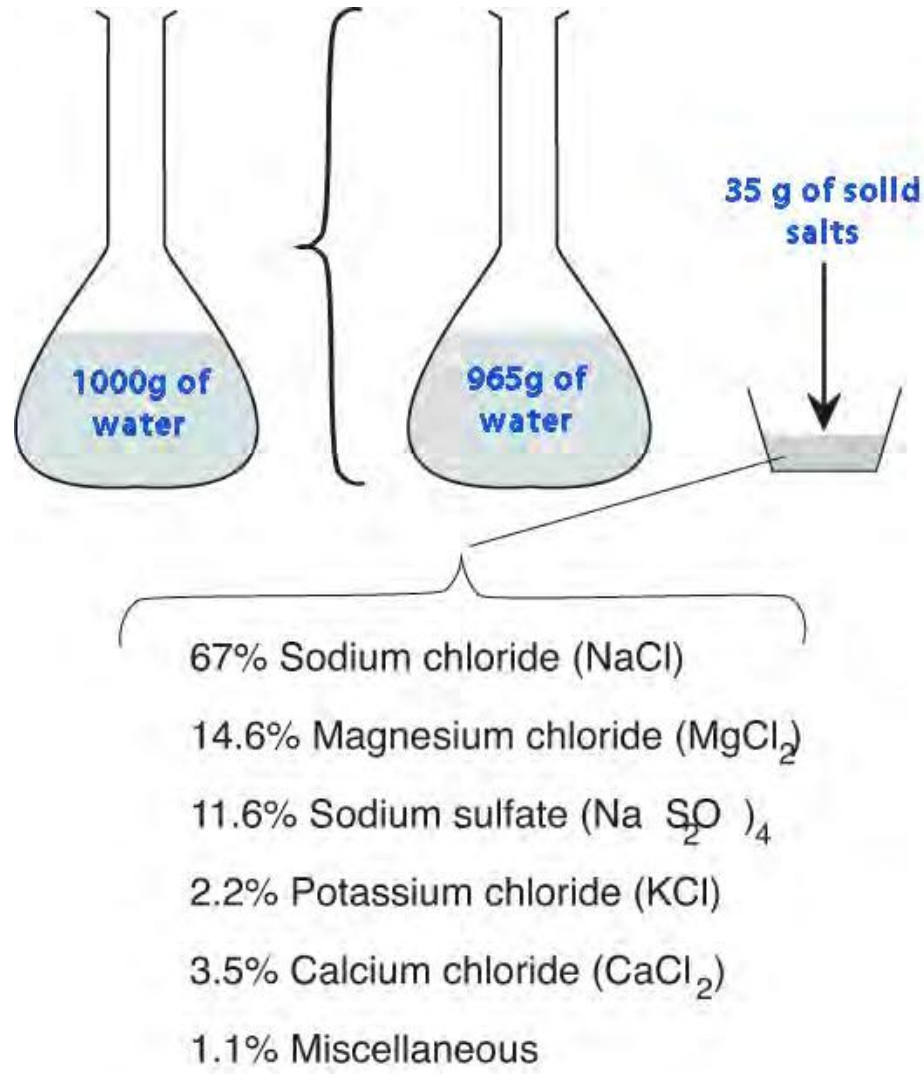
Oil spill Persian Gulf

Ionization and salinity

Salinity is the concentration of dissolved salts in water, usually expressed in parts per thousand by weight (ppt = g/L)

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

The different salts dissolved in seawater can be seen in this diagram.



Seawater composition

Illustration Bob Moffatt

Solvent properties and pH

Water can also dissolve more substances than any other common liquid because of its polarity.

Water is called a universal solvent because it can dissolve polar and ionic substances more than any other liquid.

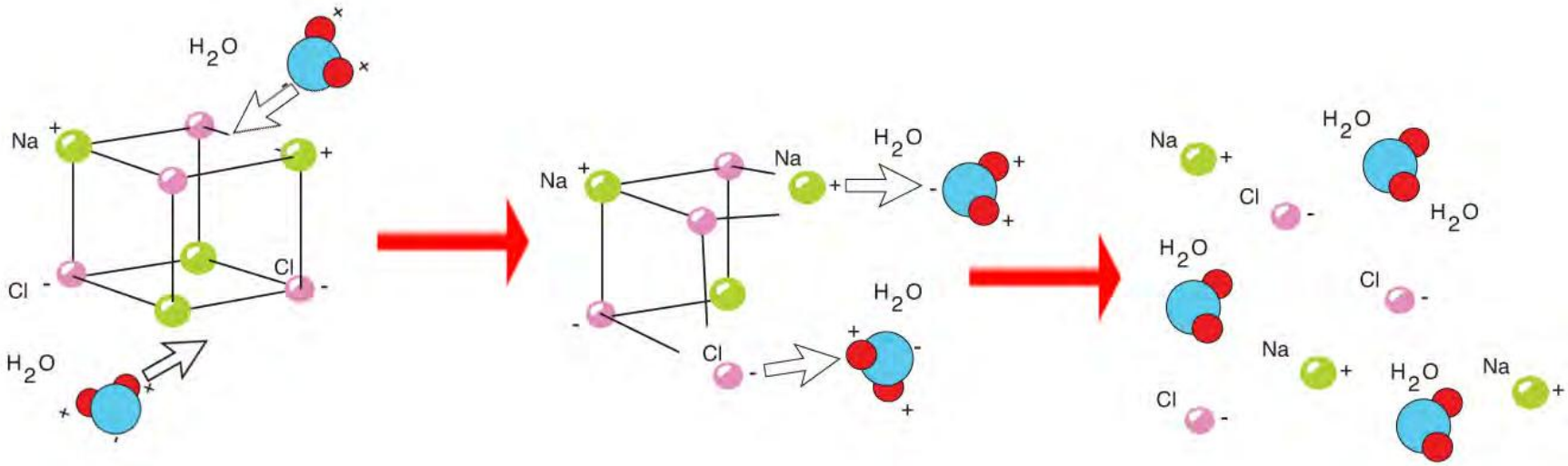
Water drop
By fir0002 | flagstaffotos.com.au [GFDL 1.2

http://www.gnu.org/licenses/old-licenses/fdl-1.2.html)
via Wikimedia Commons

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.



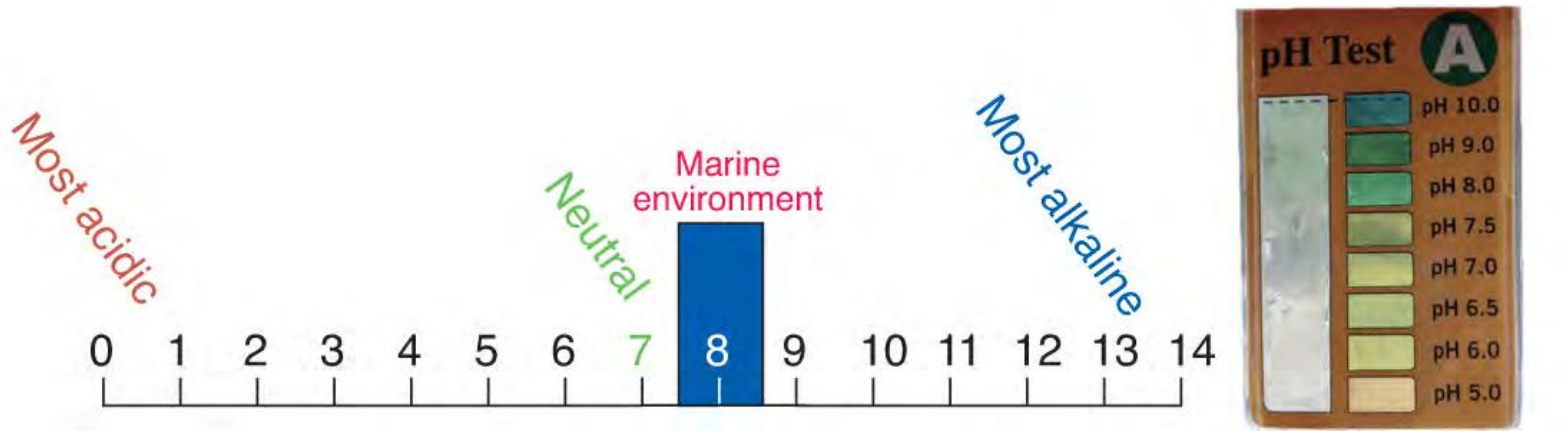
Salt and water ions dissolving

Illustration Bob Moffatt

pH

pH stands for 'potential of Hydrogen' and is a measure of the acidity or alkalinity of water soluble substances. A pH value is a number from 1 to 14, with 7 as the neutral point.
Values below 7 indicates acids (H+) which increases as the number decreases, 1 being the most acidic whereas 14 is the most alkaline (OH-).

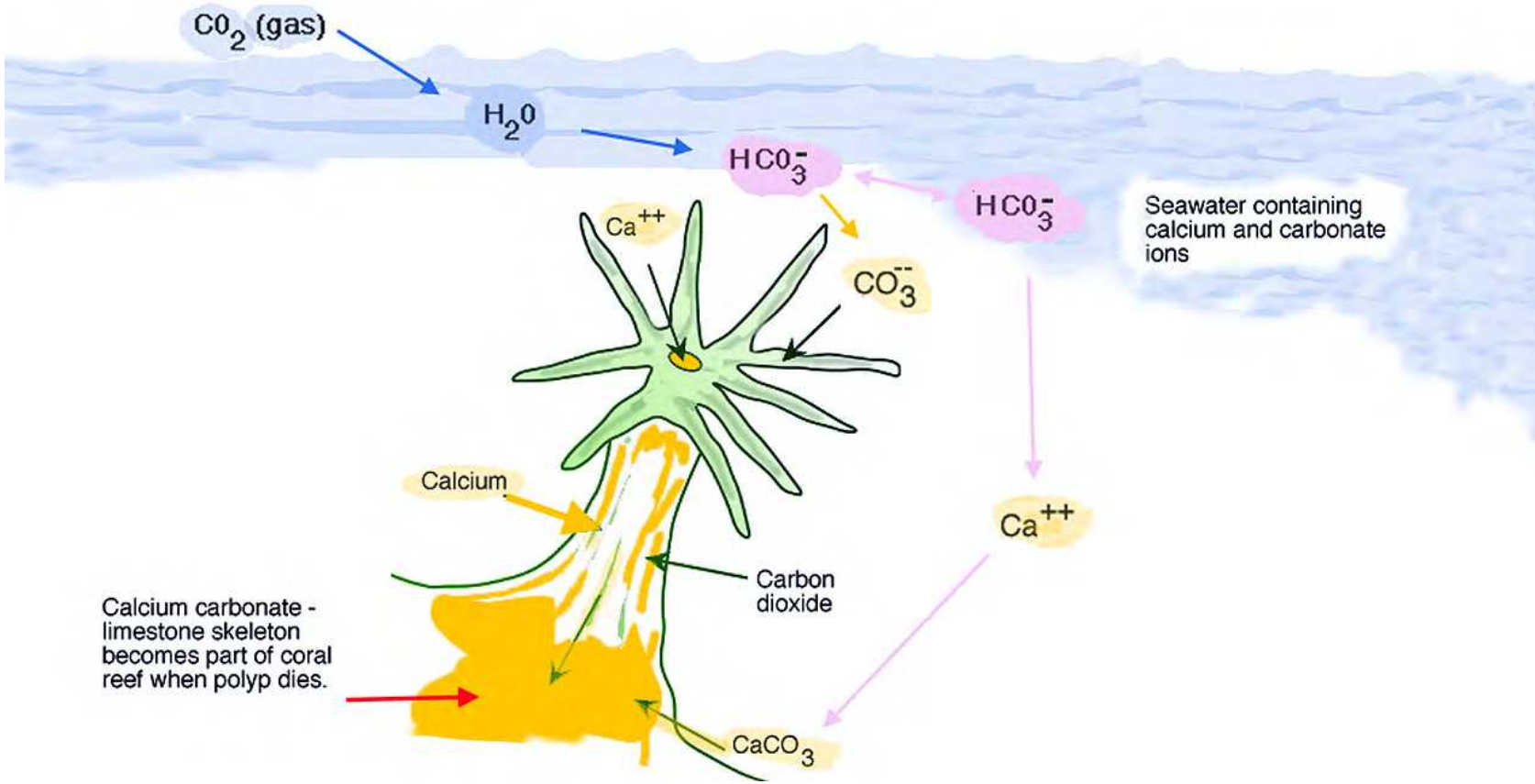
Over the past 300 million years, ocean pH has been slightly basic, averaging about 8.2. Today, it is around 8.1.



pH line and kit

Illustration Bob Moffatt

Water facilitates chemical reactions and the formation of new products because once ionic compounds dissolve, their anions (-) and cations (+) circulate through the water allowing further reactions to occur with other available ions e.g., Calcium carbonate formation.

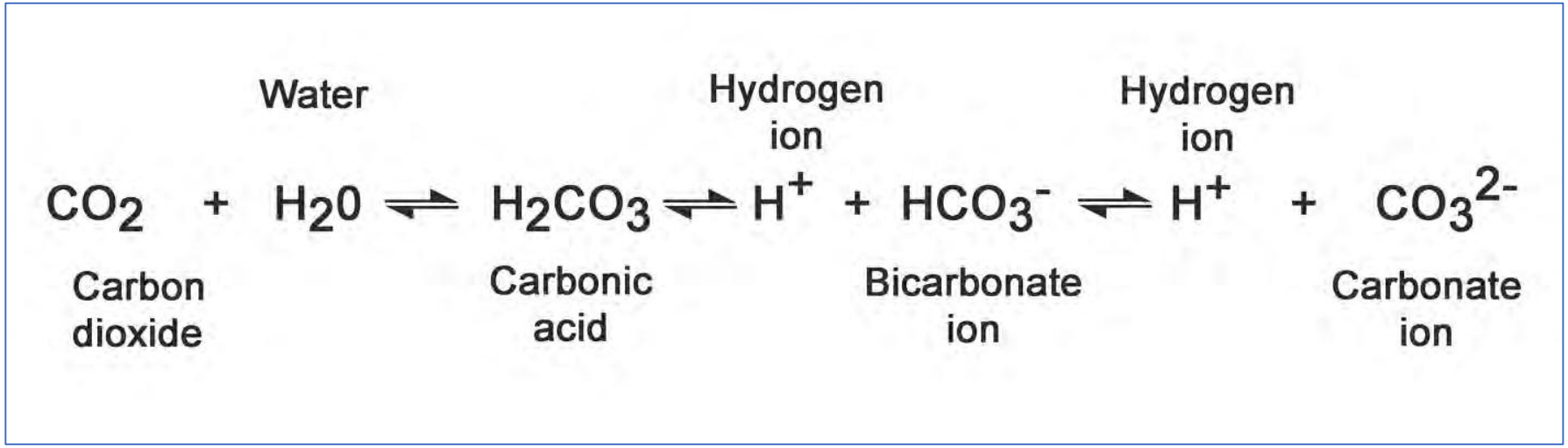


For example water allows calcium to combine with carbon dioxide to form calcium carbonate.

Illustration Bob Moffatt

When Carbon dioxide dissolves in water it exists in chemical equilibrium with Carbonic acid which dissociates into Hydrogen and Carbonate ions.

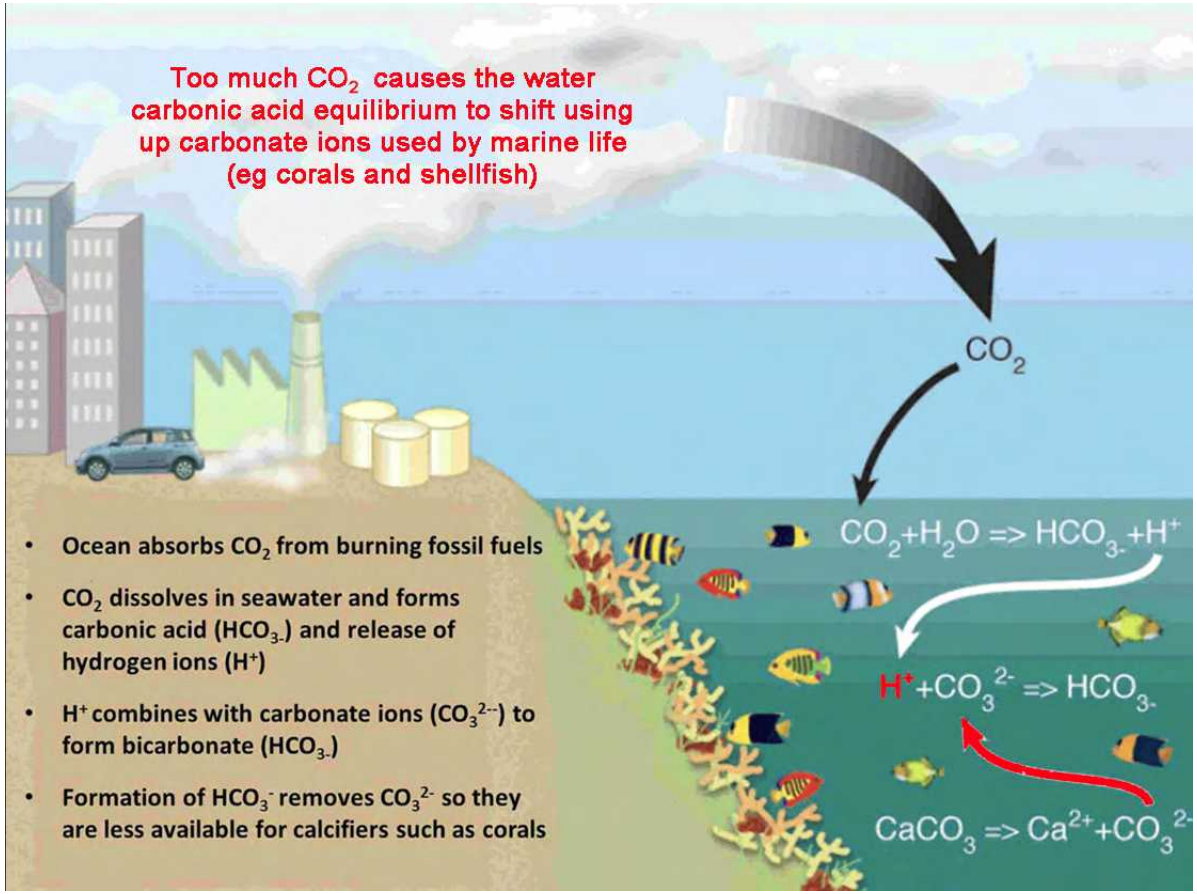
The water gets the Hydrogen ions making it increase in acidity.



Carbonic acid formation and dissociation

Illustration Bob Moffatt

As atmospheric Carbon dioxide increases, water increases the uptake of Carbonate ions to maintain the equilibrium reducing Calcium carbonate formation.

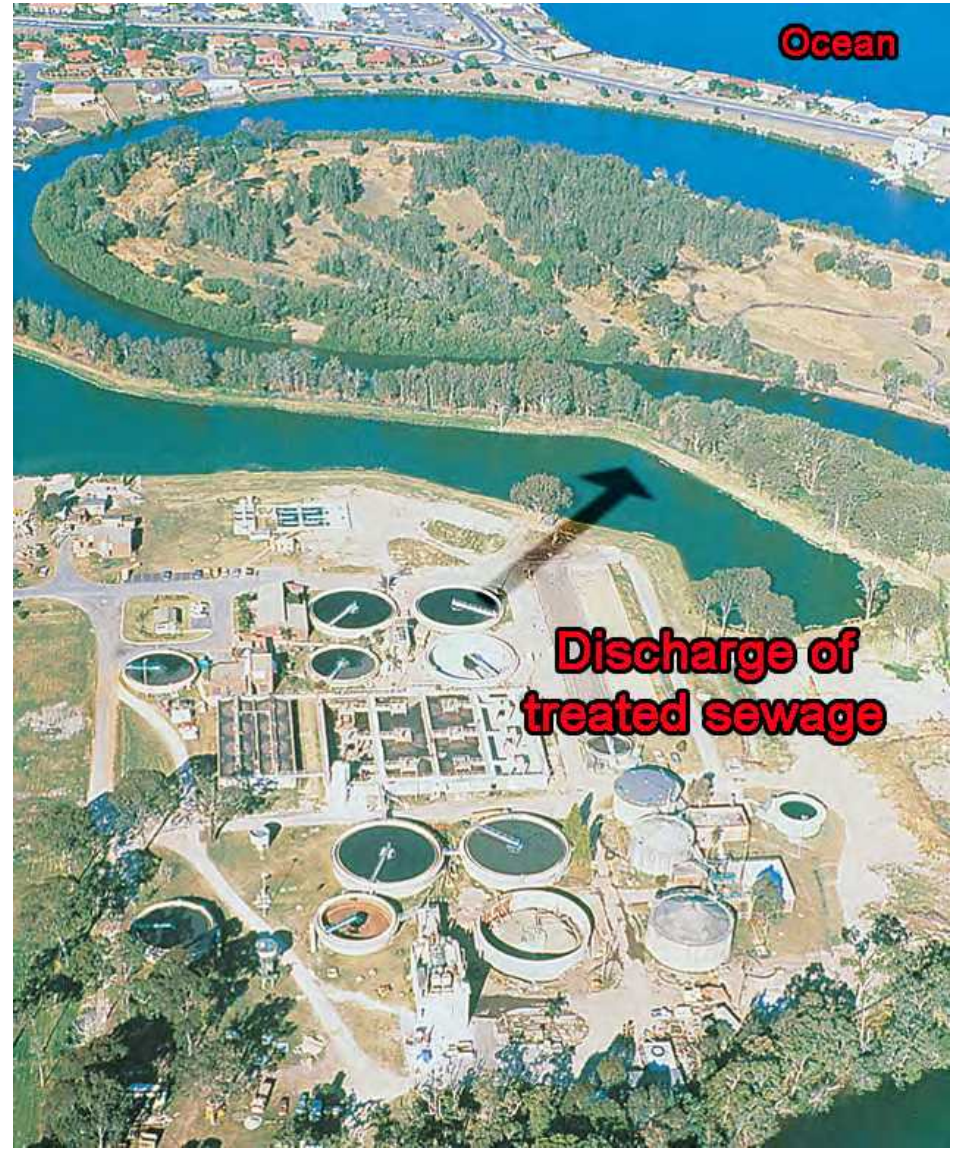


This reduces ocean pH making it more acidic.

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.

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

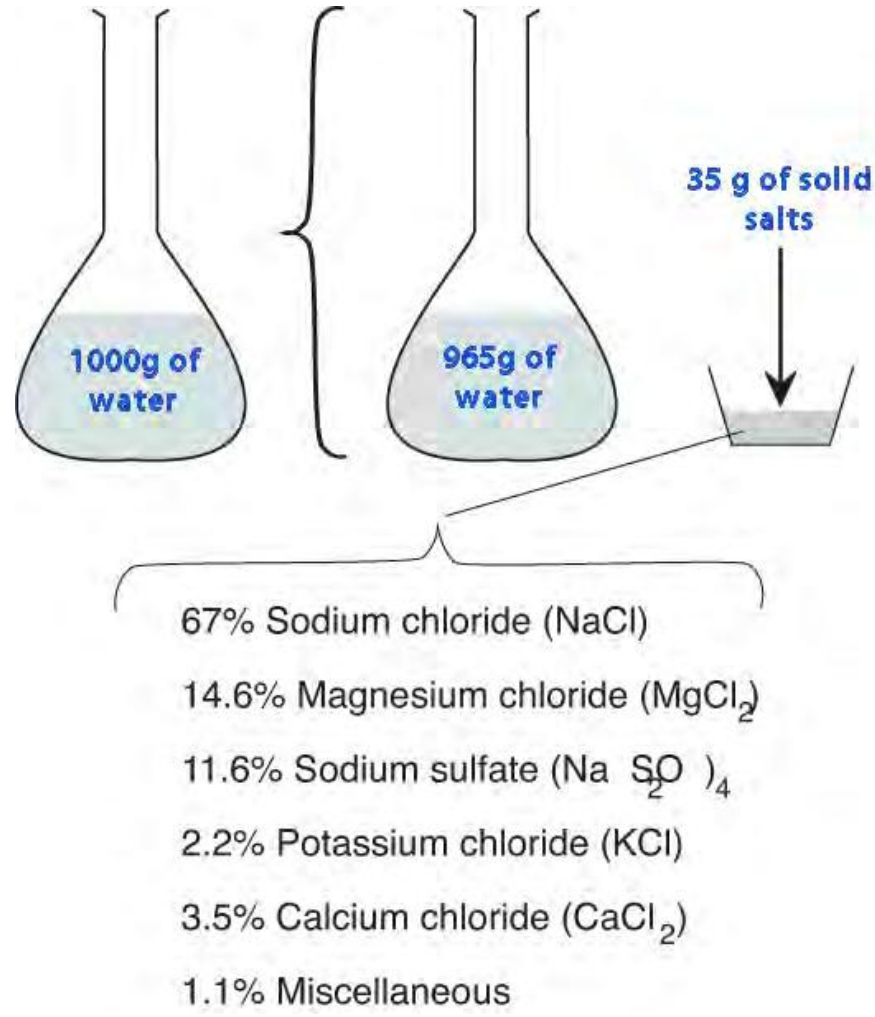
Salt cycles starts in the sea from sediments which are uplifted over millions of years by subduction, then eroded forming part of the sediment load in rivers, then back to the sea as sediment.

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

Remember: Salinity is the concentration of dissolved salts in water, usually expressed in parts per thousand by weight. (ppt = g/L)

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

The different salts dissolved in seawater can be seen in this diagram and contribute to the water's salinity level.



Seawater composition

Illustration Bob Moffatt

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^-

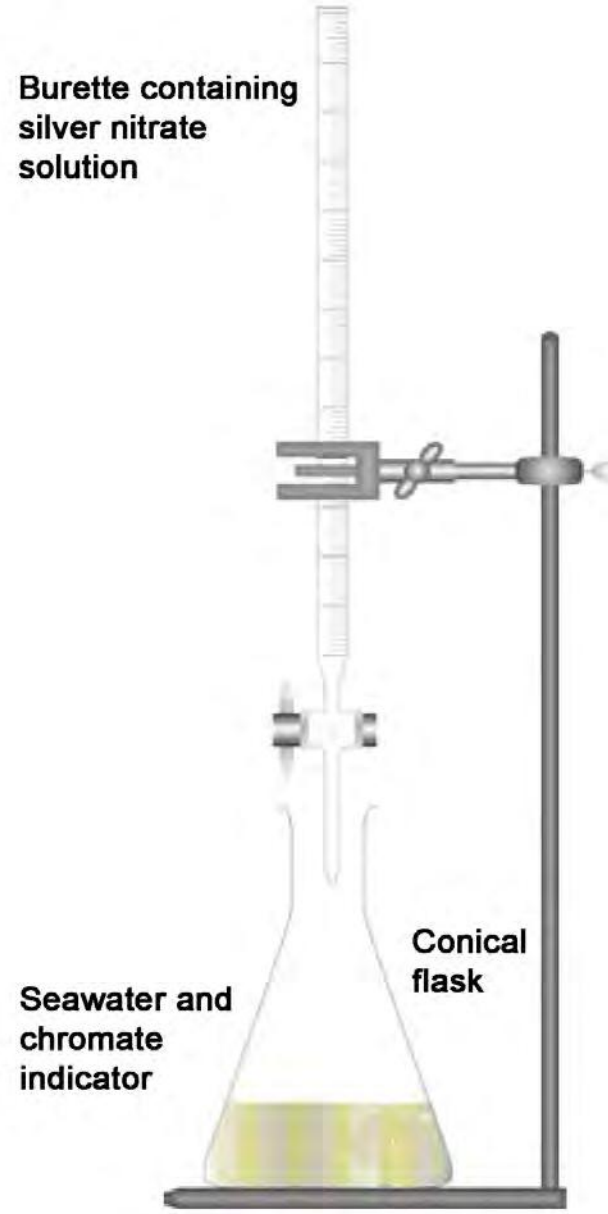
Salt and water ions

Illustration Bob Moffatt

Ionisation allows us to establish a chemical test to determine the salinity of a solution. Salinity can be measured as *molarity of Chloride ions* and can be determined using a titration method.

Solutions of seawater, Potassium dichromate and Silver nitrate are used in this titration.

There are other methods to determine the salinity of seawater. You might like to investigate these.

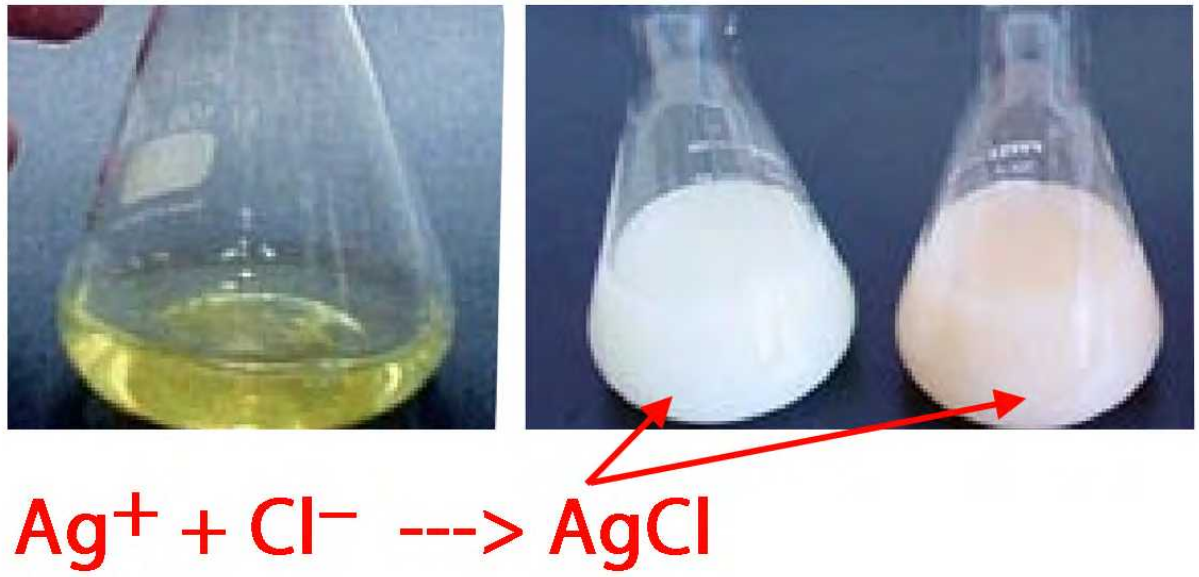


Seawater titration set up

From College of Science, University of Cantebury

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

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.

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

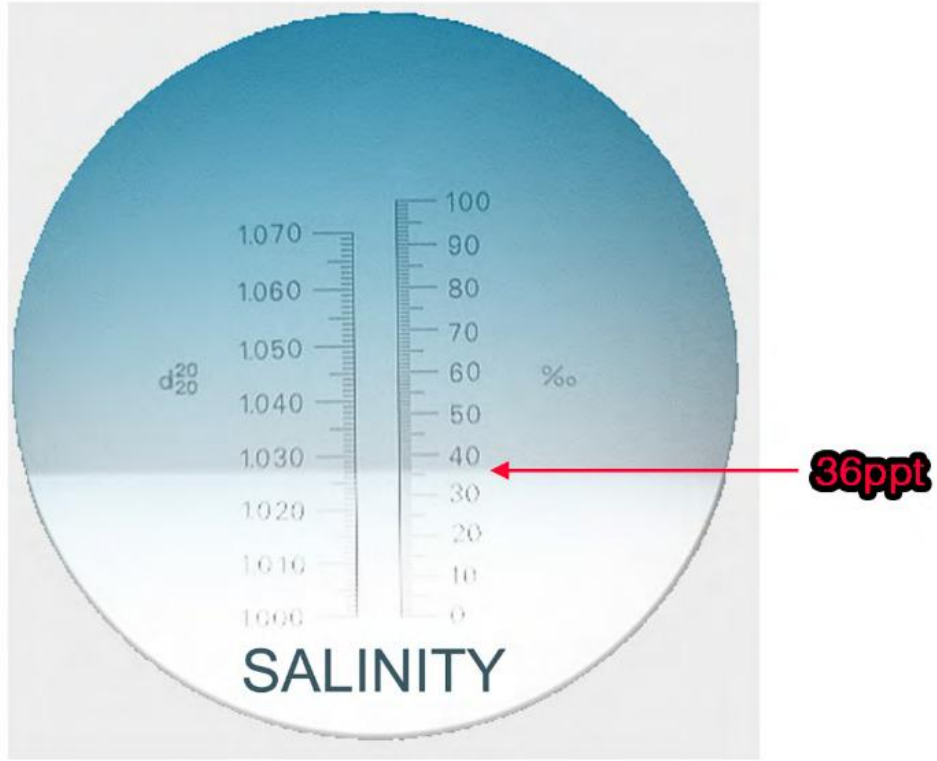
Silver chromate end point

From College of Science, University of Cantebury

Salinities can be also be measured with a salinity meter

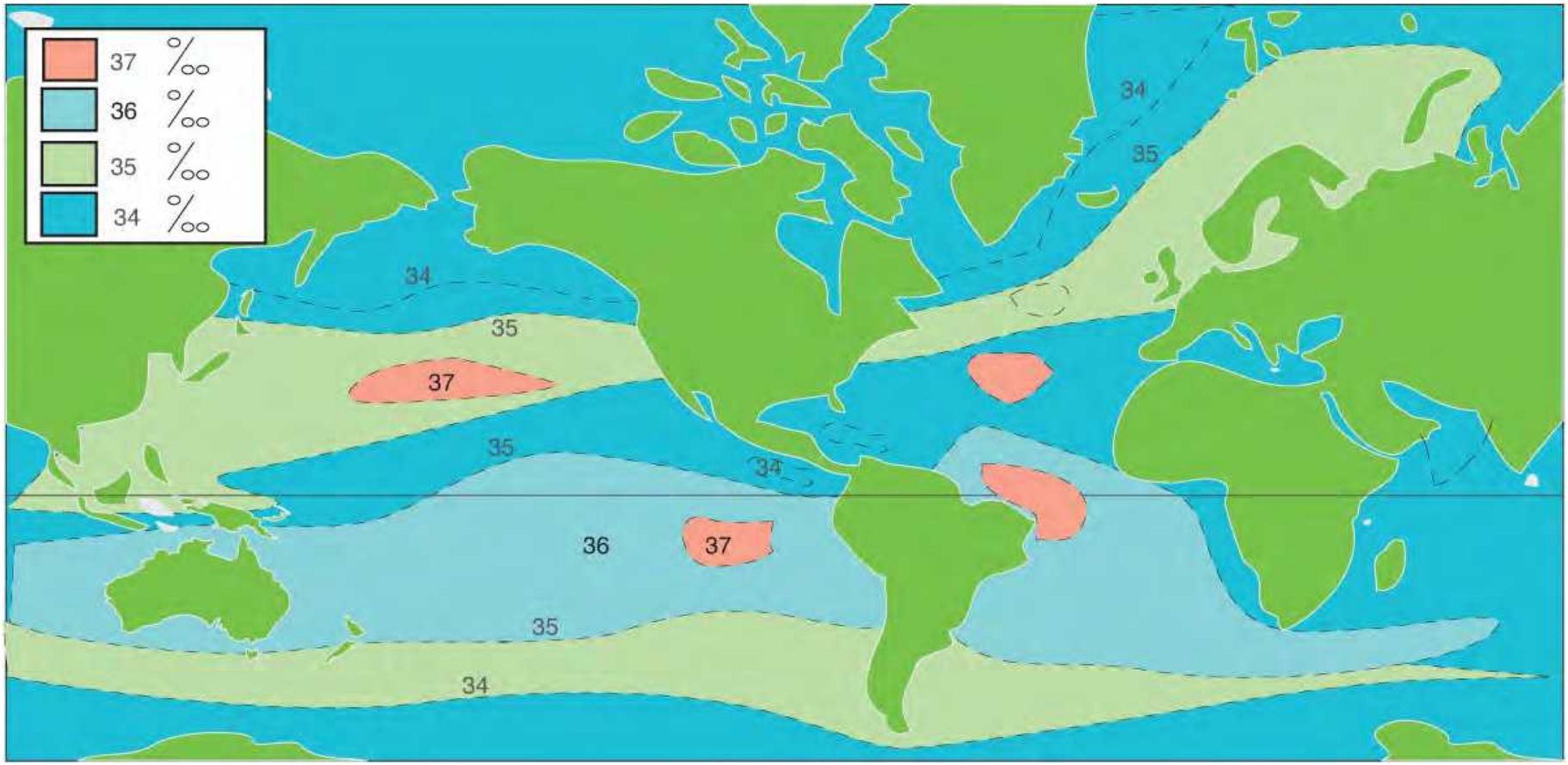
Photograph Selbys Scientific

Salinities can be measured with a refractometer



Photograph Selbys Scientific

World salinities vary from 34 - 37 ppt



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

2. Physical properties of water

A. States of matter

B. Heat capacity

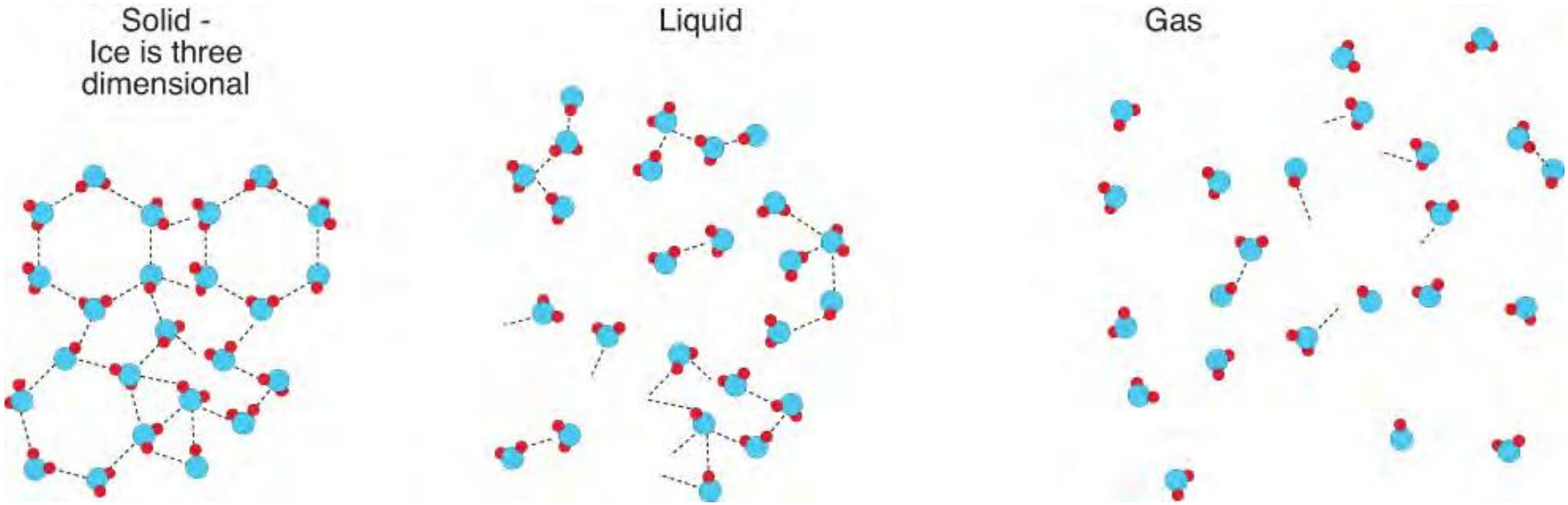
C. Density

D. Viscosity

E. Surface tension

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

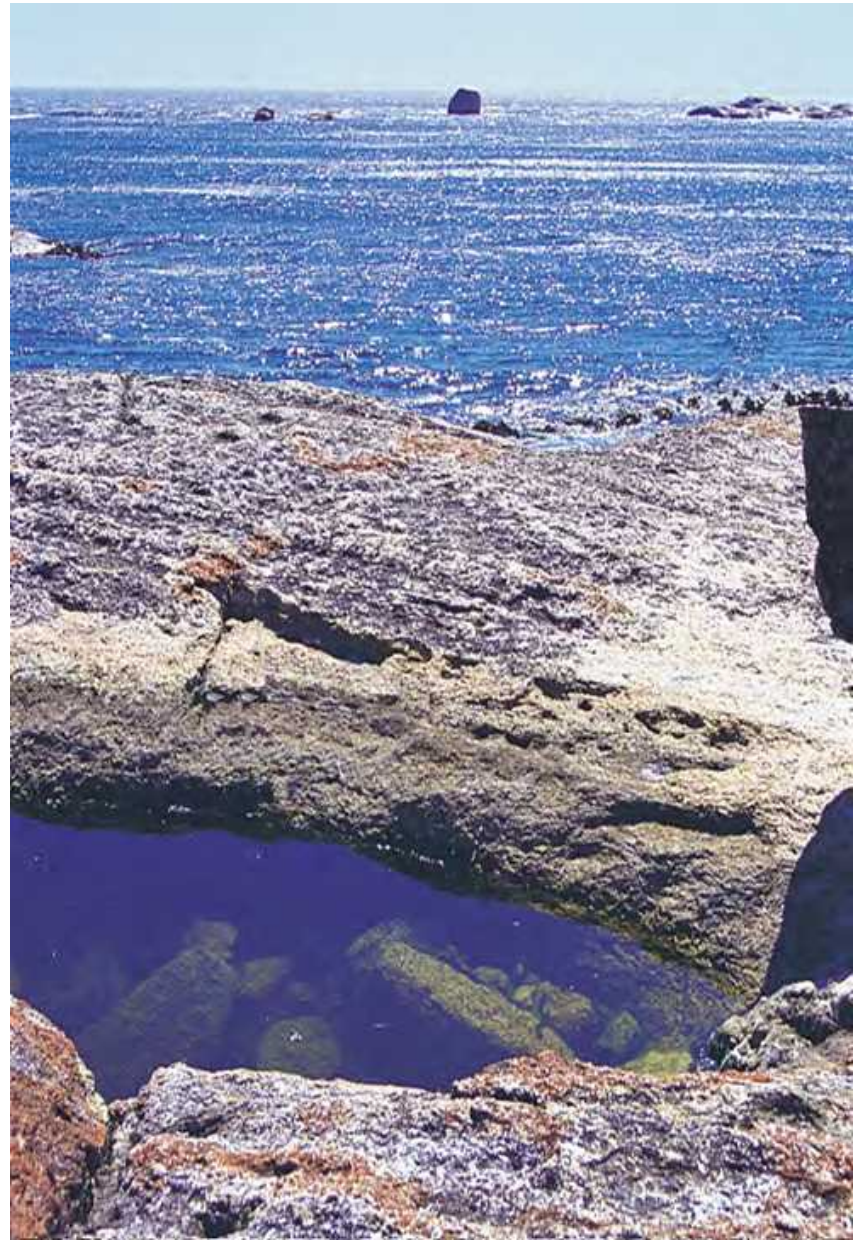
Illustration Bob Moffatt

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

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

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

As icebergs are chunks of ice originating from glaciers and are freshwater, they will be less dense than salt water and will float.

Iceberg
Photo Bob Moffatt

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 and is very important.

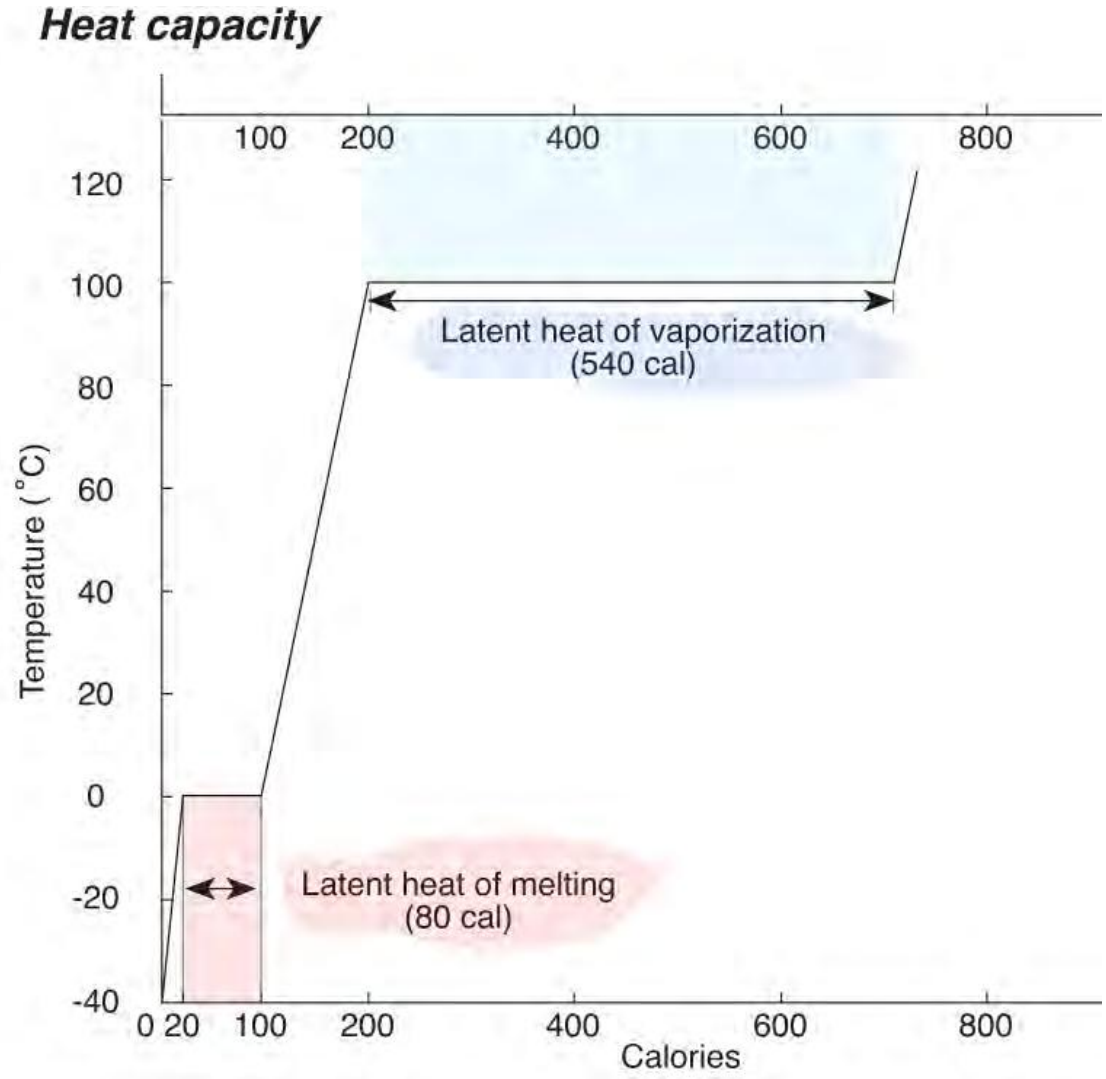
Seal on iceberg

Photo Bob Moffatt

Heat capacity

Heat capacity is the heat required to raise the temperature of a substance one degree and is expressed in calories.

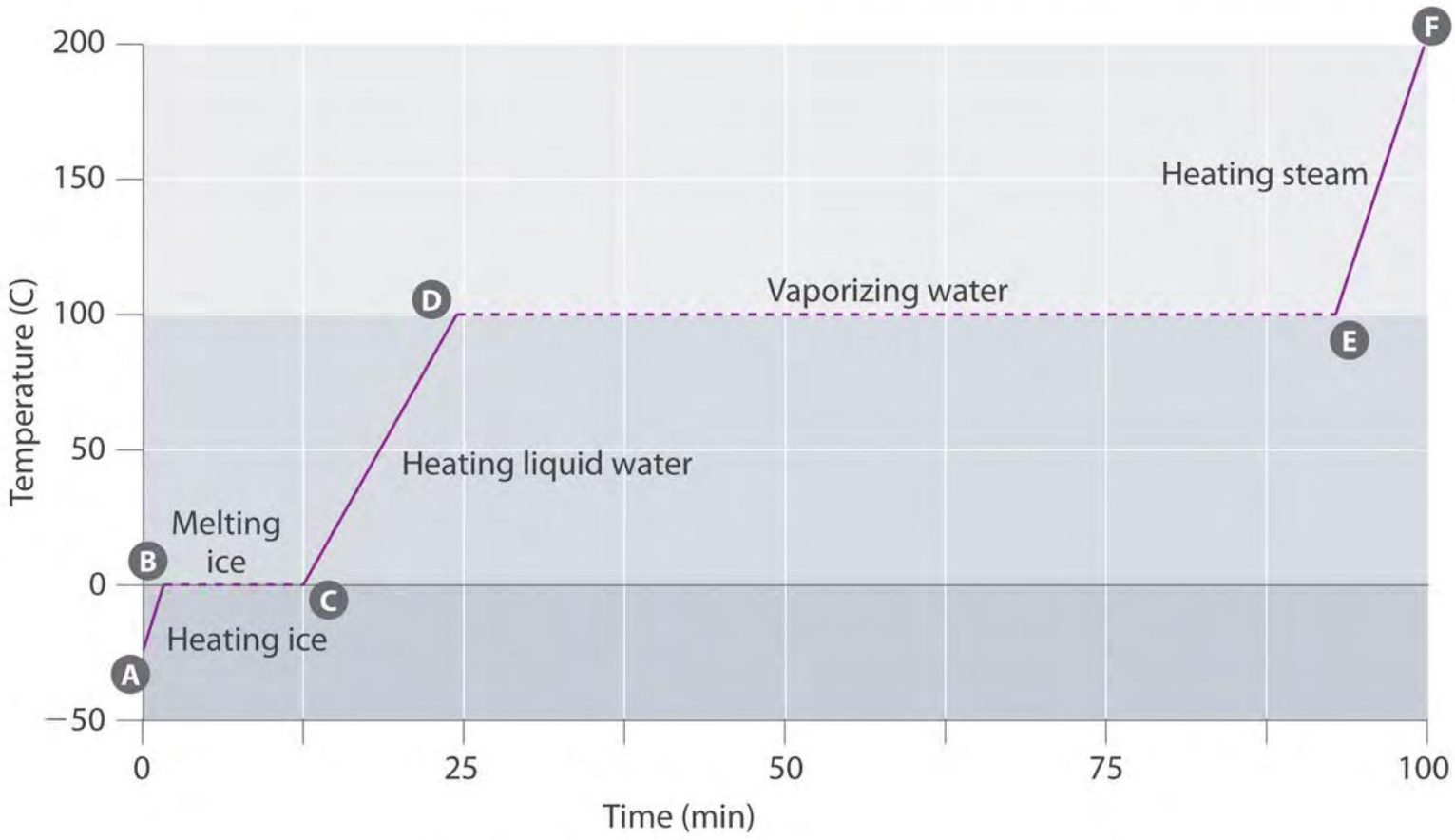
Less heat energy is required to melt ice than to vaporise water to steam.



Heat capacity of water

Illustration Bob Moffatt

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

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

Note

Temperature changes are discussed in the next topic.

Whale Shark

Below H2O

Density

The density of a substance is the mass per unit volume. (g/cm^3)

As water cools more Hydrogen bonds form in water and the movement of the molecules slows down. The molecules are drawn closer together and the mass per unit volume increases to 4^oC where its mass is equal to its volume.

The density of pure water is therefore 1 g/cm^3 at 4^0C and is used as a standard to compare density of all other substances.

Density is an important property of ocean water because it determines the vertical position of water masses and creates deep ocean currents. Seawater density is between 1.022 & 1.030 g/cm^3 and increases in density until it freezes.

As seawater freezes at -1.9^0C, its density decreases greatly, so sea ice floats.

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

Temperature has the greatest influence on density. As temperature increases density decreases (due to thermal expansion).

At a salinity of 30ppt, the colder the water the greater 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	1.00367	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	1.02479	1.02337	1.02176
40	1.03216	1.03166	1.03088	1.02985	1.02860	1.02715	1.02551

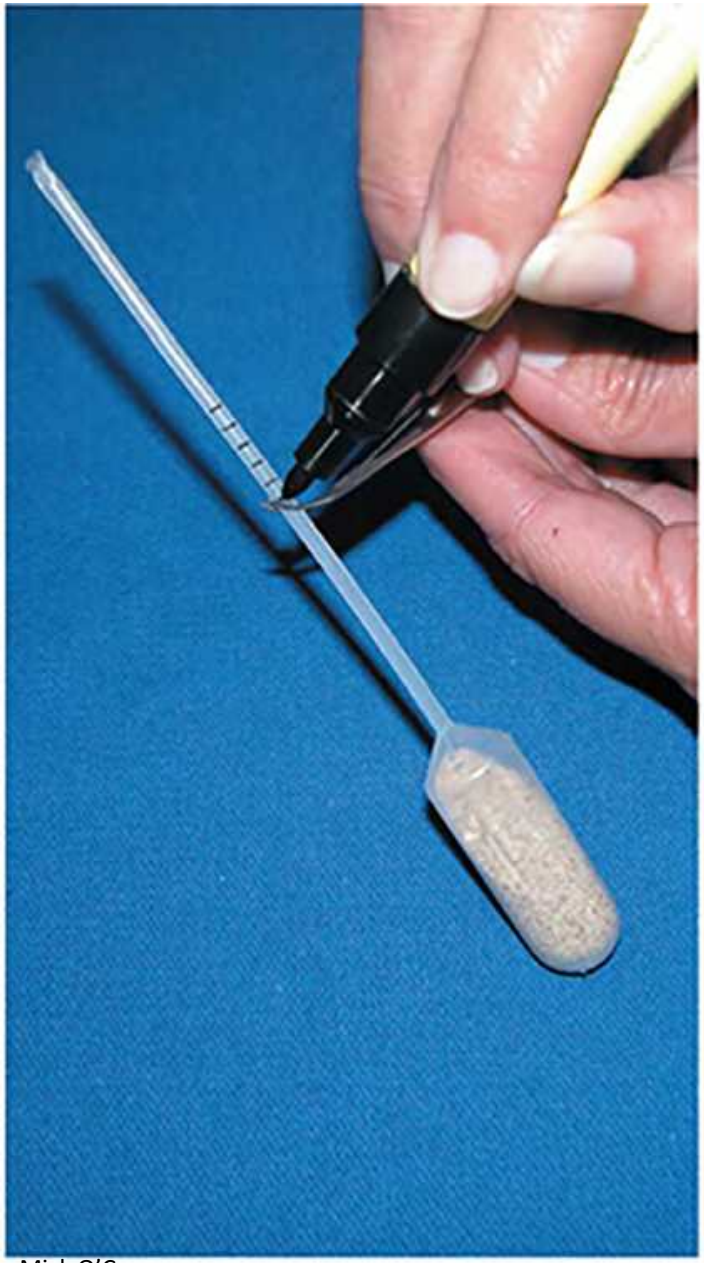
Densities

Salinity temp density comparison

Illustration Bob Moffatt

Density can be used to determine salinity by making a simple hydrometer.

Mick O'Connor



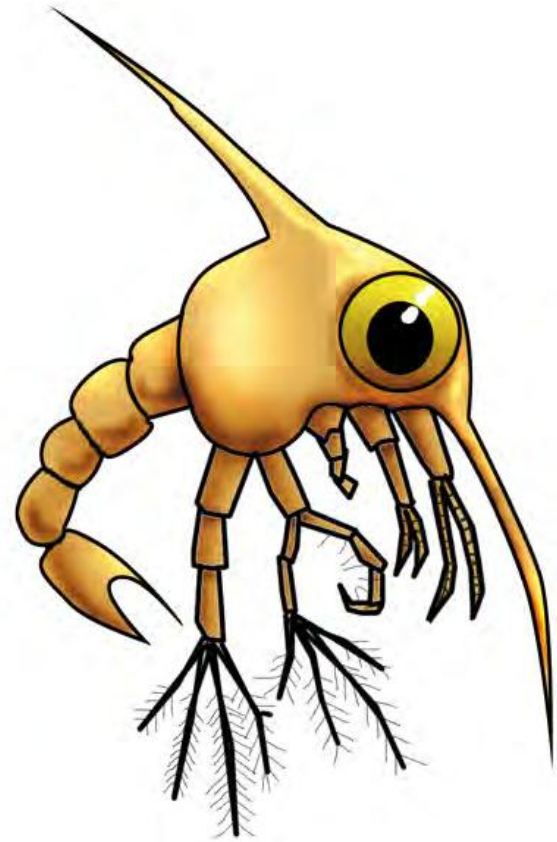
Mick O'Connor

Use a set of standard solutions to calibrate your home made instrument.

Mick O’Connor

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

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

Figure Antarctic Krill
Photo ANARE

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

Based on an original activity by Tim Ryan, Maryborough State High School

METHOD

1. Using stand and clamps, set up the 4 pieces of glass tubing in a vertical position.
2. Cork each glass tube as shown in Figure 1
3. Fill each glass tube to an approximate height of 25 cm with one of the liquids below. The liquids in each tube should be of the same height.
4. Release a sphere into a filled tube and record the time it takes to reach the bottom.
5. Repeat step 4 using the other three liquids.

MATERIALS AND EQUIPMENT (PER GROUP)

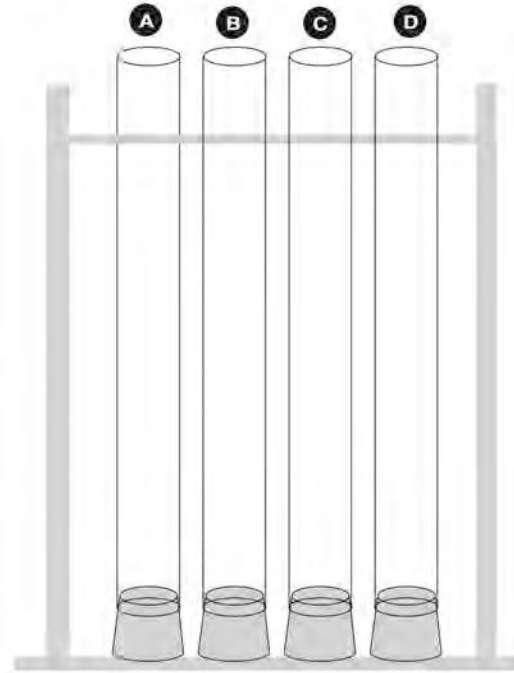
Equipment required

- honey or golden syrup
- clear oil (motor oil)
- cooking oil
- 4 metals or heavy spheres (marbles/sinkers will do)
- 4 lengths of glass tubing 30 cm, (the wider the better).
- 4 large test tubes mat be used (the sphere must fit inside the glass tubing)
- 4 corks to seal glass tubing
- stand and clamps

QUESTIONS

1. In which liquid did the sphere take the longest time to sink?
2. How long did it take the sphere to reach the bottom of the glass tubing?

   How long will it therefore take for it to sink 1 metre?
3. How long will it take for the sphere to sink to the bottom of the Pacific Ocean which has a mean depth of 4188 metres?

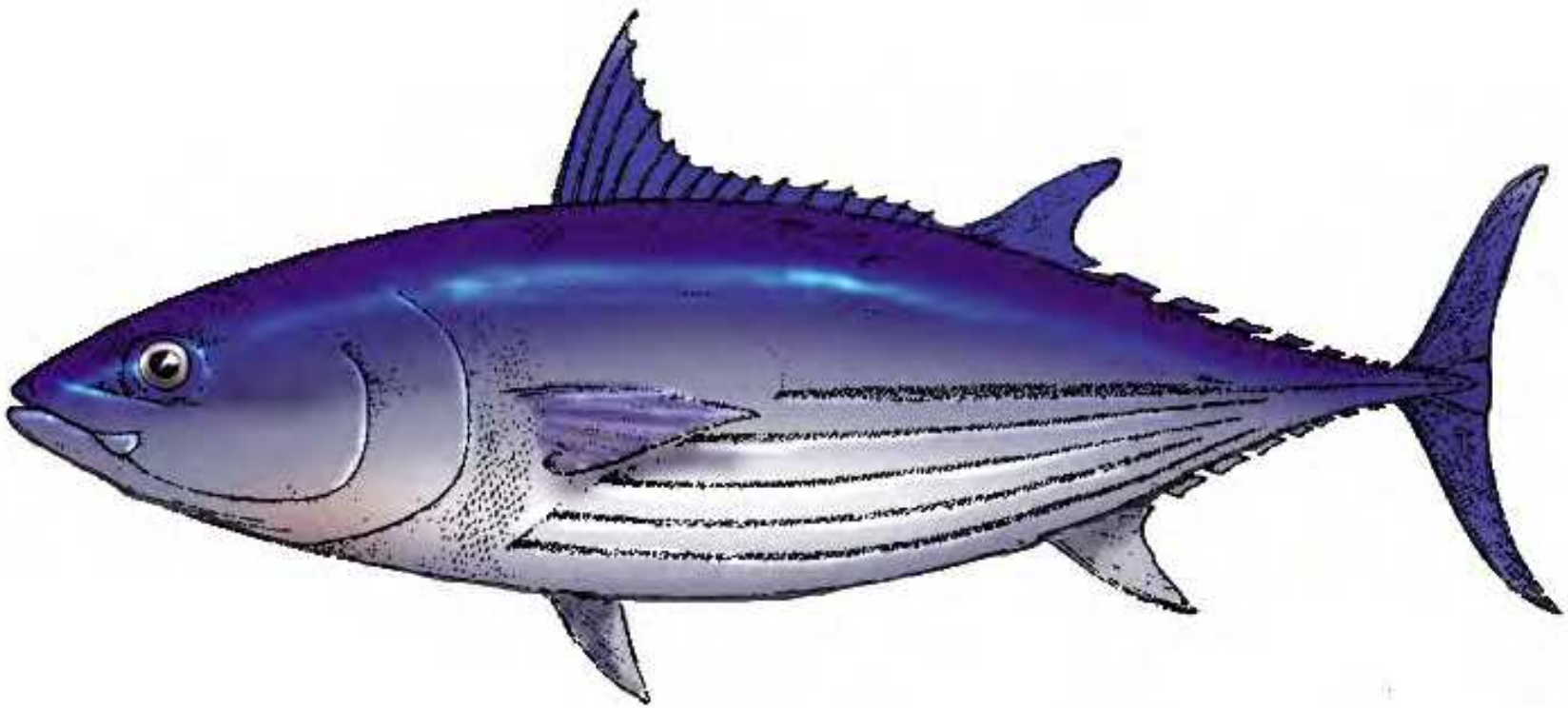


Viscosity experiment

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 streamlined or fusiform. Also, fish that need to be stable in fast flowing water have humps on their backs.



Tuna

Illustration Kerry Kitzelman

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.

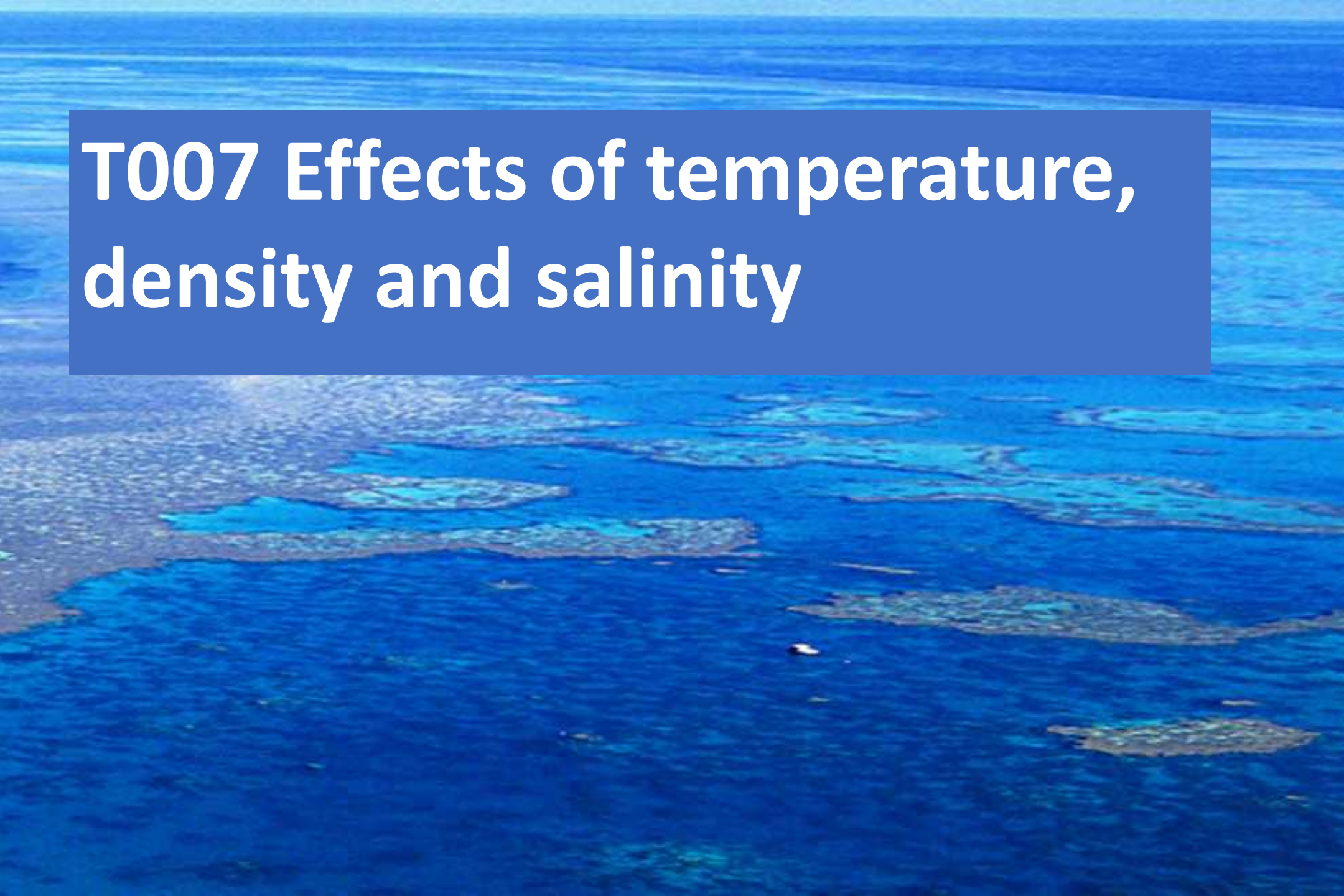
This allows light animals to literally 'walk on water'.

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

Water strider

Describe

1. How salinity can be determined by titration. Write a set of equations to illustrate how determination is made.
2. How salt ionises in water.
3. How density can be used to determine salinity.



T007 Effects of temperature, density and salinity

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.

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

Question

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

A. Thermocline

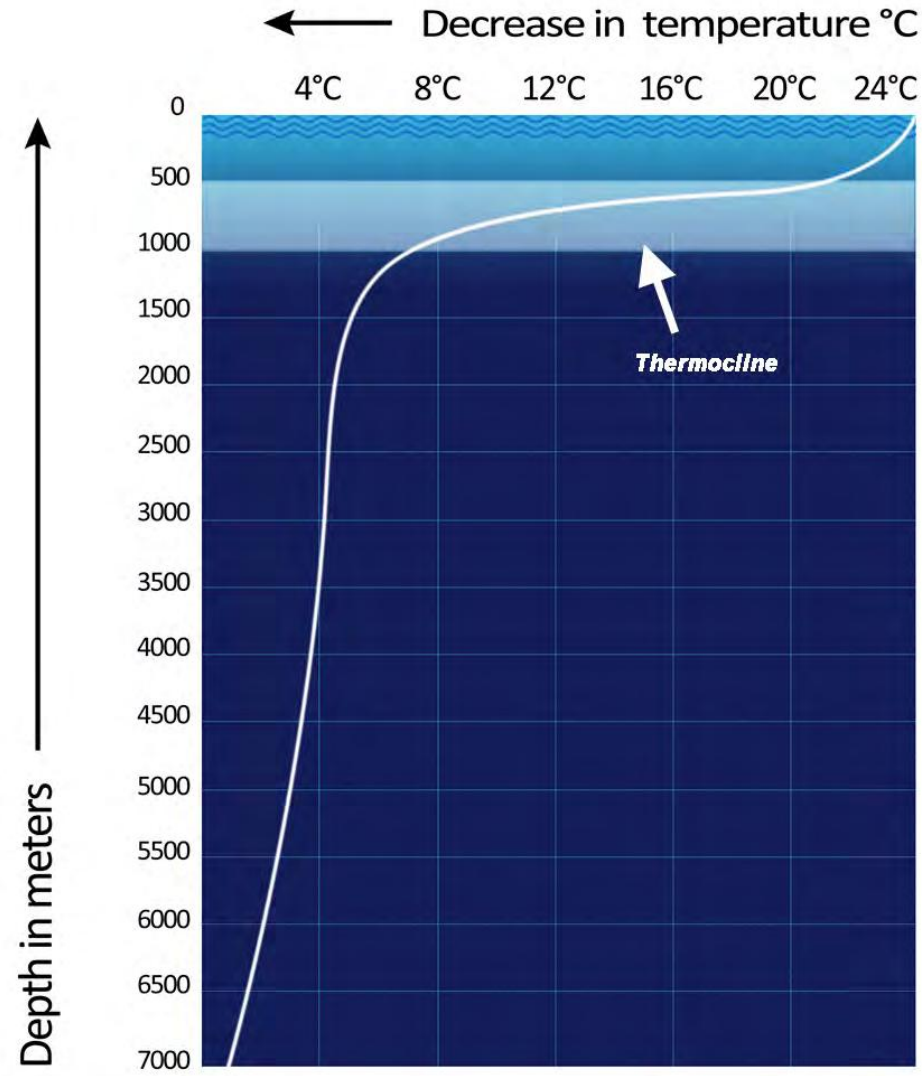
B. Halocline

C. Pycnocline

Thermocline

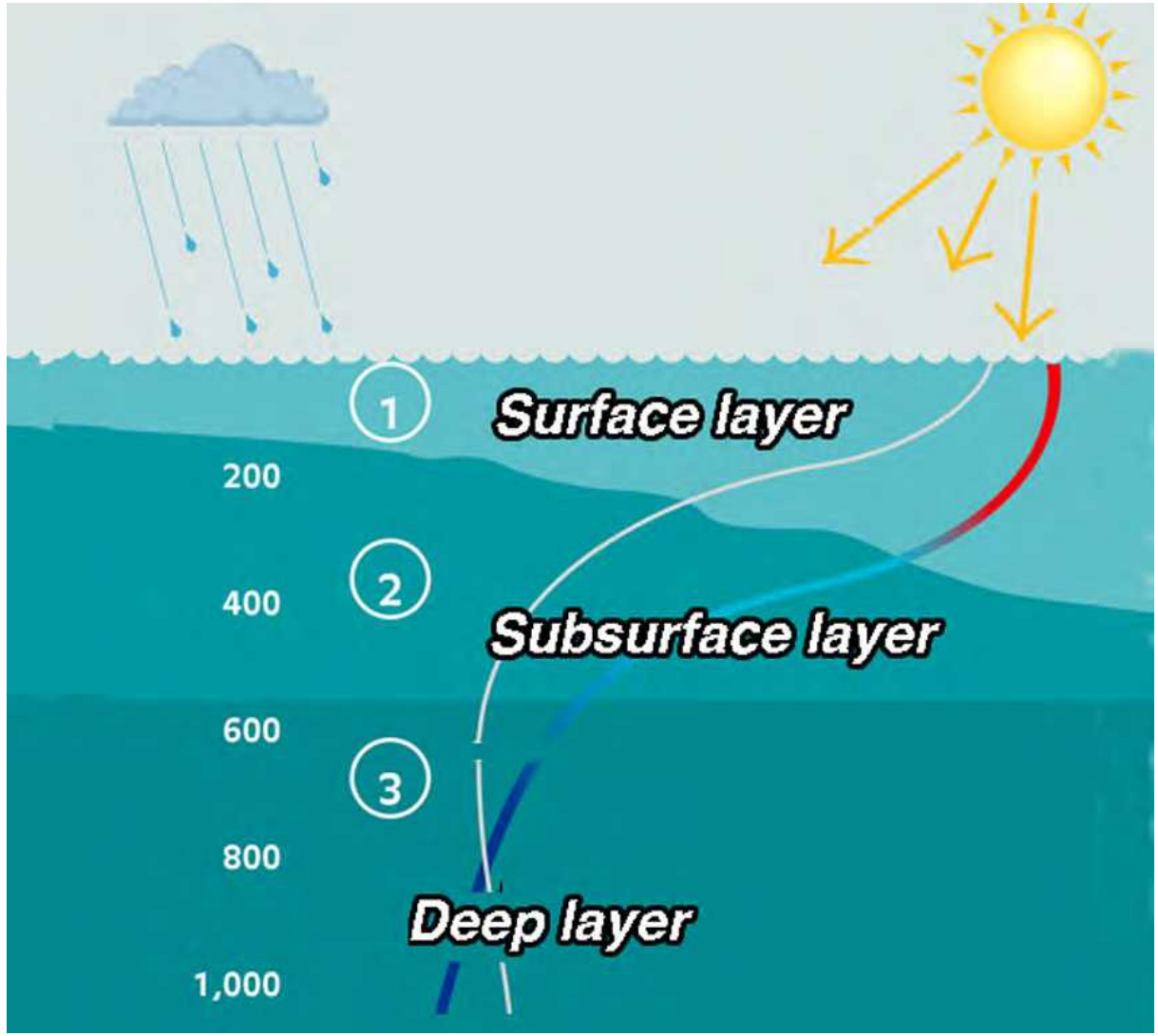
A thermocline is a distinct layer in the ocean in which temperature changes more rapidly with depth than it does in the layers above or below.

(*thermo* = heat, *cline* = slope)



Thermocline

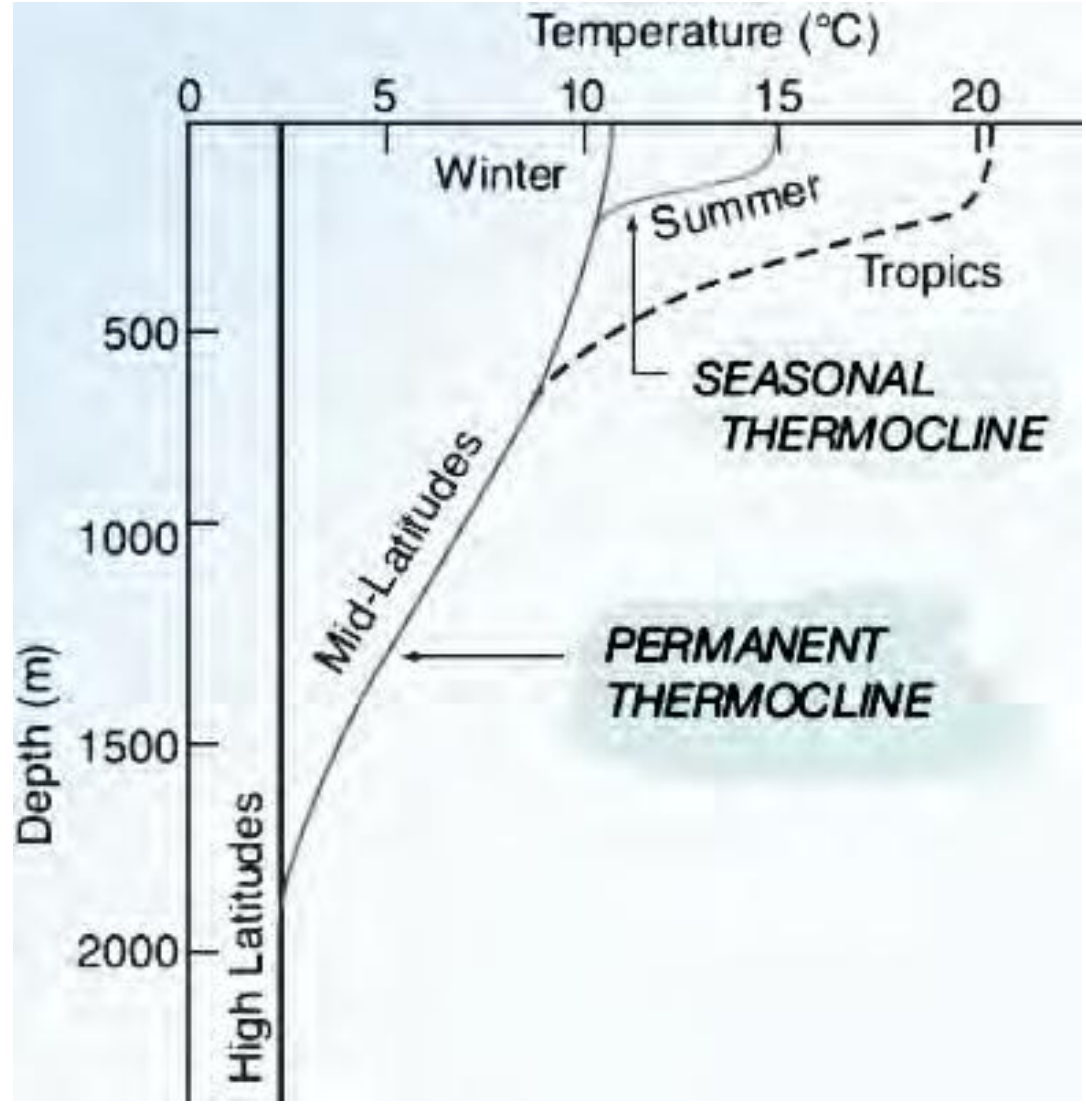
In the ocean, the thermocline divides the upper mixed temperature layer warmed by the sun from the constant deep cold water below.



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

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



Thermocline seasonal depth

Thermocline latitude depth comparison

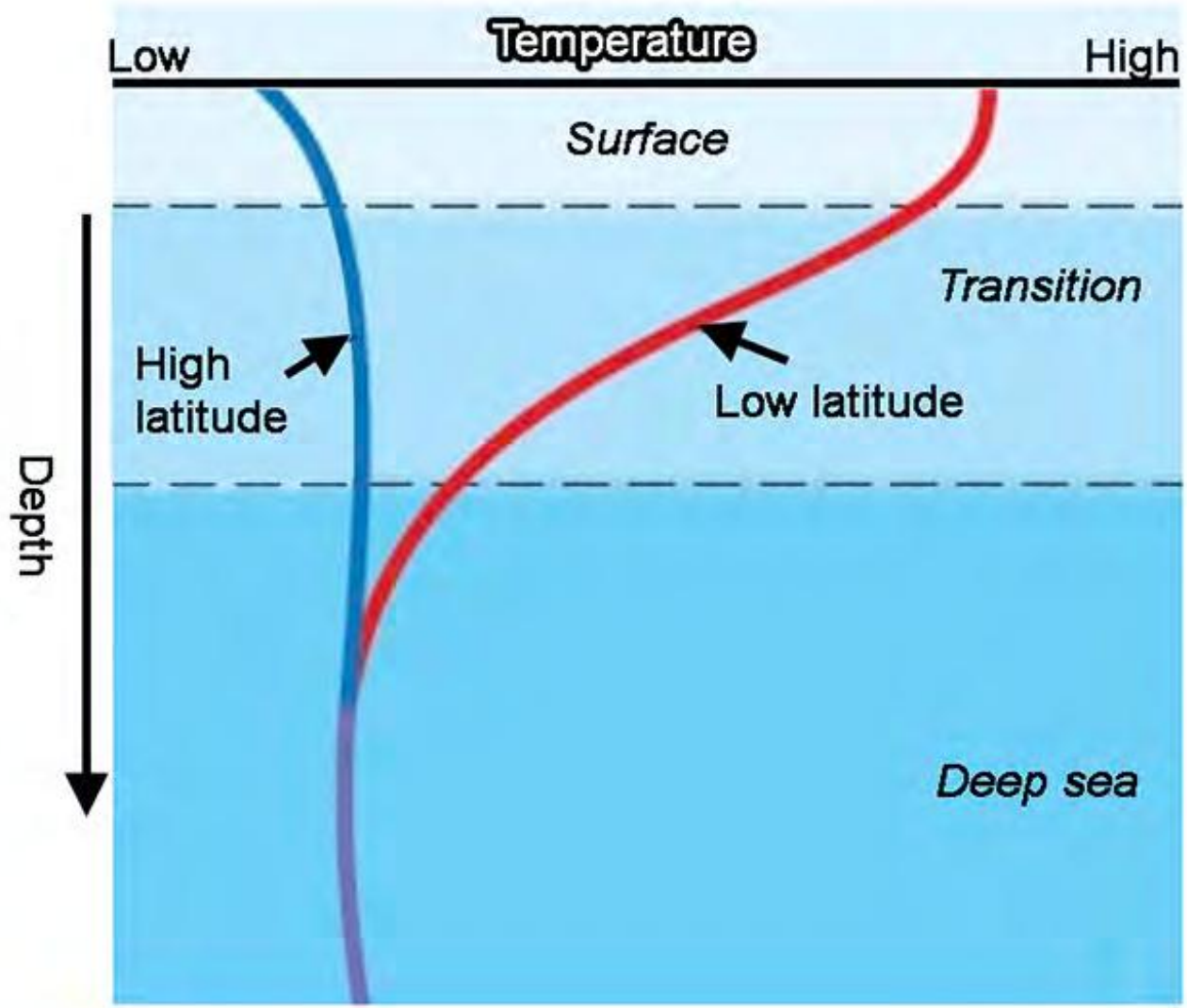
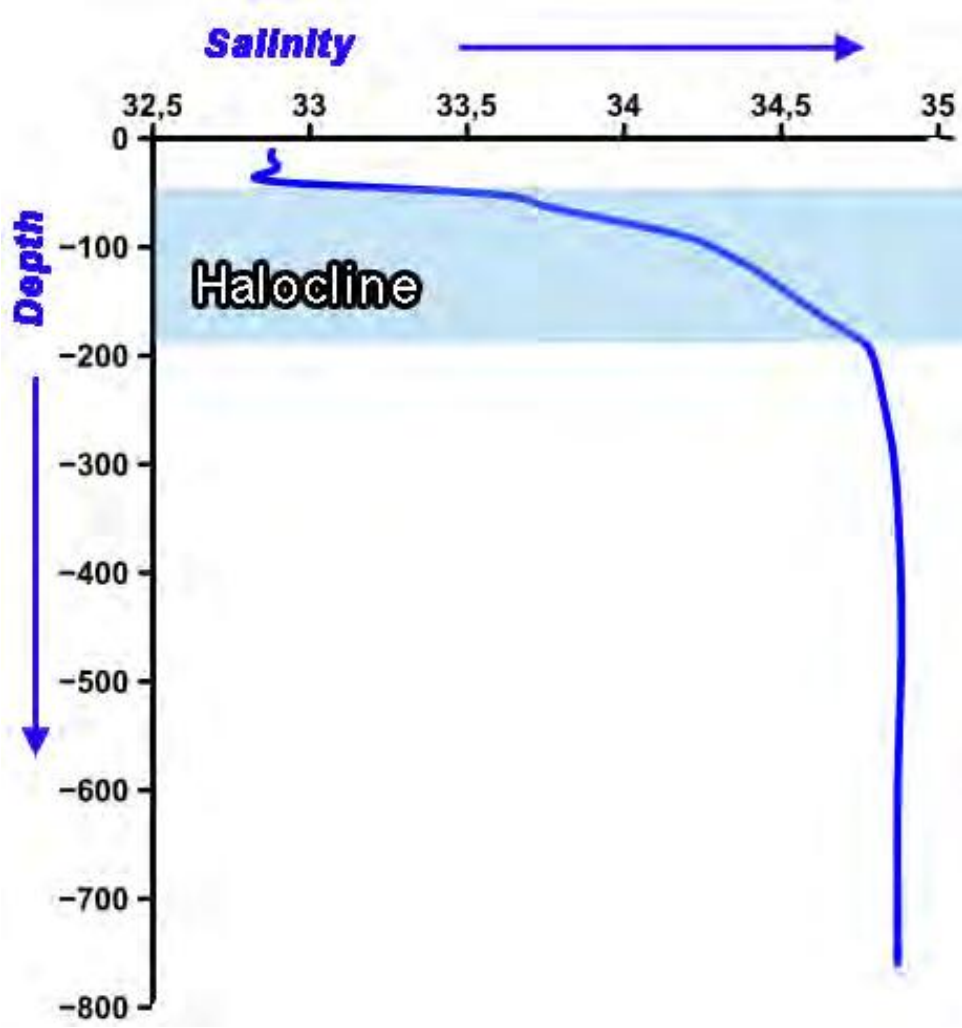


Illustration Bob Moffatt

Halocline

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

(*halo* = salt, *cline* = slope)



Halocline

Illustration Bob Moffatt

Salinity in lower latitudes is greater than in higher latitudes because of the ice melt and surface runoff.

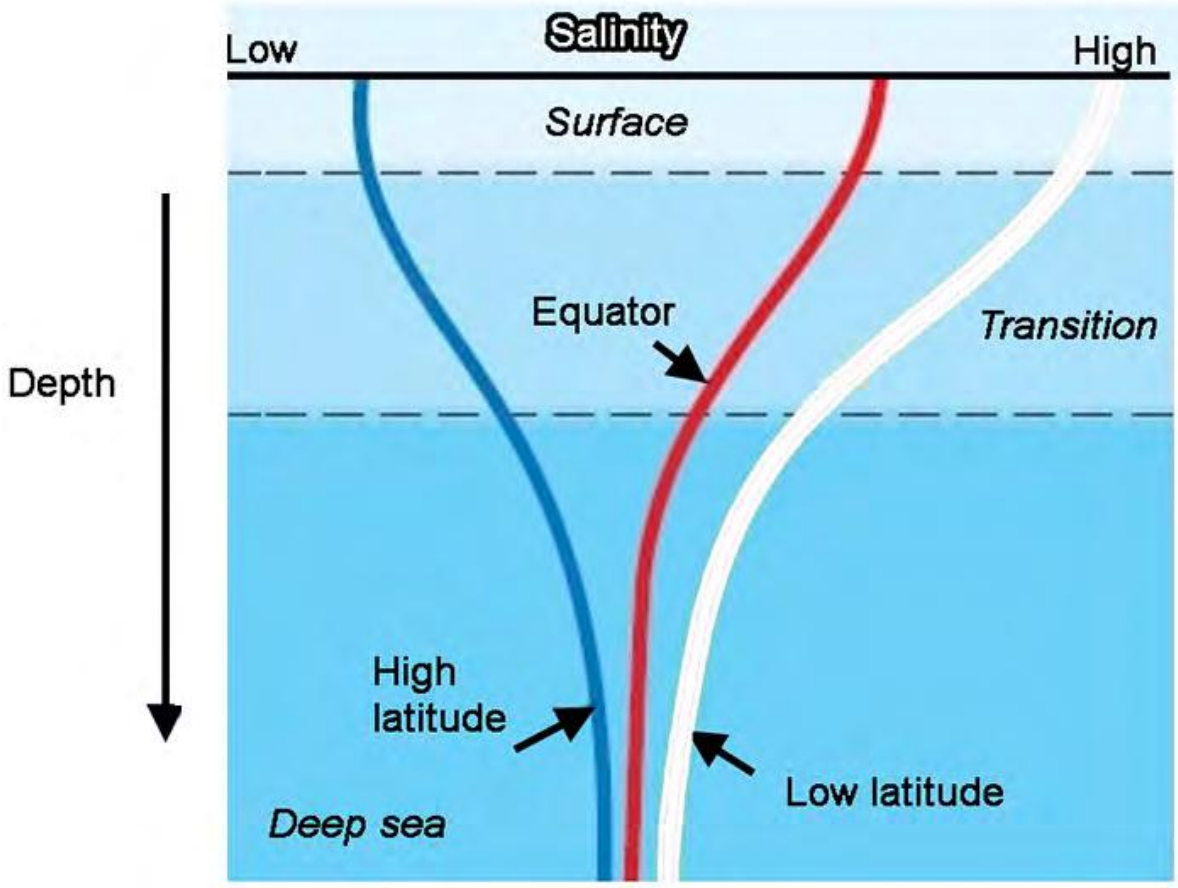


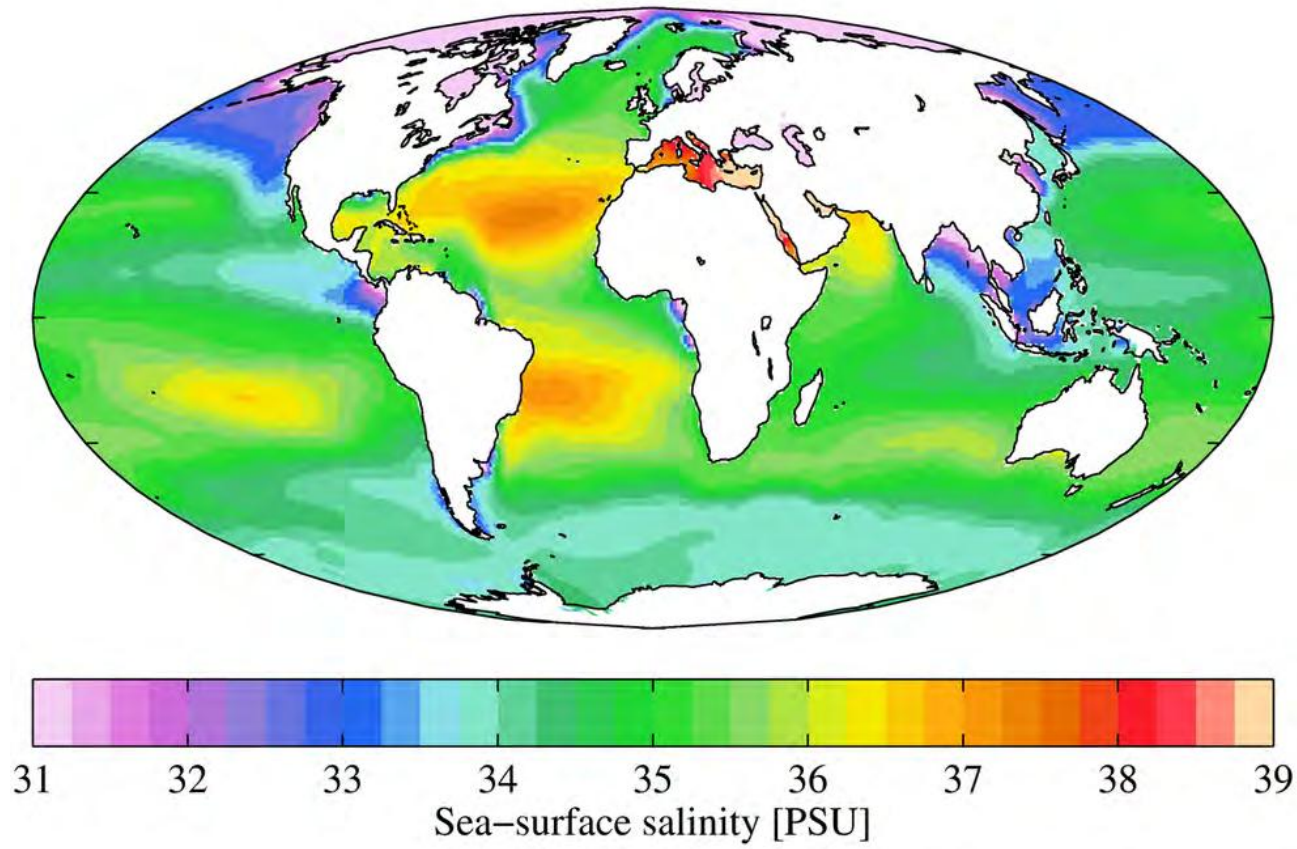
Illustration Bob Moffatt

Factors that affect salinity are: precipitation, runoff, melting ice bergs, formation and melting of sea ice and evaporation.

In the mid latitudes, 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.

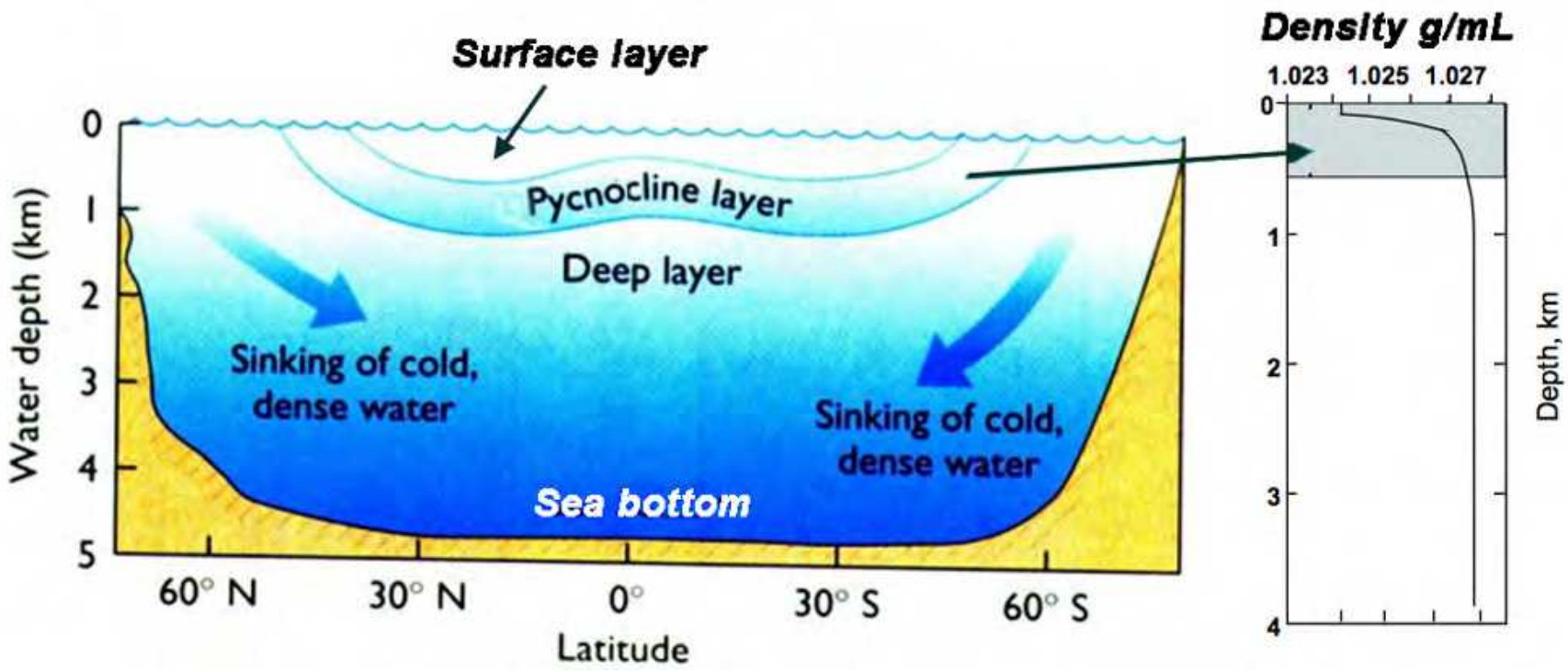
The halocline is responsible for maintaining water column stability allowing for the formation of sea ice, and limiting the escape of carbon dioxide to the atmosphere.



Sea surface salinities

Pycnoclines

A pycnocline is the layer where the density gradient is greatest within a body of water usually between 300 and 1000 m. (*pycno* = density, *cline* = slope)

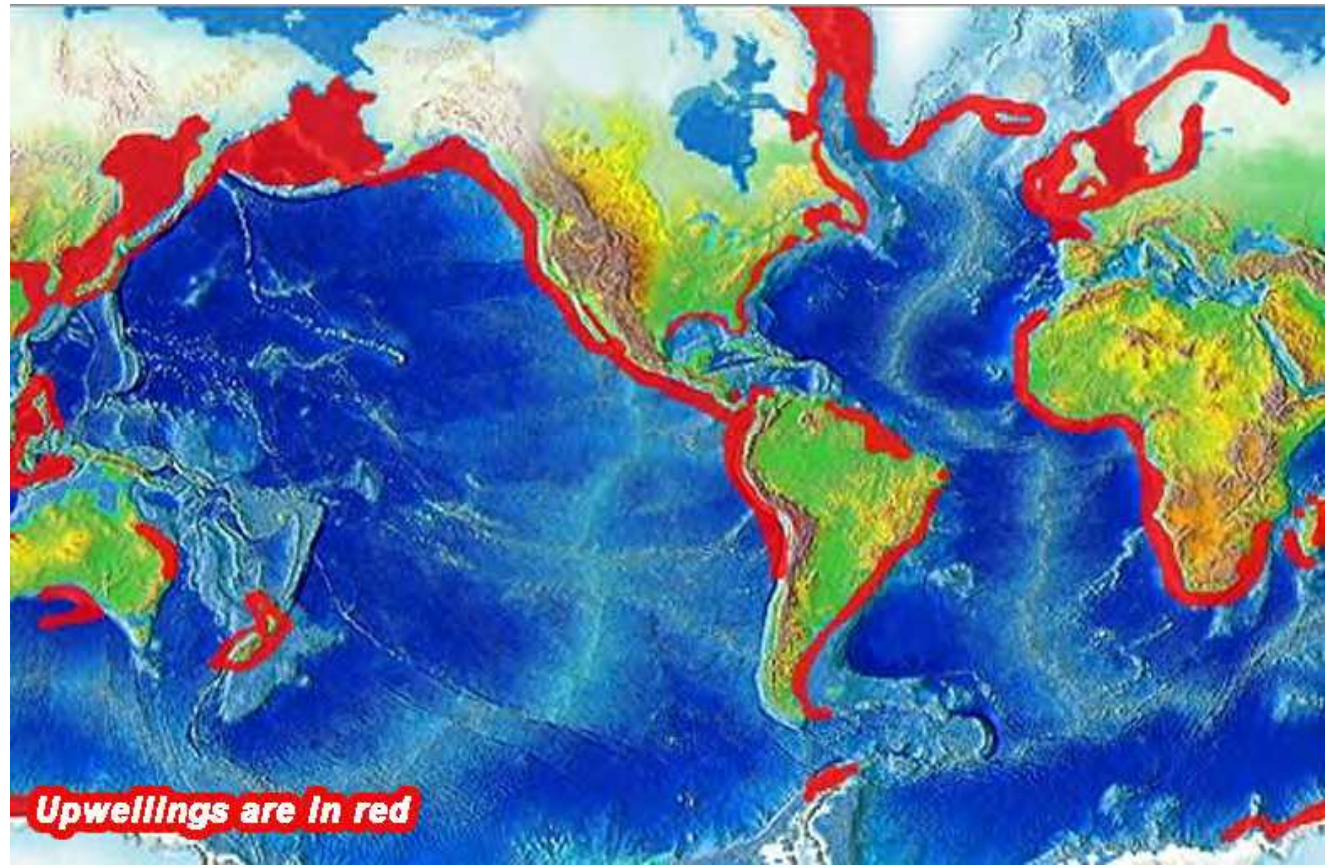


Pycnocline layer

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

The physical properties in a pycnocline driven by density gradients also affect the flows and vertical profiles in the ocean. For example, seawater with a density of 1.03g/cm^3 added to freshwater would sink below the fresh, creating a deep ocean current.

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



World upwellings

An upwelling brings nutrient-rich, cold, salty water to the surface.

In your notebook

Define the terms

Thermocline, halocline and pycnocline.

Use graphs to illustrate changes with depth.

T008 Oxygen minimum zone

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.

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 (DENSITY) bacterial stability
C. Nutrients from upwellings affected by thermoclines

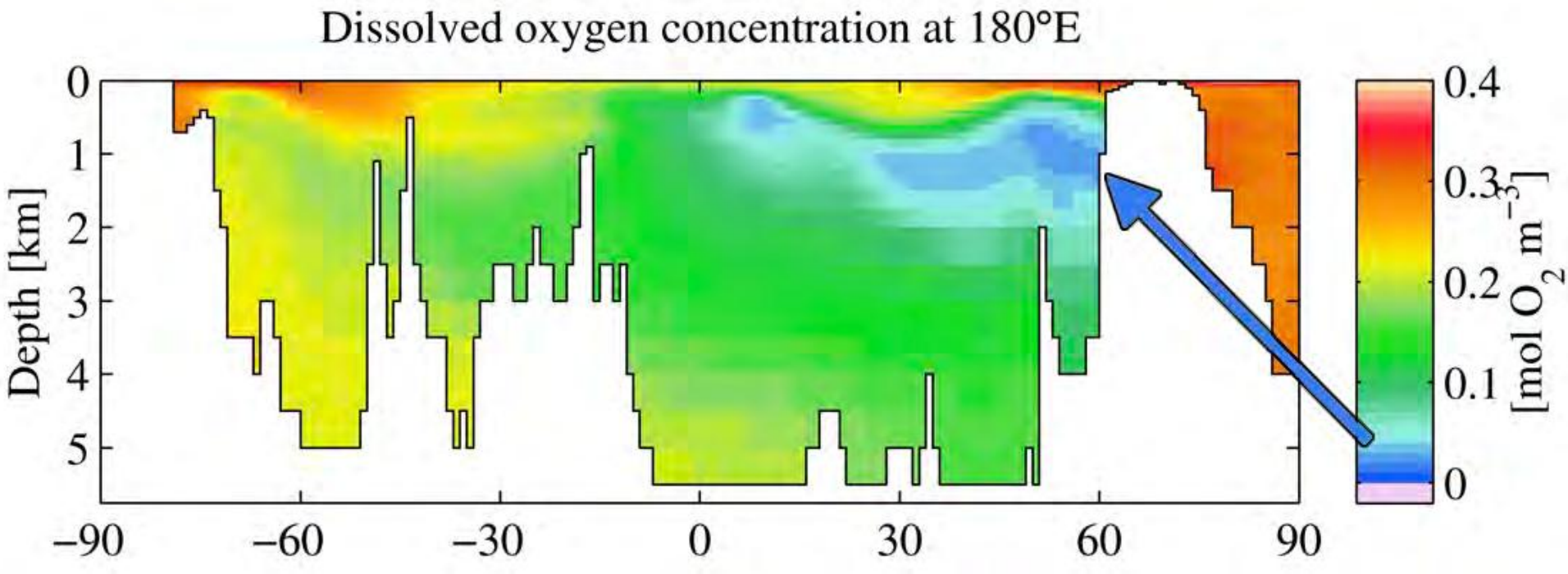
Remember

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

Reference

Oxygen minimum zone
https://en.wikipedia.org/wiki/Oxygen_minimum_zone

These zones vary with latitude.



Oxygen minimum zone

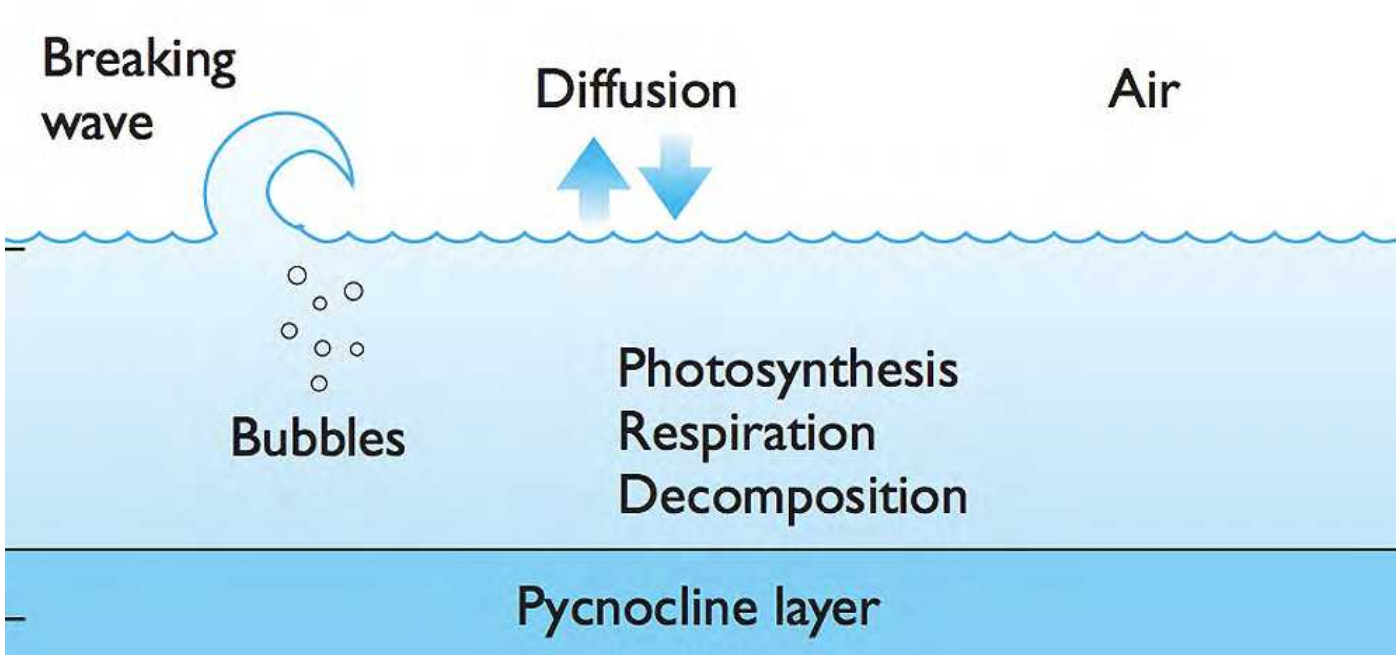
By Plumbago [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons In the upper panel a minimum in oxygen content is indicated by light blue shading between 0° (equator) and 60°N at an average depth of ca. 1,000 m (3,300 ft).

Question

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

Surface ocean layers and nutrient production

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

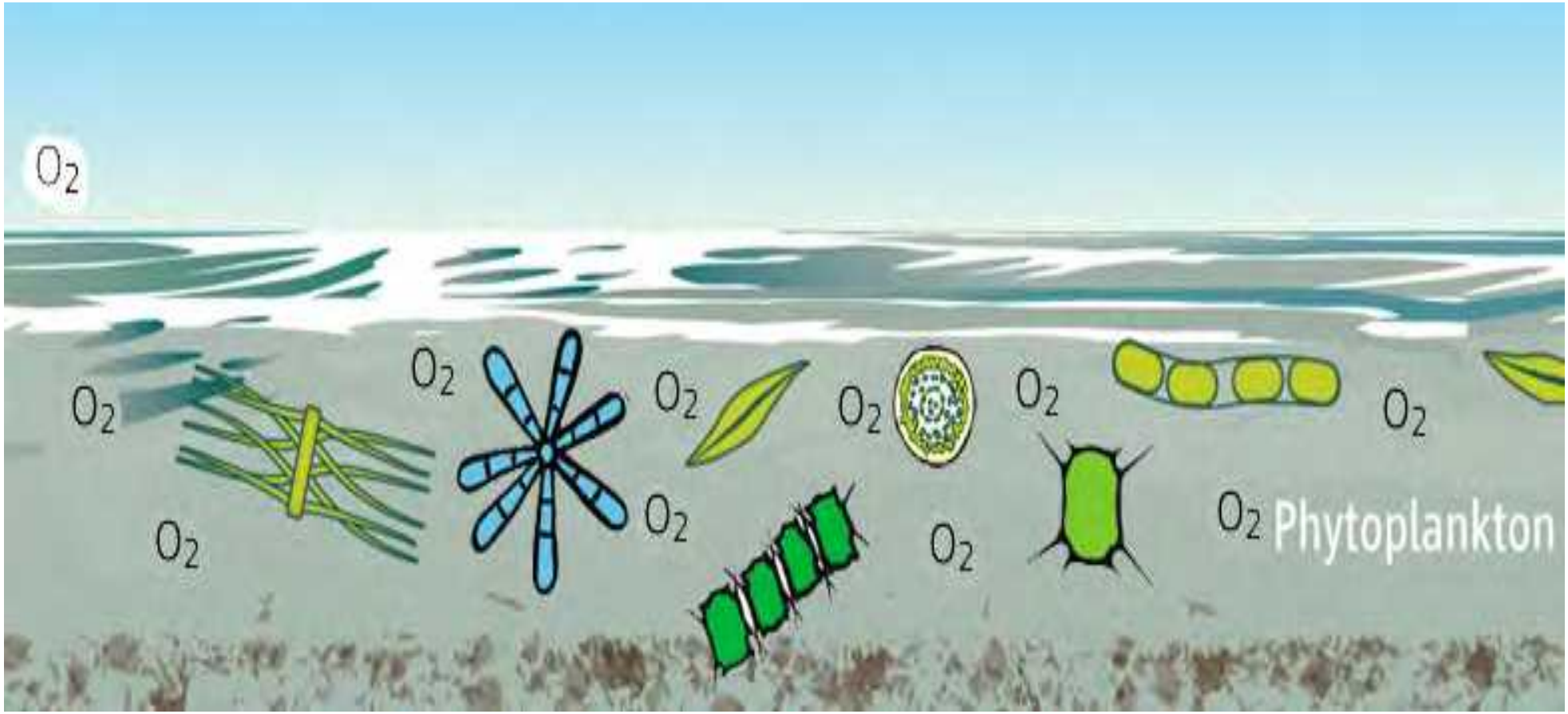


Remember **pycnocline** is density.

Oxygen at the surface

From Jones and Bartlett Chapter 4

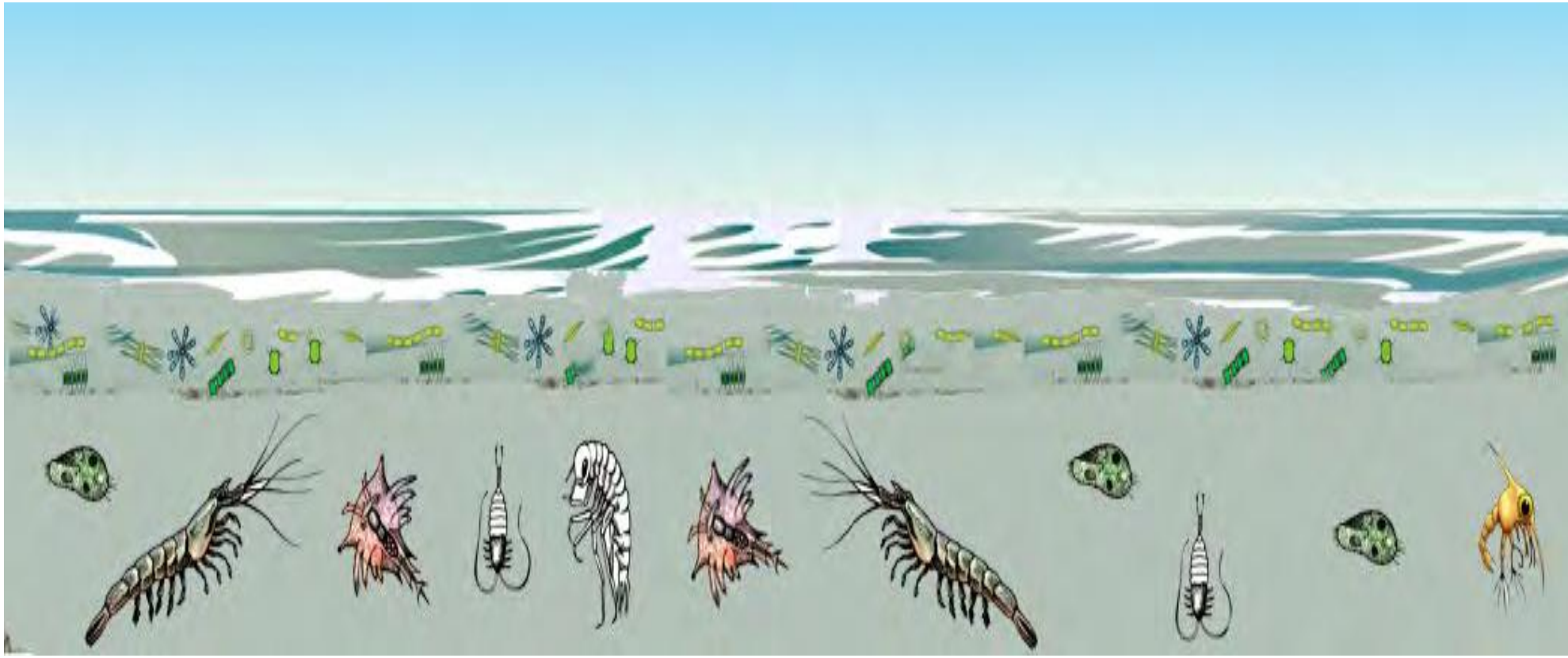
Phytoplankton also produce large amounts of oxygen through photosynthesis and eventually die.



Phytoplankton in surface layers

Illustration Bob Moffatt

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

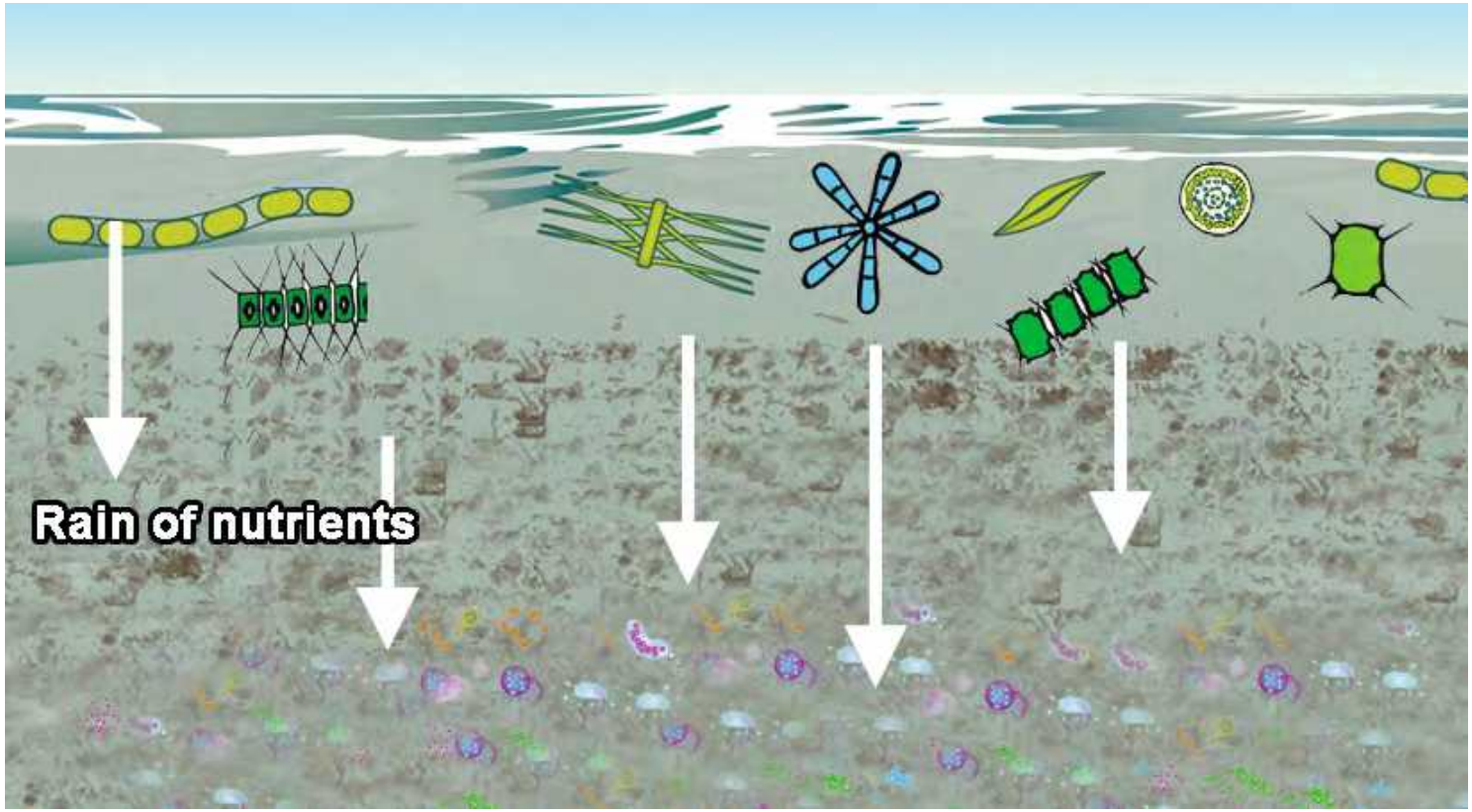


Phyto and zoo plankton in surface layers

Illustration Bob Moffatt

Photosynthesis produces high concentrations of oxygen, animals use this to respire, they die and are decomposed 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 and sinks to the bottom.

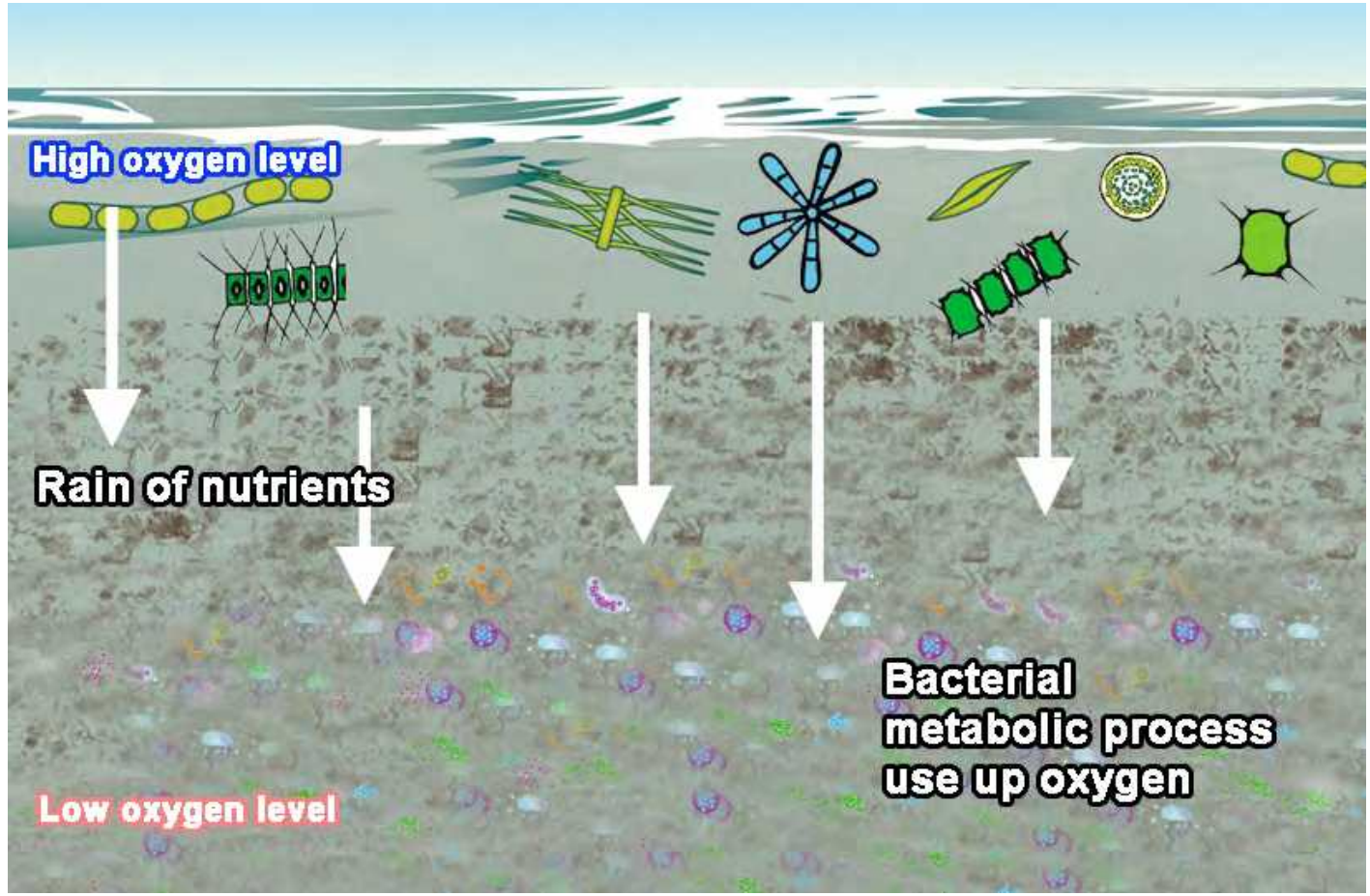


Nutrient rain

Illustration Bob Moffatt

Pycnocline stability

The sharp pycnocline in the water column is stable and prevents vertical mixing of water at these intermediate depths, physically preventing oxygen from entering the zone below the surface.



Decomposer layer and OMZ

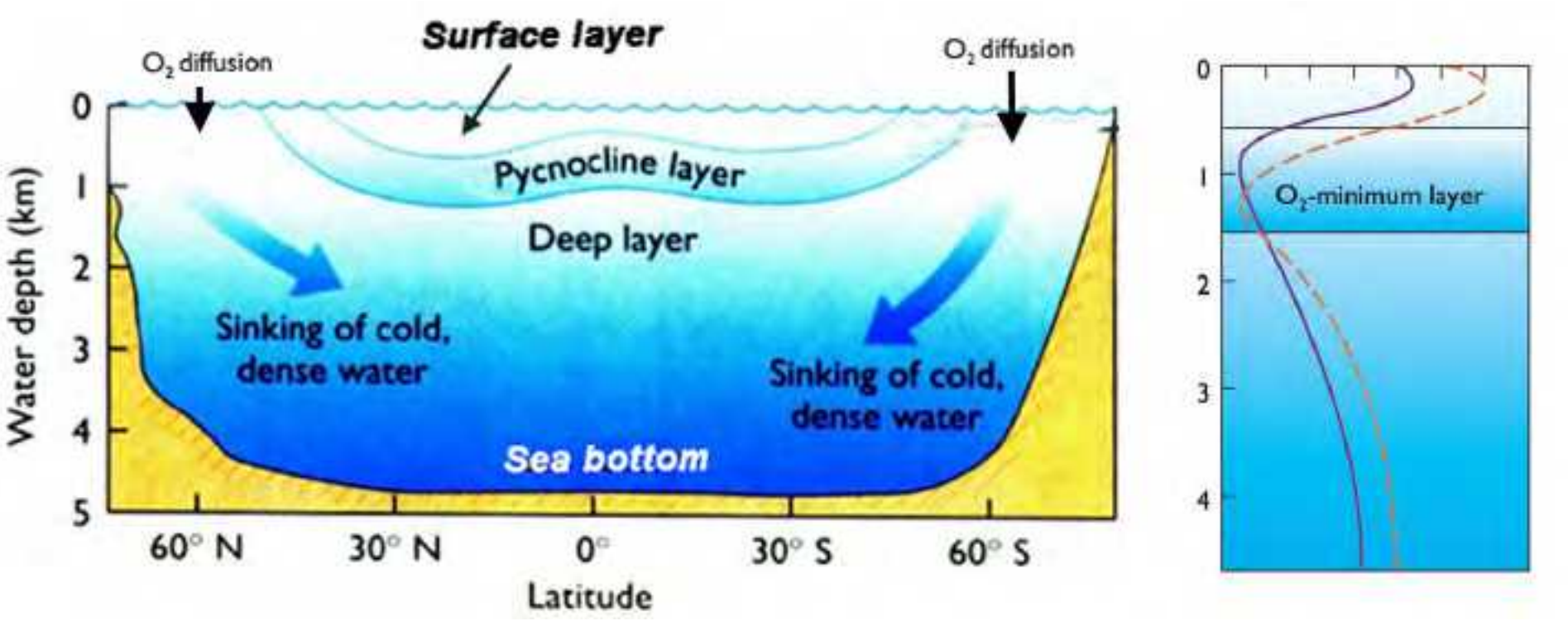
Illustration Bob Moffatt

Biologically, aerobic bacteria feed on a rain of nutrient matter from above using oxygen in the process.

This is how the OMZ is created.

Oxygen is used in the bacterial metabolic process of decomposition, lowering its concentration within the water, creating the Oxygen mimimum zone (OMZ) also called ‘shadow zone’.

This usually occurs between 200 m and 1500 m depending upon circumstances.

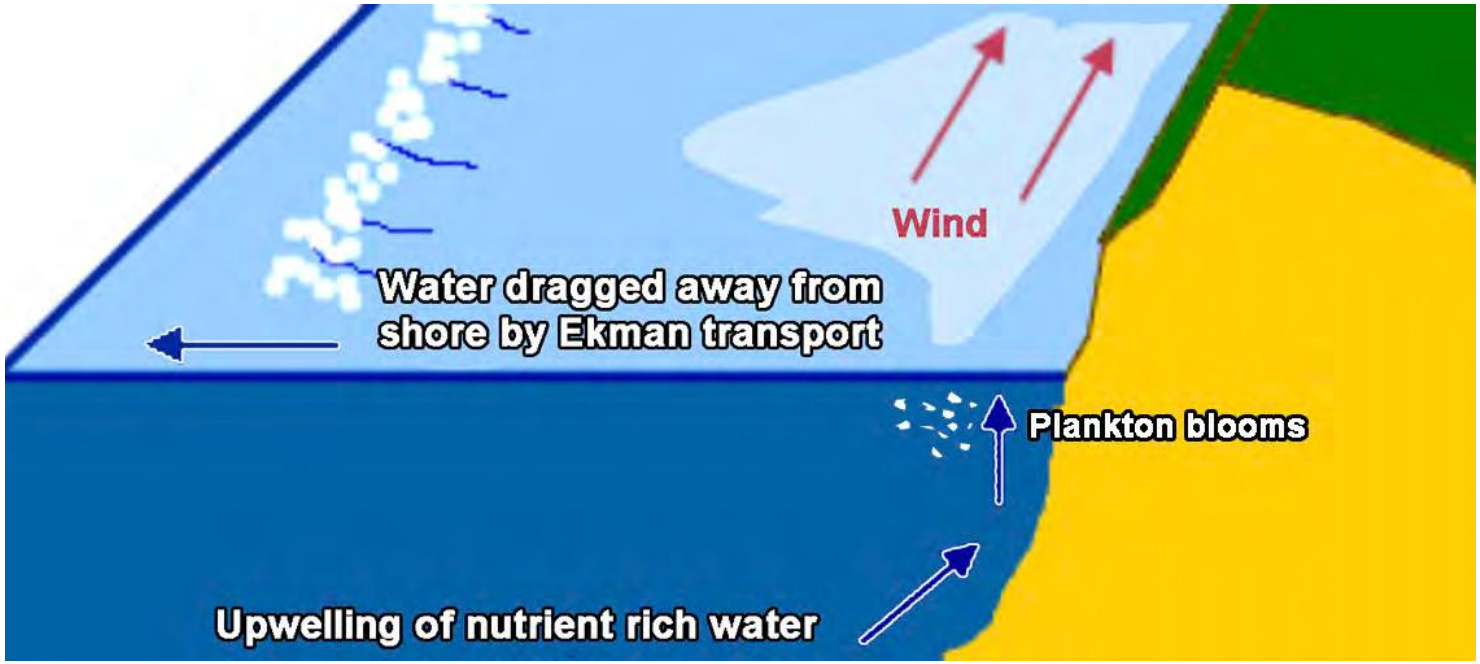


Oxygen mimimum layer and pycnocline

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

Upwelling nutrients and thermoclines

Nutrient-rich water rises 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 e.g., sardine and tuna runs.

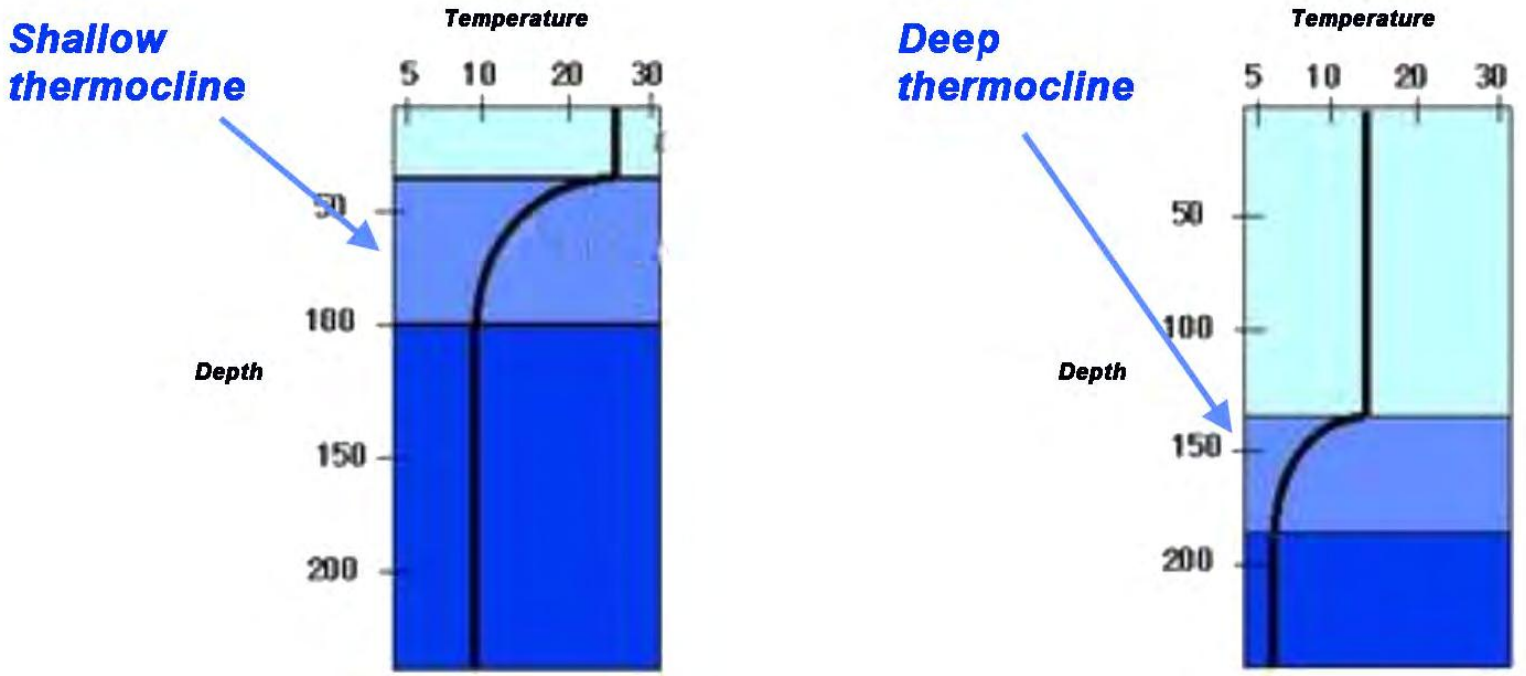


Upwelling and Ekman transport

Illustration Bob Moffatt

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

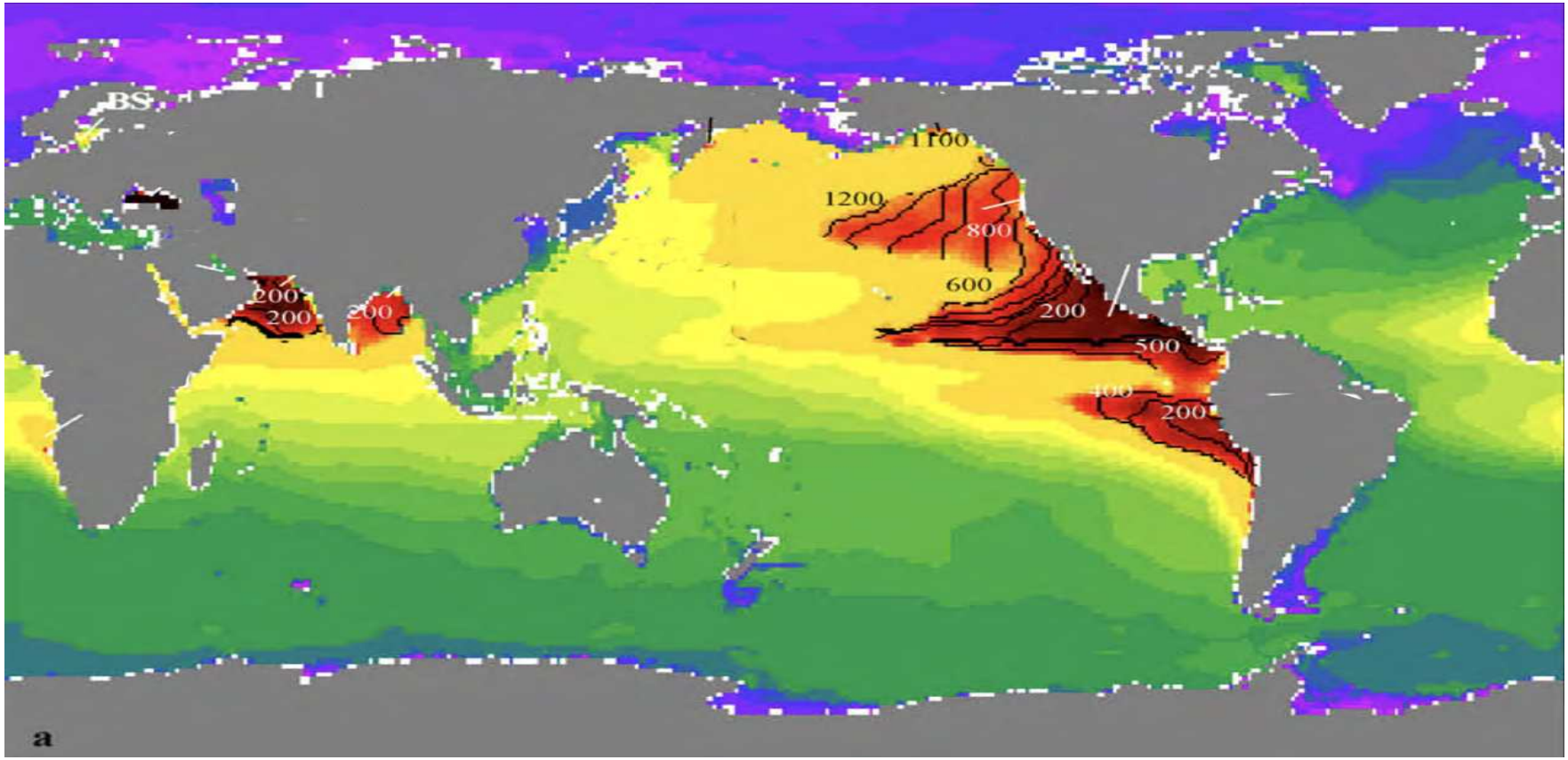
A deeper thermocline limits the amount of nutrients brought to shallower depths by upwelling processes.



Deep and shallow thermoclines

Illustration Bob Moffatt

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 (IM) at depth where O2 concentration is minimal, indicating the extent of the OMZs (in red) according to the WOA2005 climatology

Question

Draw diagrams to show how thermoclines and nutrients produce an oxygen minimum zone within the open ocean.

Describe how the pycnocline is involved.

T009 Deep ocean circulation

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.

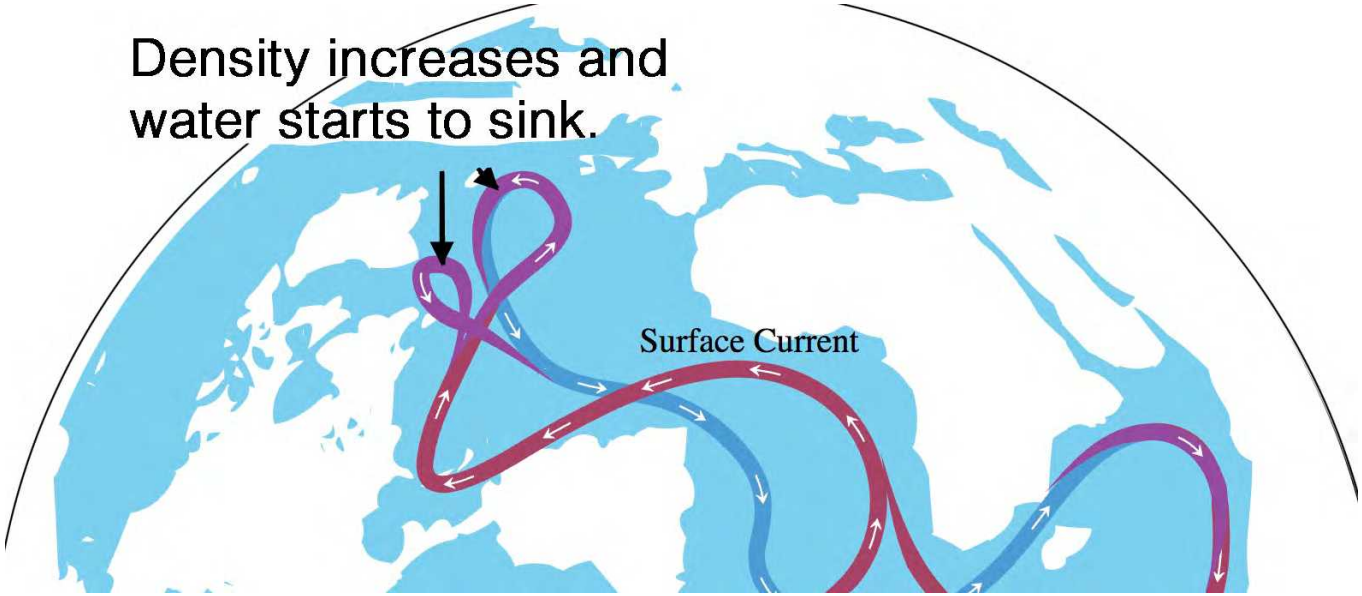
Question

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

Use a diagram to explain your answer.

Density differences

As water currents pass through the tropics, higher temperatures cause the water to evaporate increasing salt concentrations. Temperature increases, salinity increases and density increases and water begins to sink.



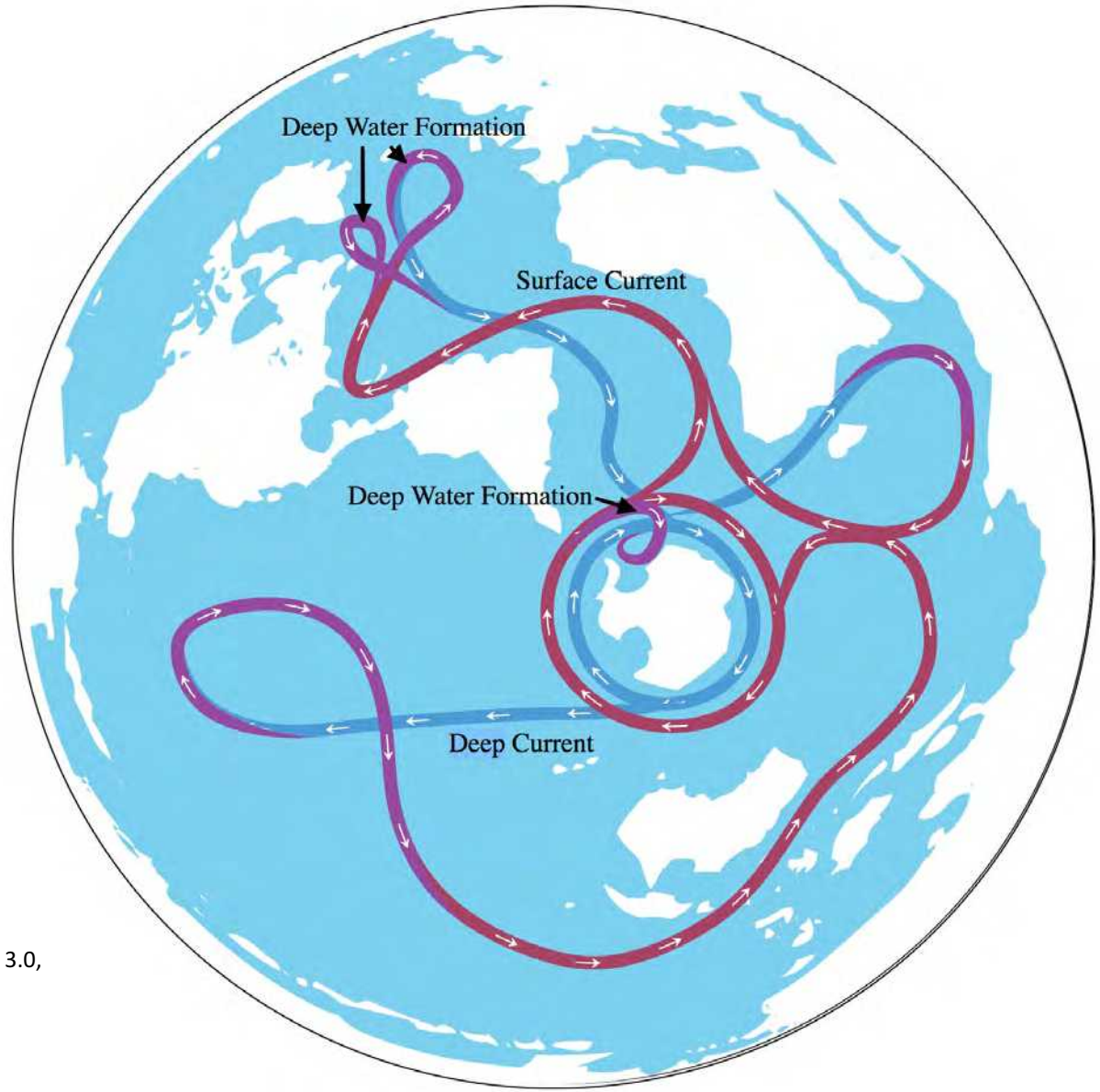
Density increases in lower latitudes

Remember

Temperature has a greater influence on density than salinity.

Cold, dense water in polar zones sinks relatively rapidly over a small area, while warm (downwelling), less dense water in temperate and tropical zones moves to the surface more gradually across a much larger area.

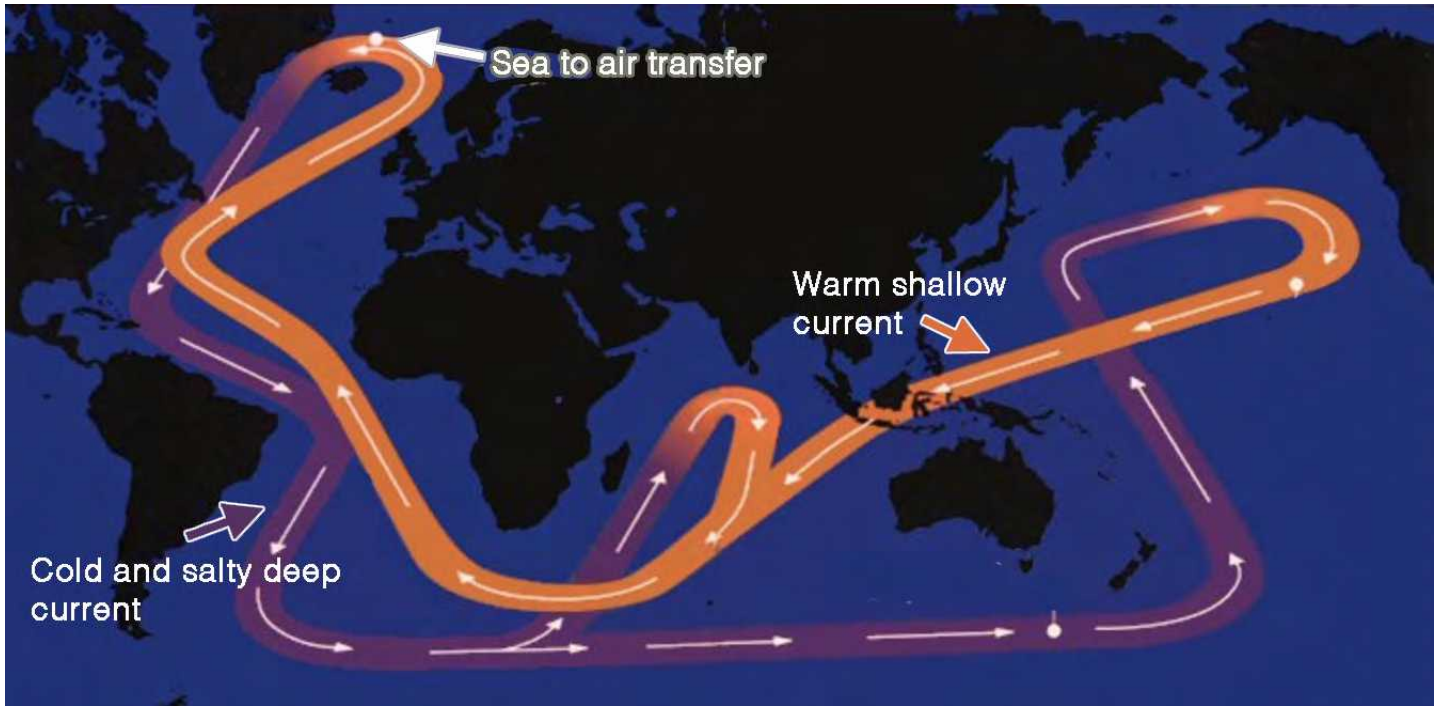
Great quantities of dense water sinking at high latitudes are offset by equal quantities of water rising elsewhere in the ocean causing a circulation (conveyor belt) of warm and cold water.



Conveyor belt

Thermohaline (*thermo* = heat, *haline* = salt) circulation is mainly vertical.

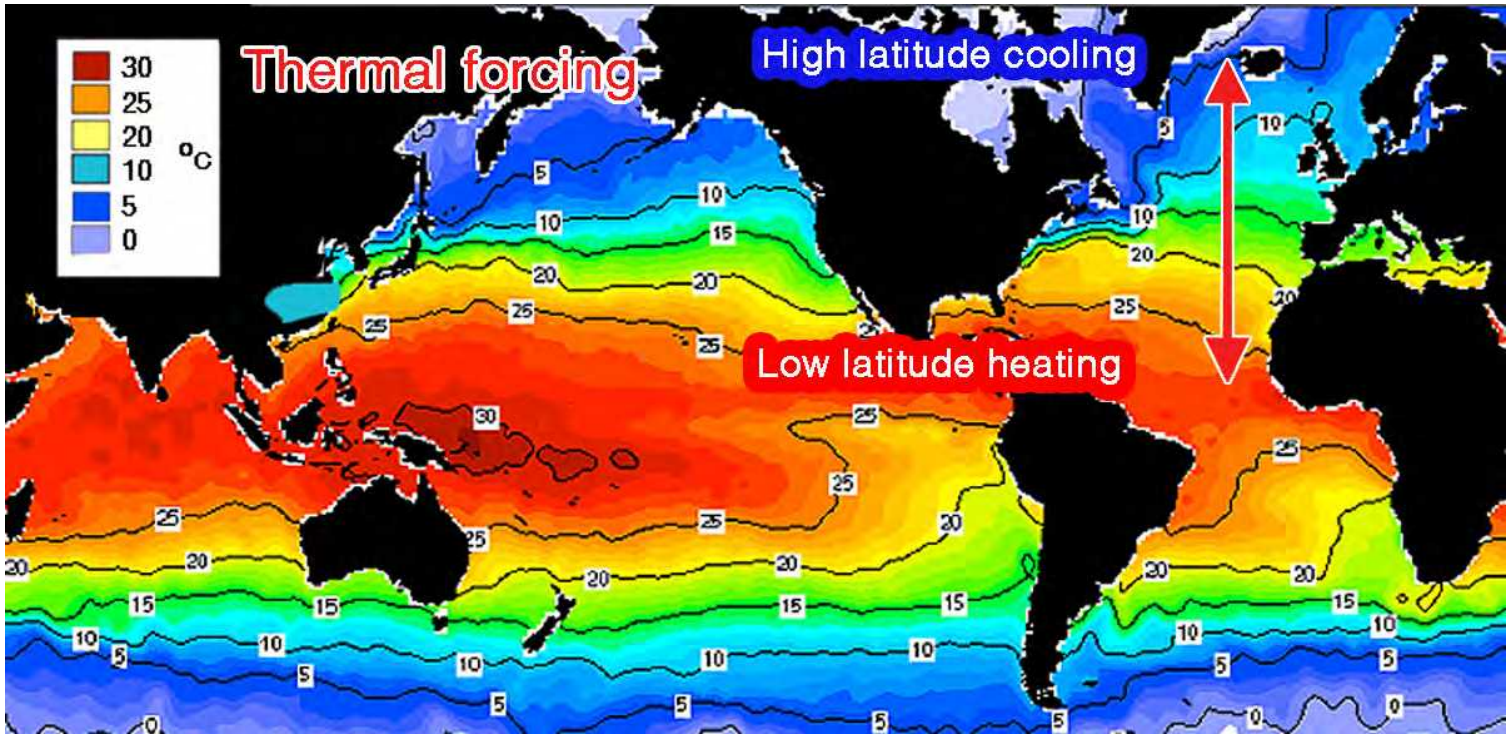
•It is driven by the formation and sinking of salty (because sea ice forms), cold water in the Greenland-Iceland-Norwegian Sea (downwelling), and is probably responsible for the large flow of surface water past Indonesia, from the Pacific to the Indian Ocean.



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.

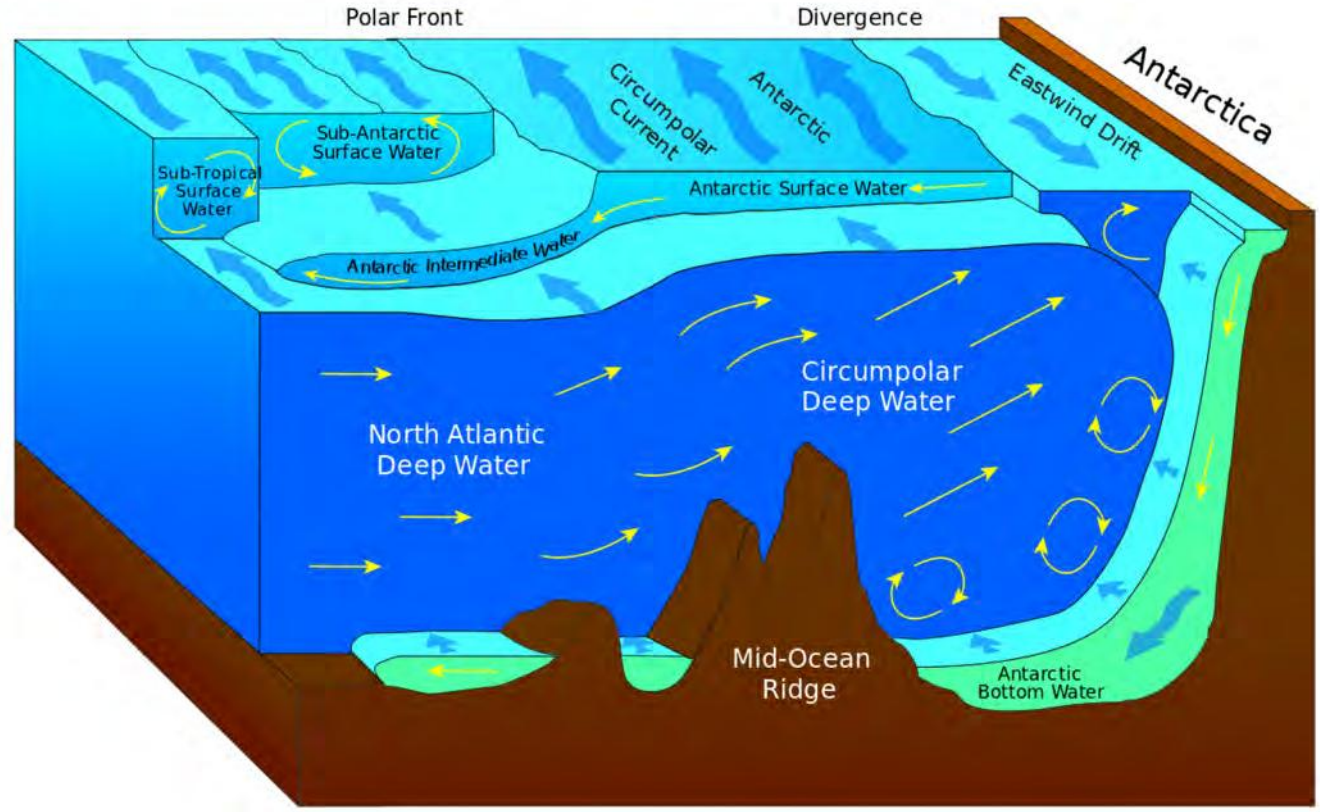


Thermal forcing

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

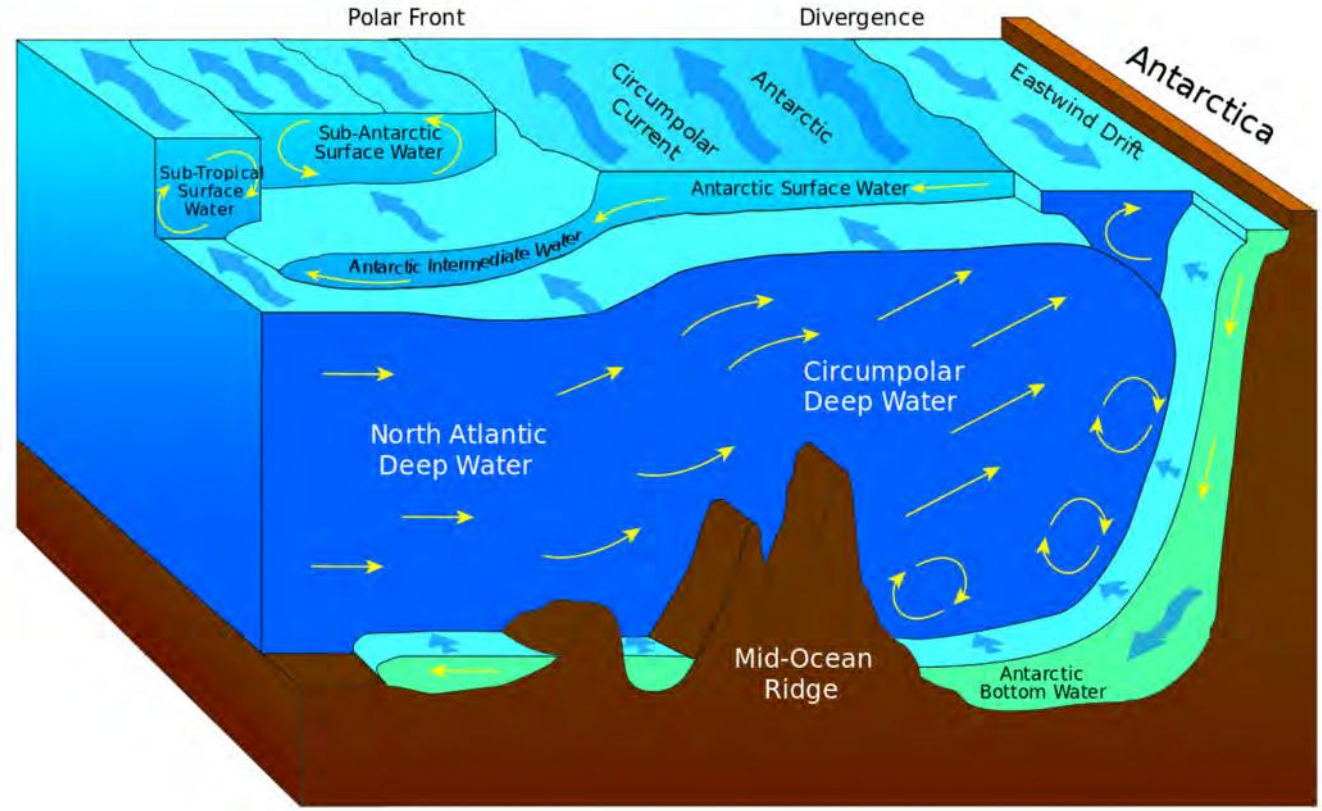
Water movement

The North Atlantic Deep Water flows very slowly into the deep abyssal plains of the Atlantic toward Antarctica, above the more dense Antarctic Bottom Water, where the water mass joins the Antarctic Circumpolar Current (ACC).



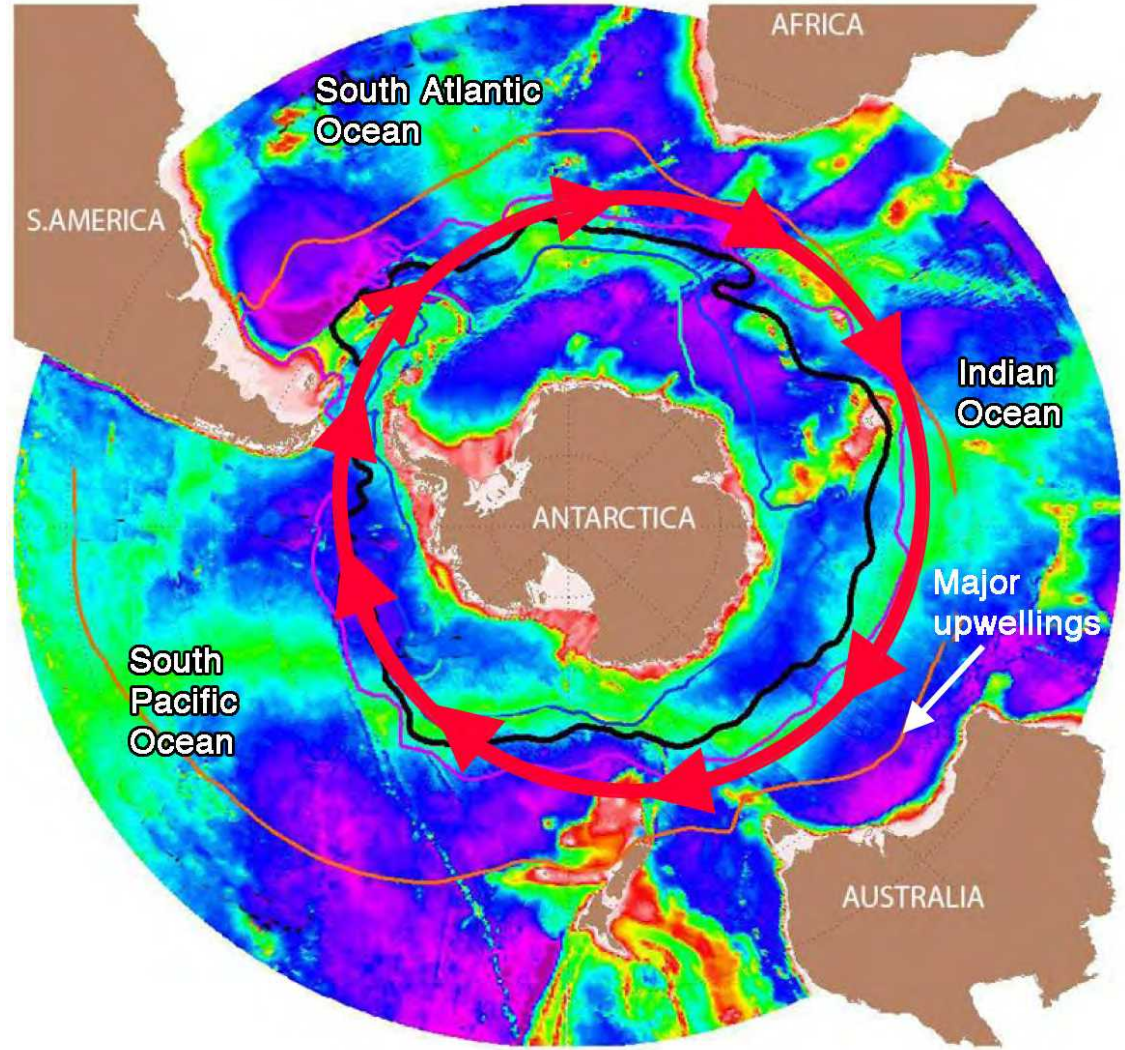
Water mass bodies of the Southern Ocean

Because the temperature and salinity are constant at depth, there are no thermo or pycnoclines so vertical mixing can occur, hence upwelling and downwelling occurs easily.



Water mass bodies of the Southern Ocean

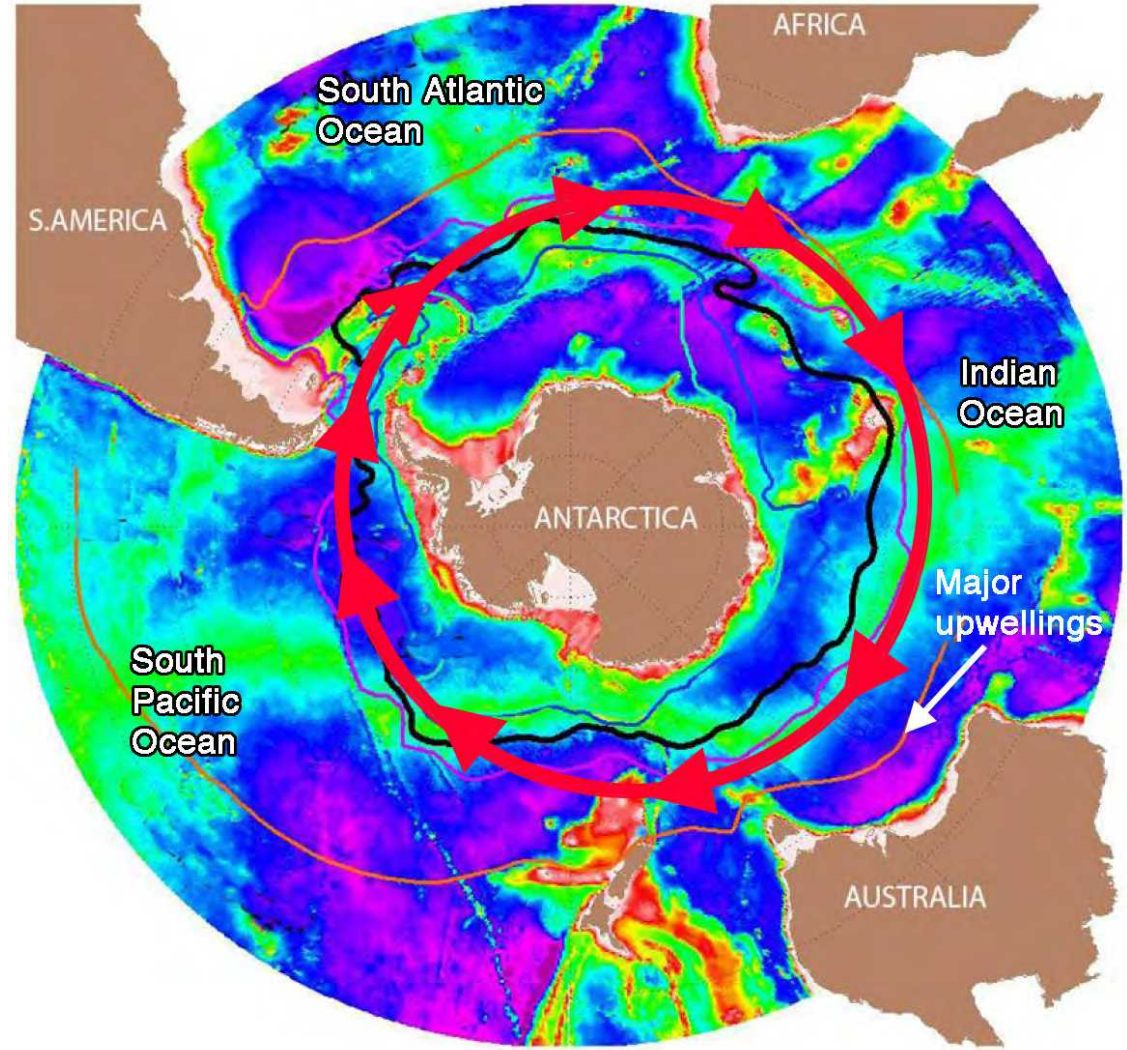
In Antarctica, the combined effect of evaporative cooling and brine exclusion causes the density of the Antarctic Bottom Water to be so high, that it in fact underflows the current from the Atlantic Basin. However, mixing does occur and Oceanic Common Water is created lining the bottom of the Indian and Pacific Oceans.



Antarctic circum polar current

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

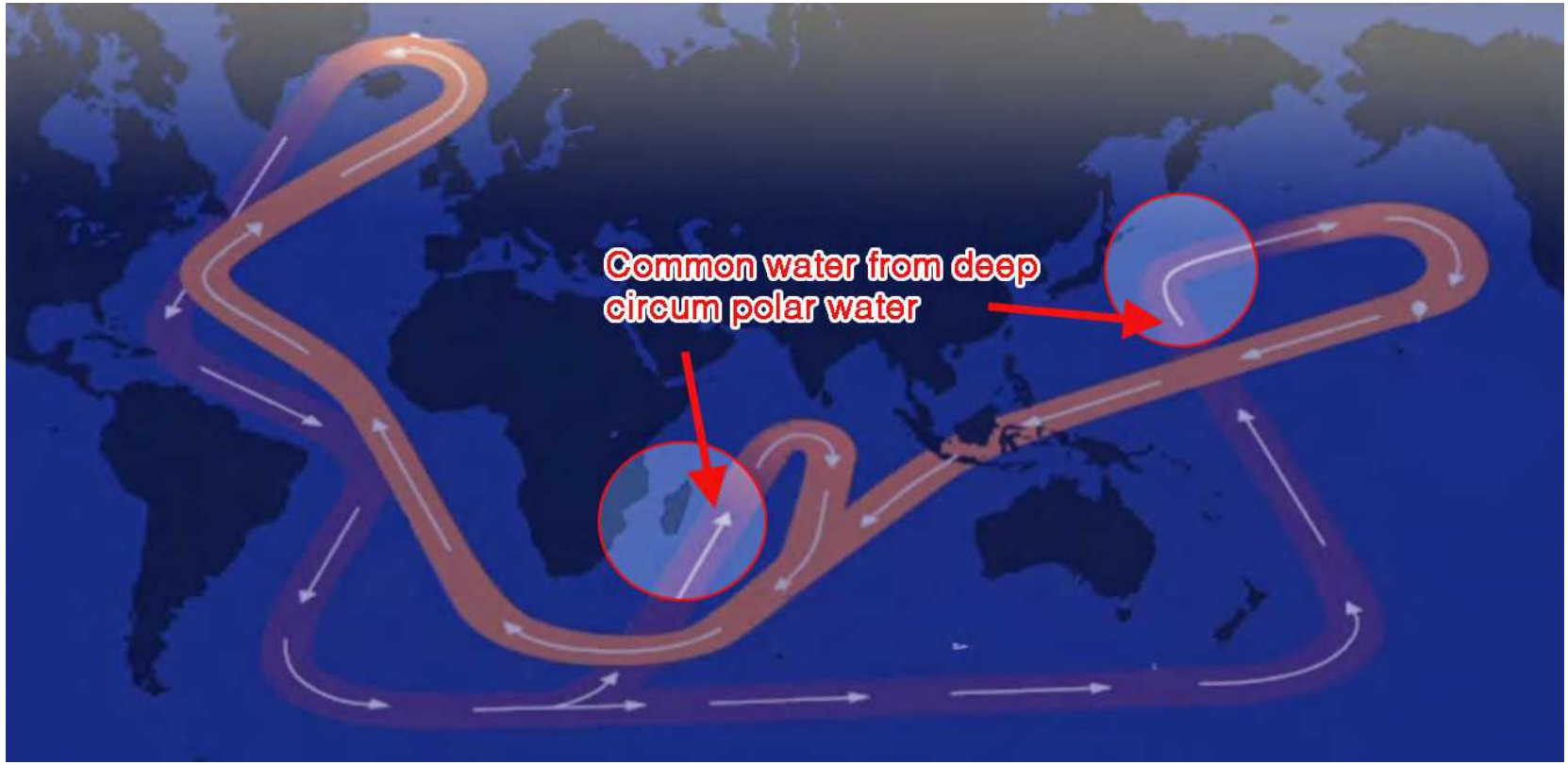
Flow of the ACC in the Southern Ocean meets rugged topography causing upwellings bringing deep water to the surface and with it nutrients, oxygen and salt.



Antarctic circum polar current

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

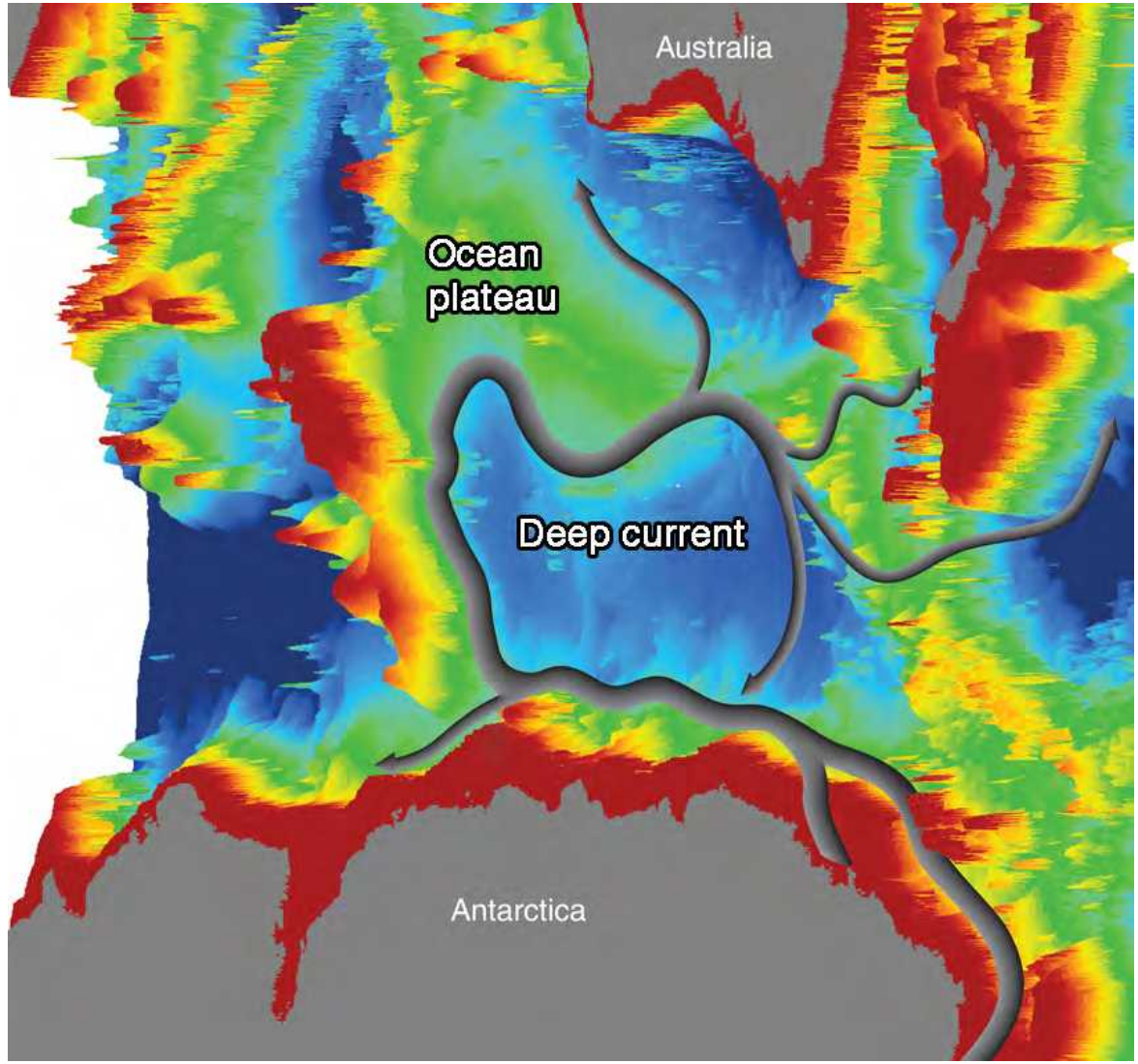
Antarctic Circumpolar Currents are mixed to create the so-called “Common Water” which flows northward, around Southern Africa where it is split into two routes: one into the Indian Ocean and the other past Australia into the Pacific.



Common water rising

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

CSIRO has recently discovered a deep ocean current found between Australia and Antarctica on an ocean plateau. It carries the equivalent amount of water as 40 Amazon Rivers.

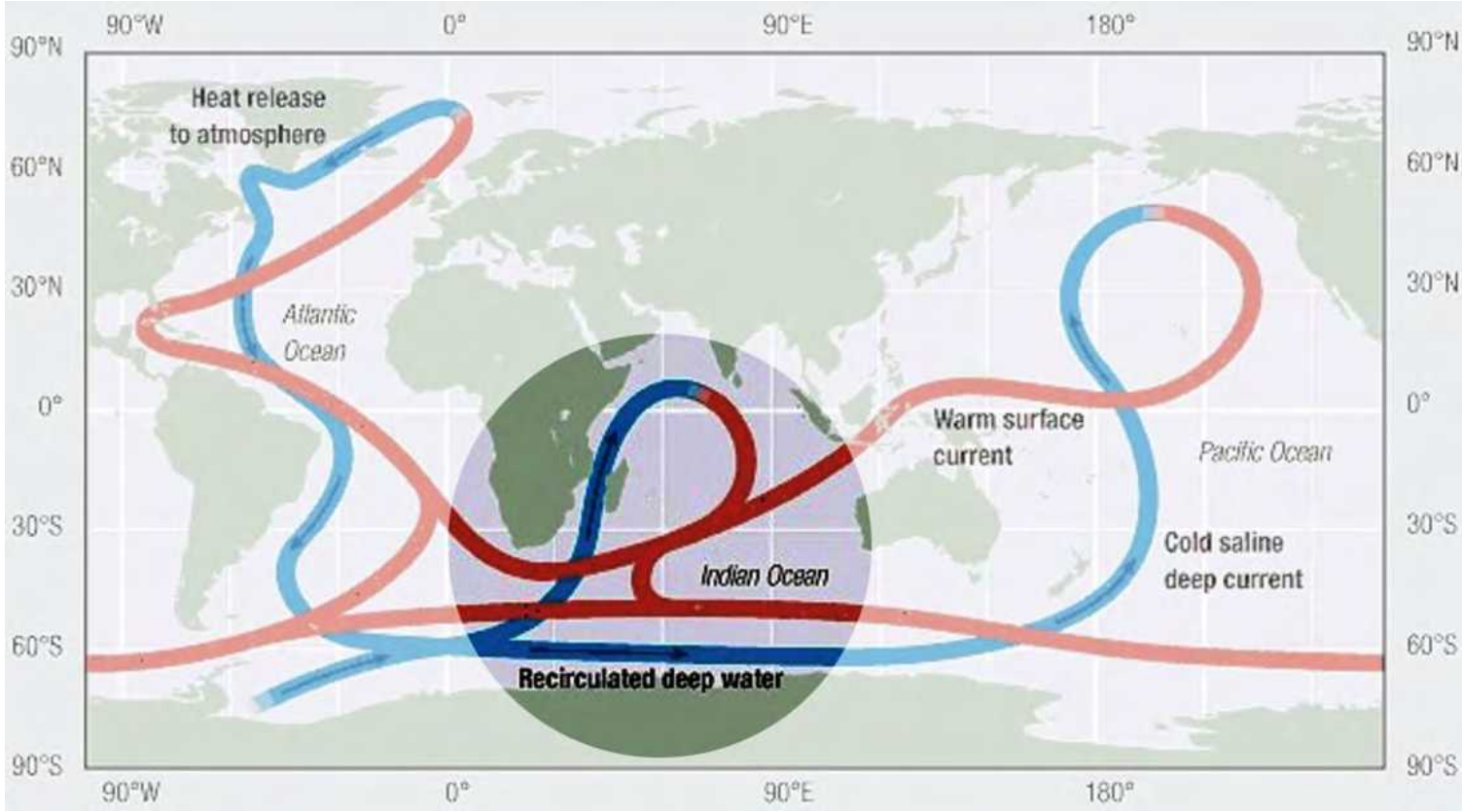


Kerguelen plateau deep ocean current

These cold, highly oxygenated currents supply oxygen to ocean depths along the conveyor.

Salinity

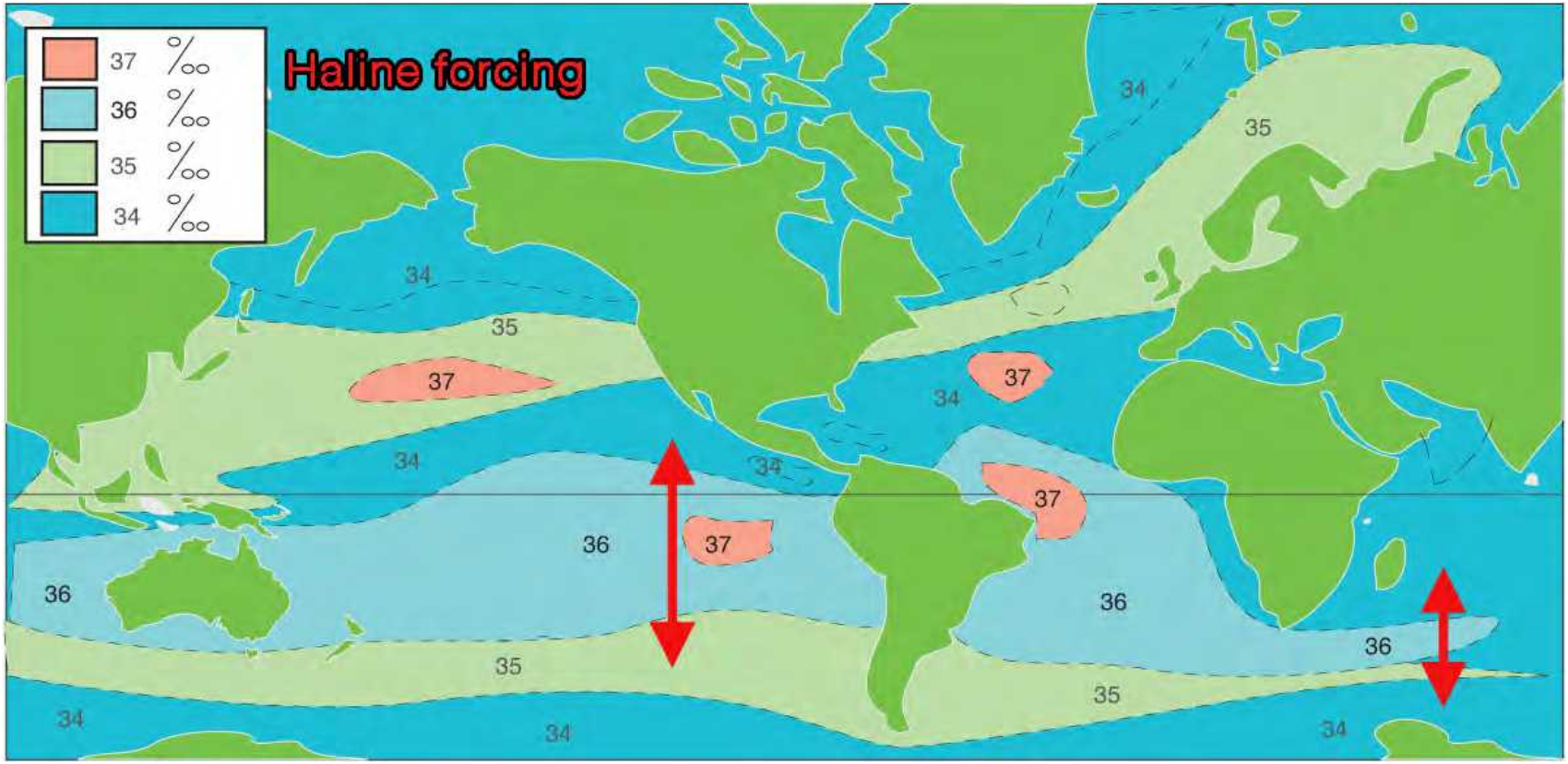
In the Indian Ocean, some of the cold and salty water from the Atlantic are refreshed, by means of vertical exchange, with the warmer upper ocean water from the tropical Pacific



Indian Ocean deep water refreshment

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

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

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.

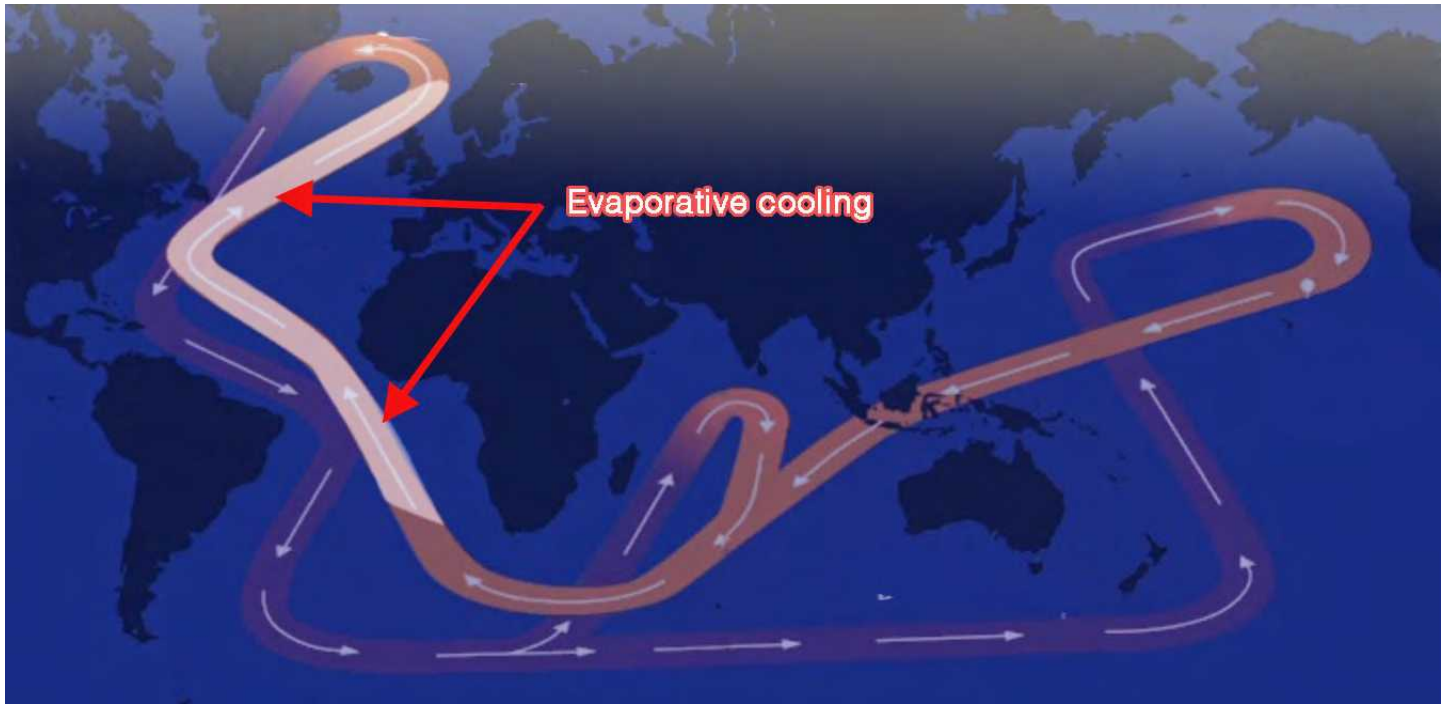
The outflow of bottom water makes the sea level of the Pacific Ocean 20 cm higher than the Atlantic Ocean.

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

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

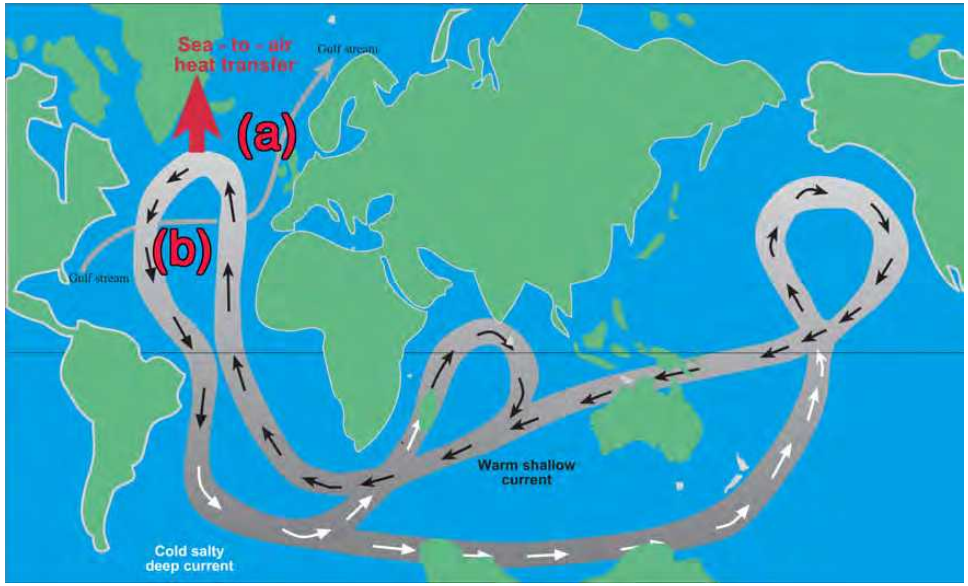
Adapted from http---www.rapid.ac.uk-sis-popups-currents_thc.php.jpg

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.

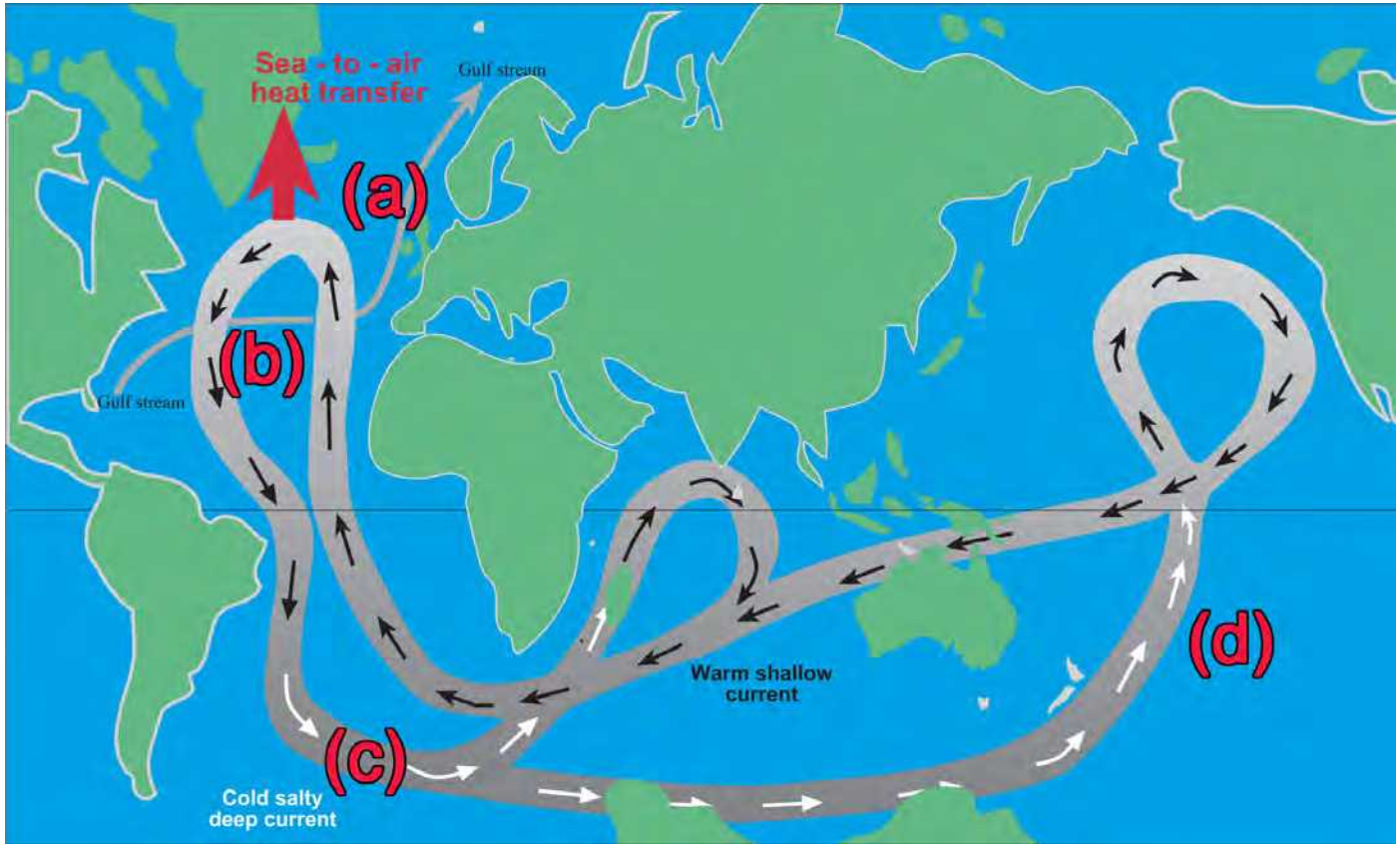
b) Gravity then causes it to sink to the bottom of the ocean. As more warm water is transported north, more cooler water sinks and pushes this water along the ocean floor.



Ocean current conveyor belt a and b

Illustration Bob Moffatt

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

Describe four ways temperature, wind and gravity move water the ocean conveyor belt.

Illustrate your answer with diagrams.

Ch 3 Ocean conservation

T010 Argue ocean knowledge

T011 Exclusive economic zone

T010 Oceans need further investigation

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.

Syllabus statement

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

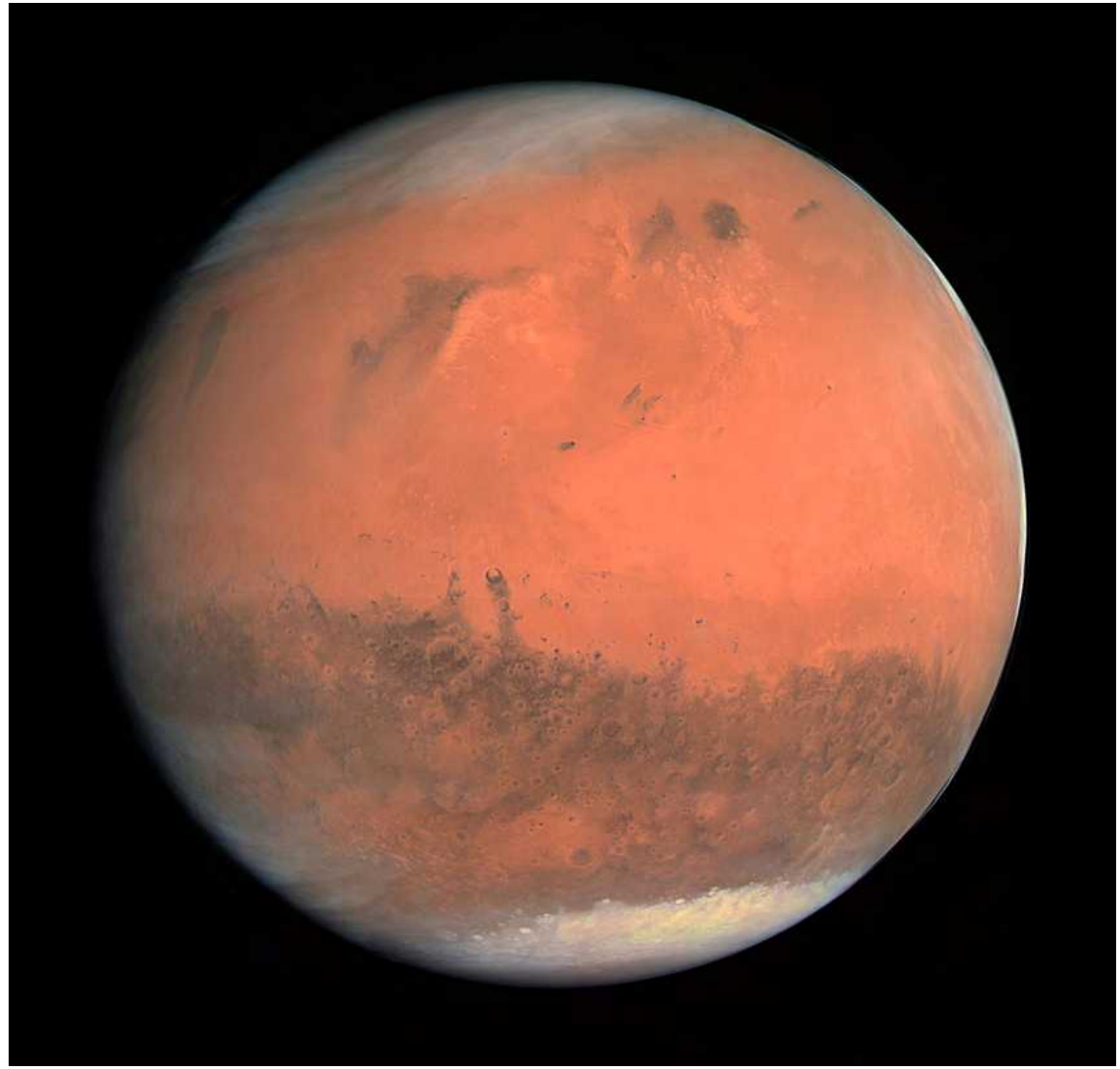
Argue

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

Question

Argue a case for further ocean research.

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

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 North West Island
Photo Bob Moffatt

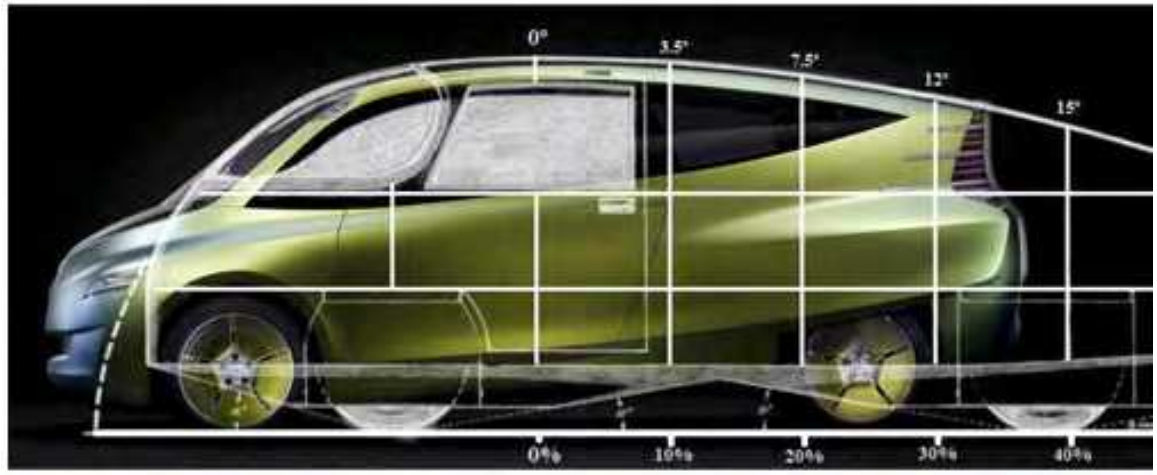
Ocean exploration is about making discoveries, searching for things that are unusual and unexpected.

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

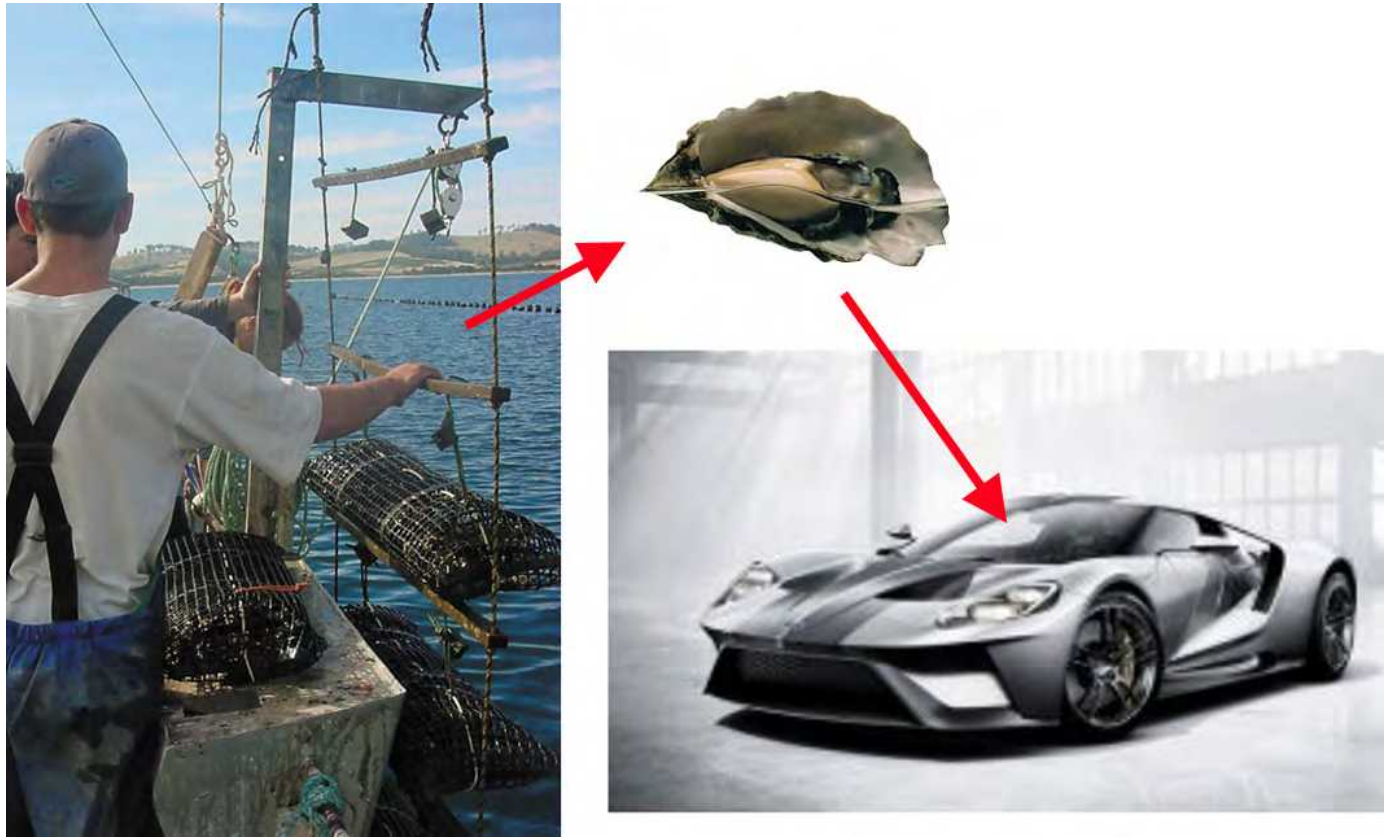
Particular qualities found in marine species are being used to develop technologies that serve our everyday needs.

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



Yellow box fish and Mercedes-Benz-Bionic

Unbreakable windshields derived from oyster shell bioassays.



Oyster and car windscreens

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

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

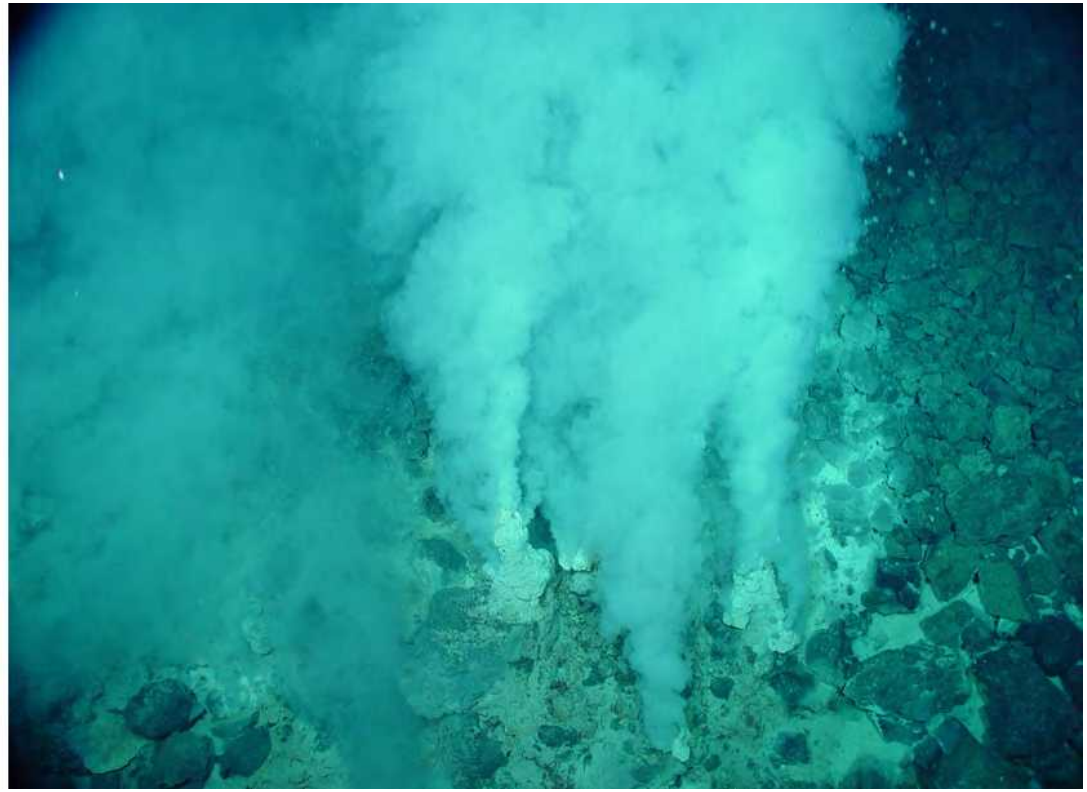
It is disciplined, systematic, and includes rigorous observations and documentation of:

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

CSIRO Current meter

Illustration CSIRO

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.

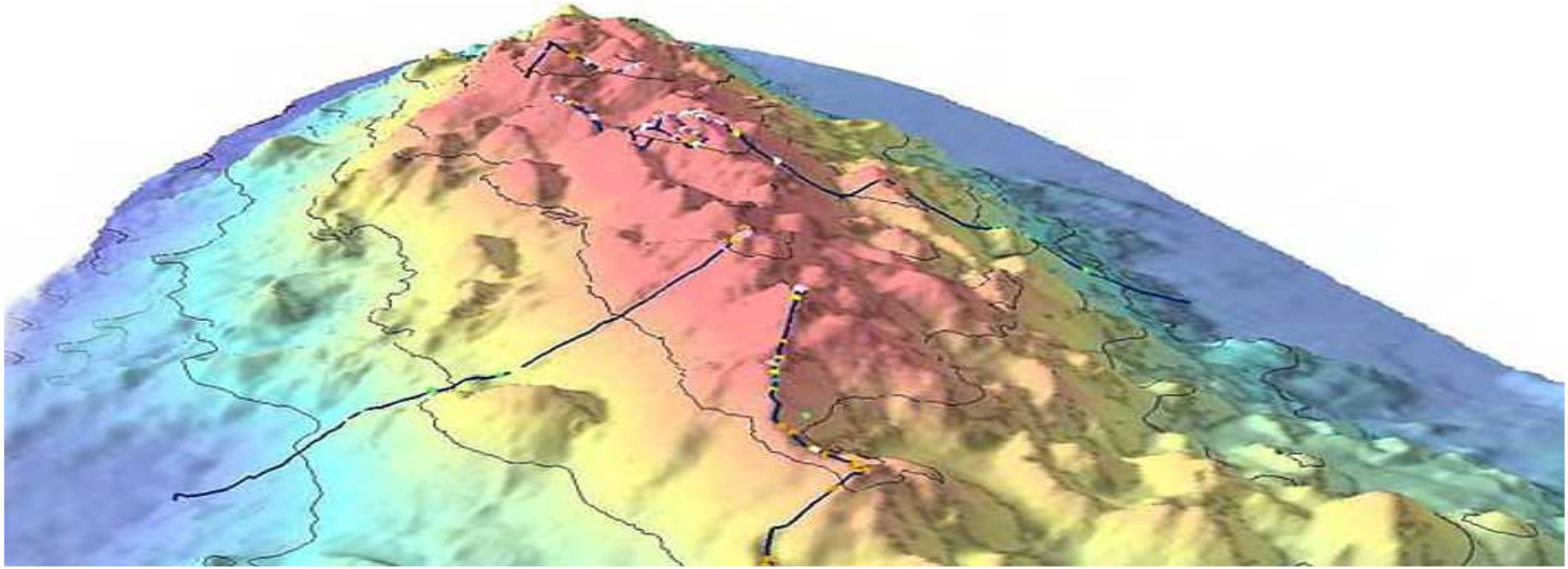


Deep sea smokers

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

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

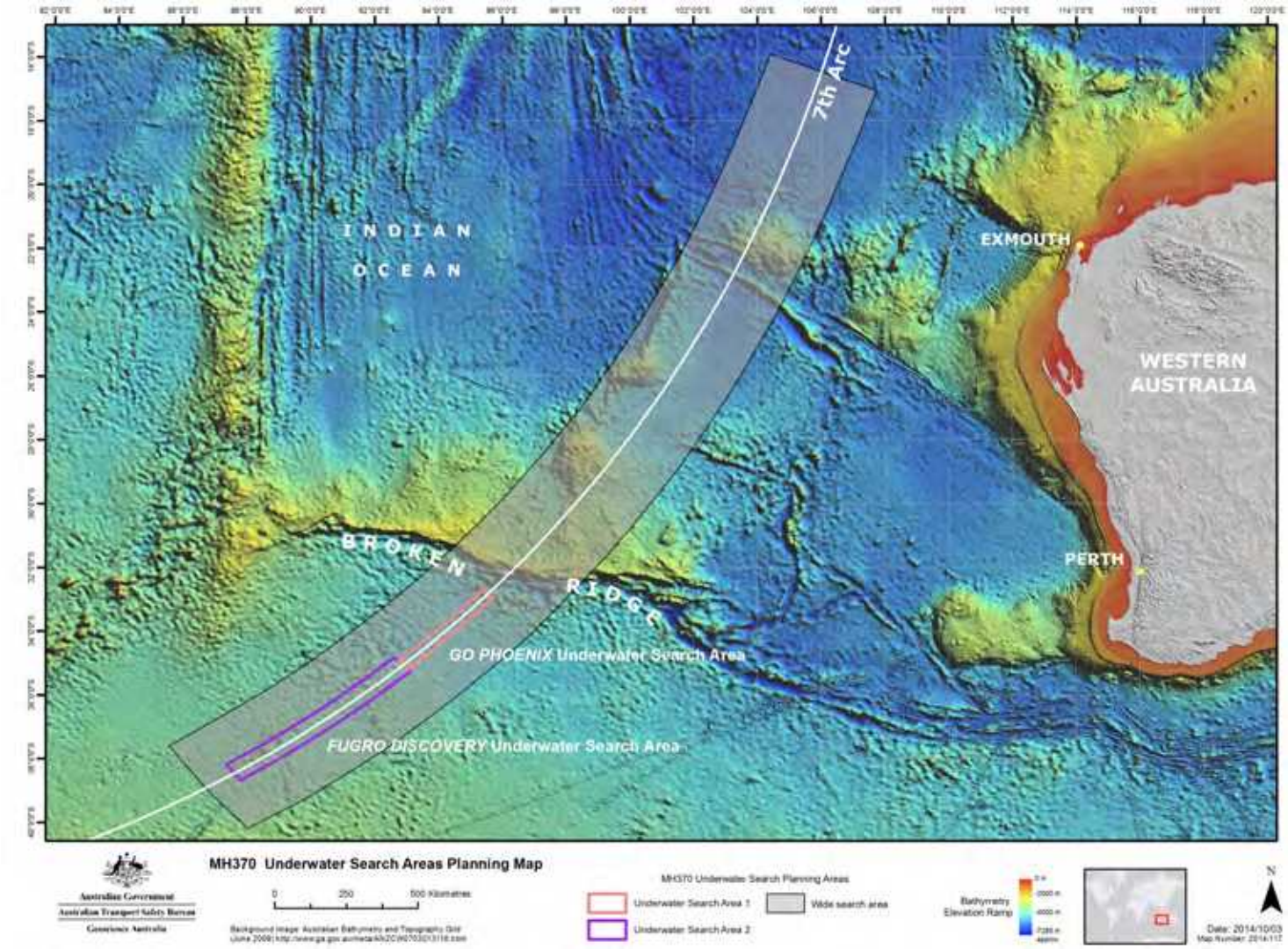
For example significant coral nurseries have been found on seamounts which might lead to seamount tourism expeditions in the future.



Davidson expedition seamont

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.

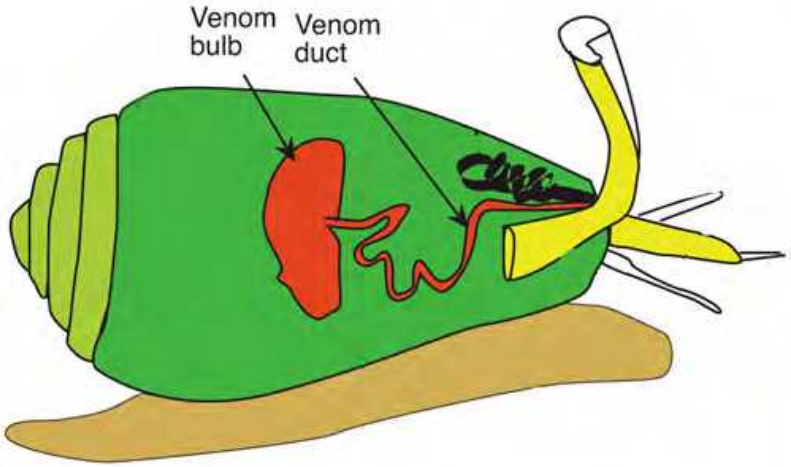


Search area MH370

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

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.

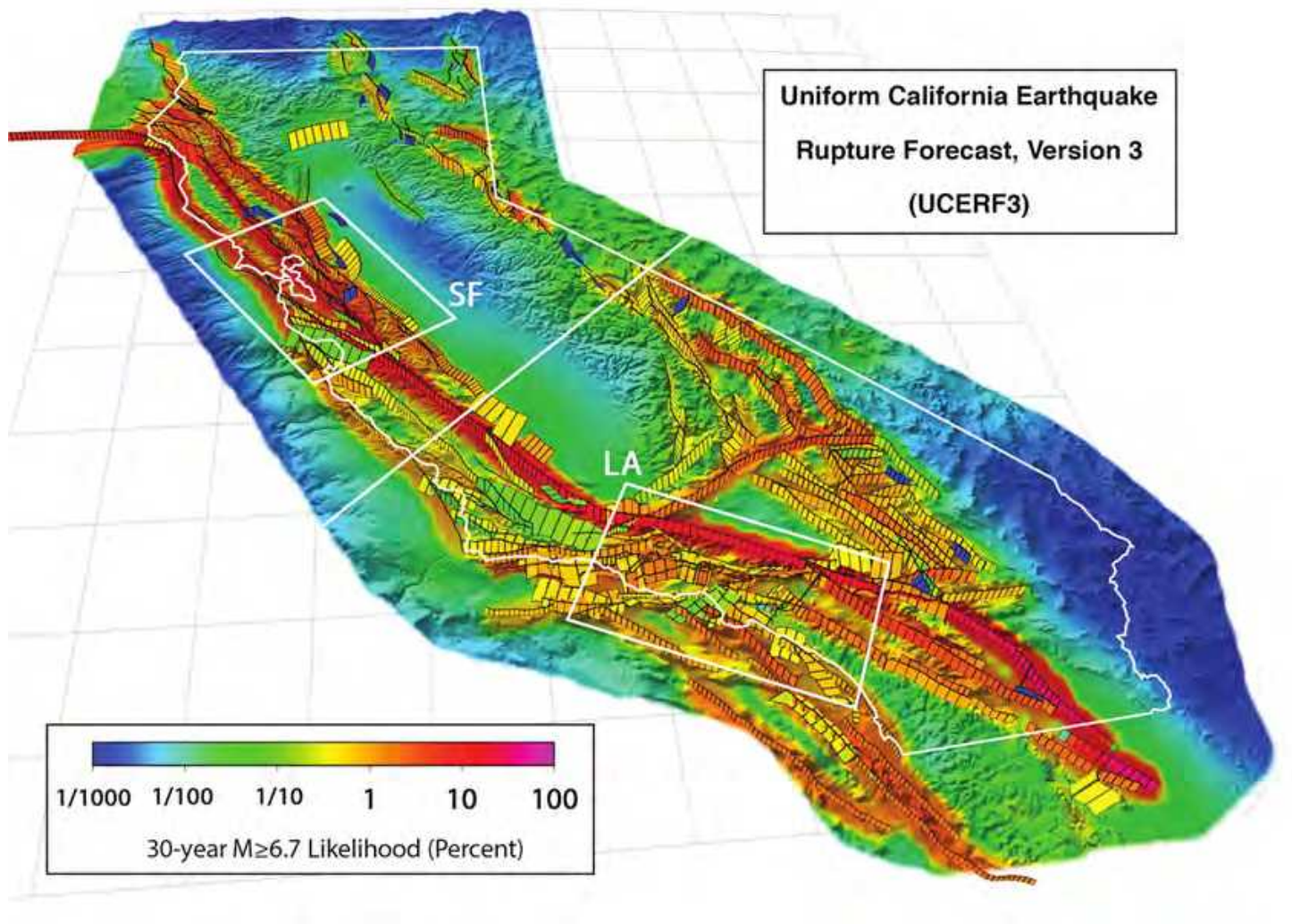
Could conefish venom contain a cure for cancer?



Cone shell and venom gland

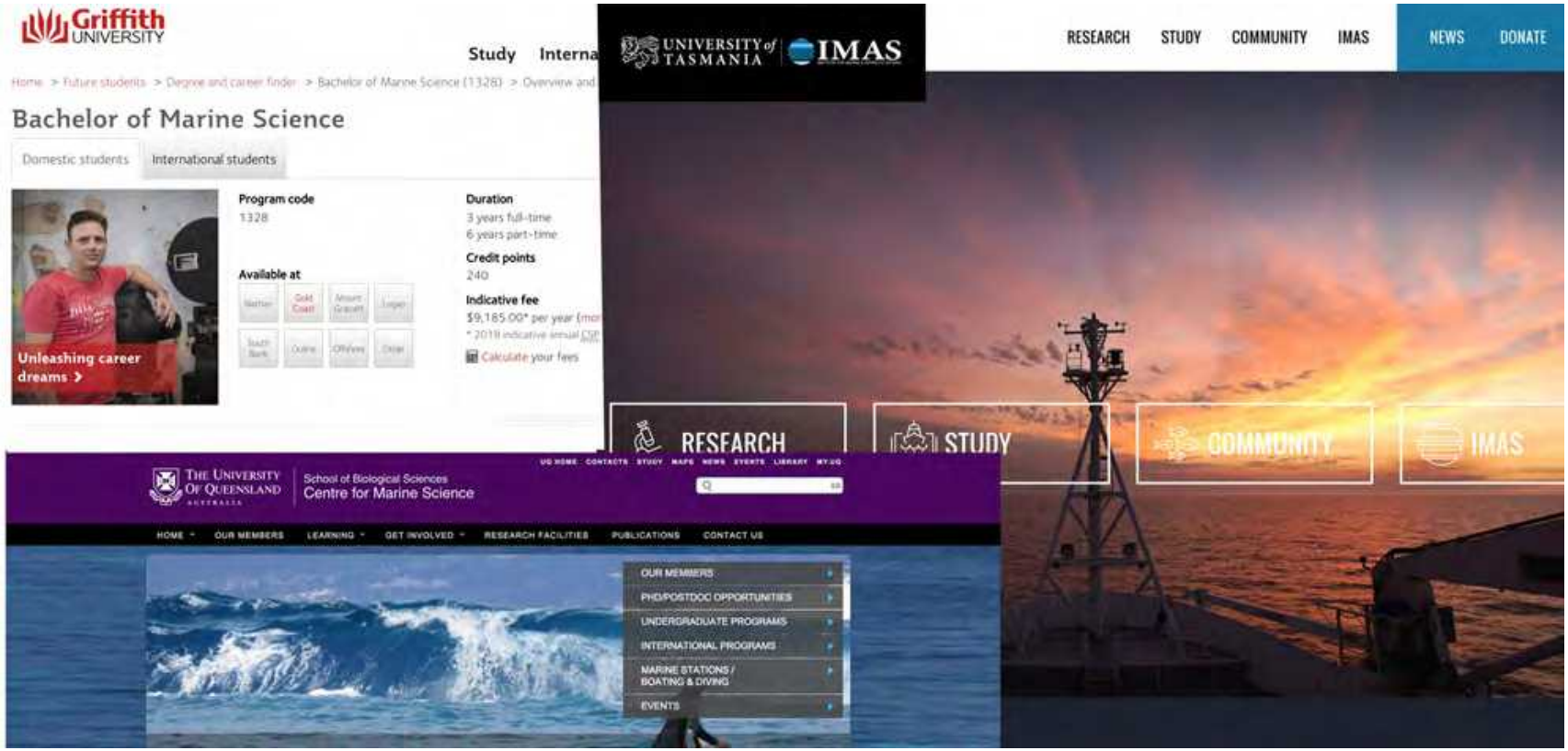
Photo Neville Coleman, Illustration Bob Moffatt

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

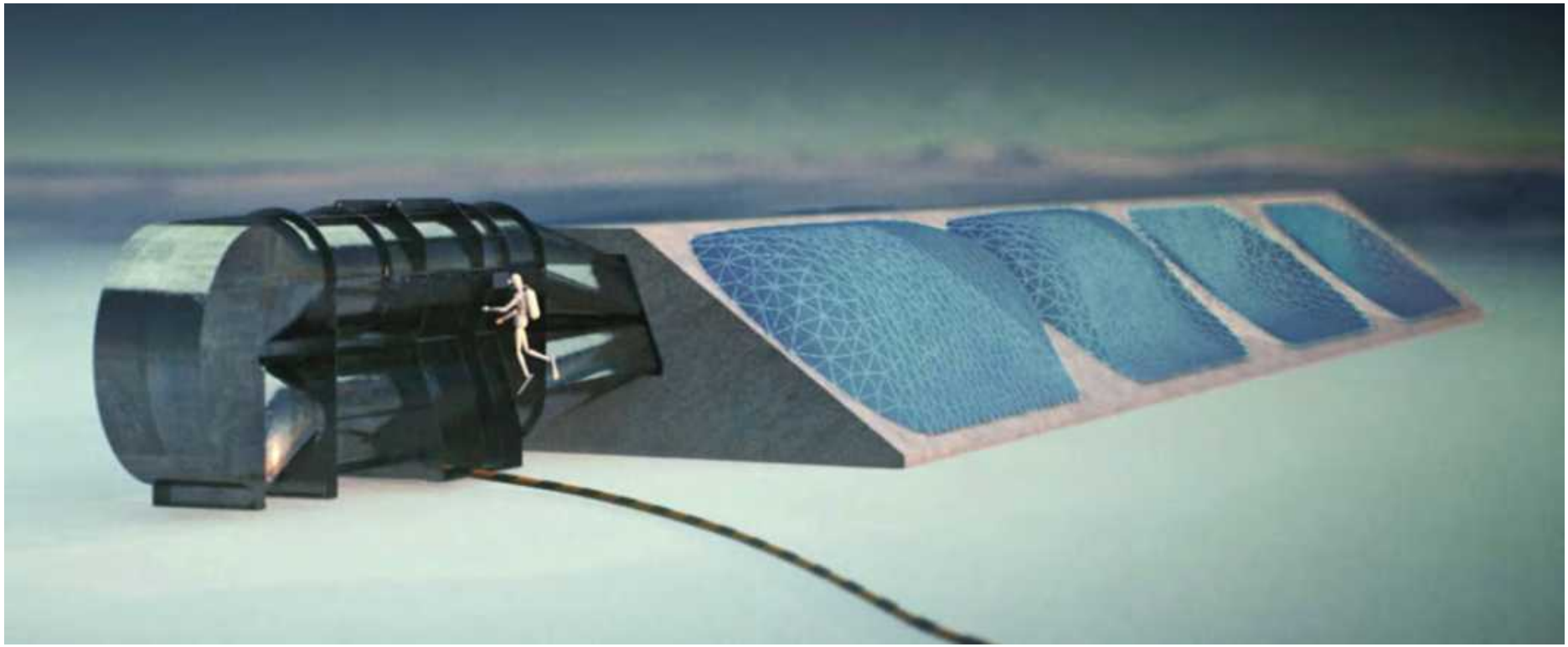
Ocean exploration can improve ocean literacy and inspire young people to seek careers in science, technology, engineering, and mathematics (STEM).



University places

From: Griffith, AMC and University of Queensland welcome pages

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

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

Give 5 reasons why we need to study the oceans.

T011 Resource management and economic values

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.

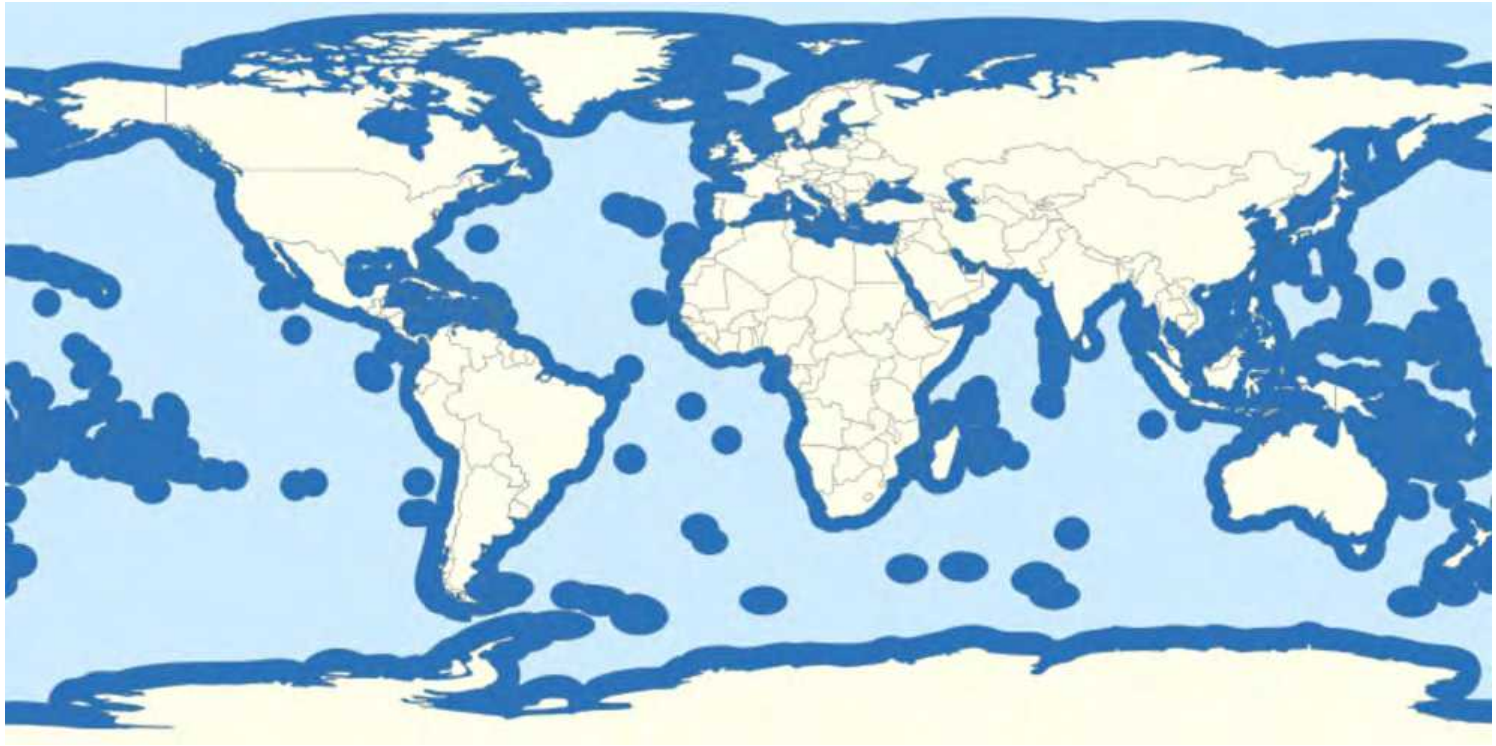
Question

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

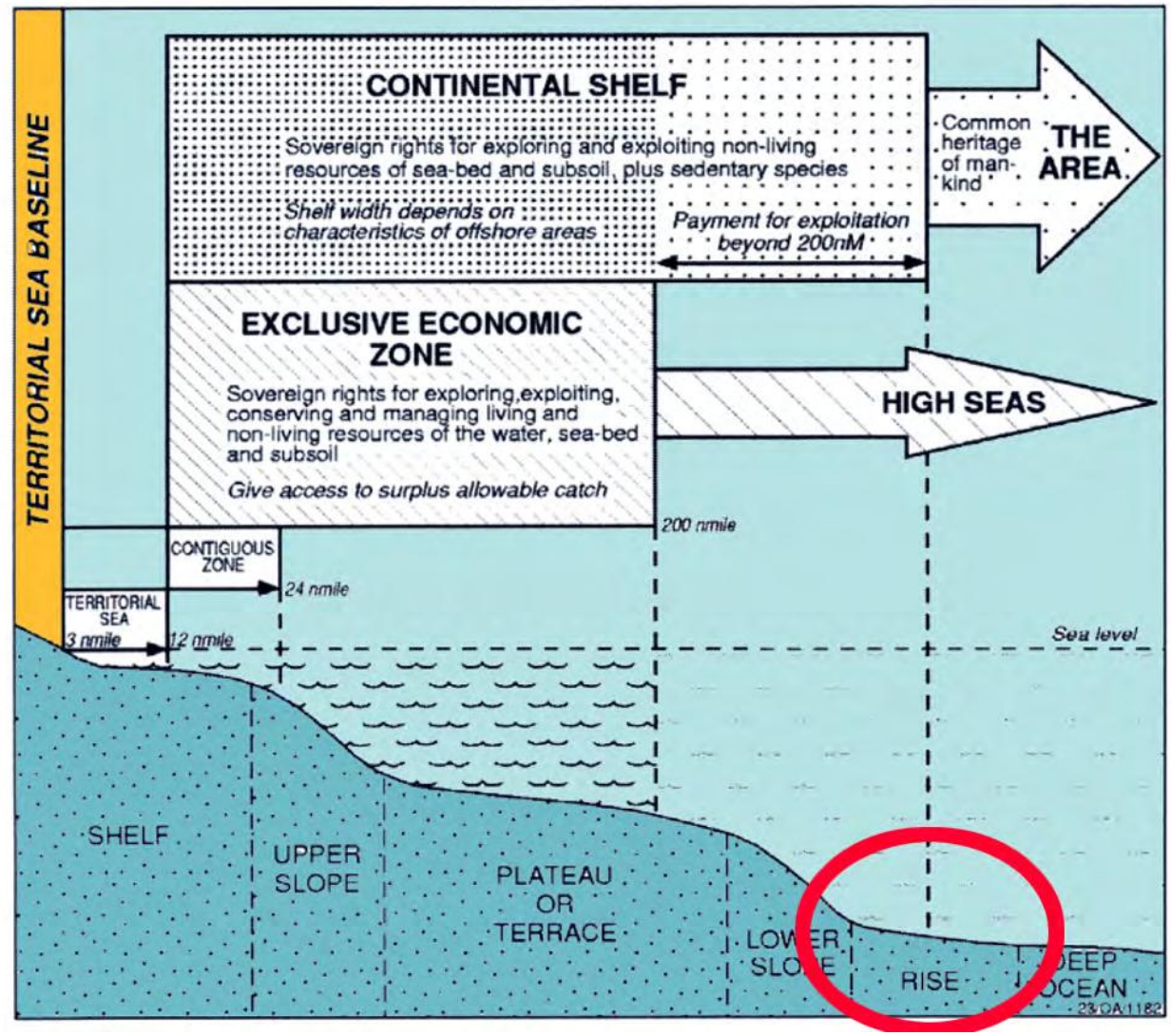
Sovereign rights

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



World's exclusive economic zones, shown in dark blue

Our EEZ starts at the base of the rise of our continental shelf, 200nM out from the Territorial Sea Baseline.

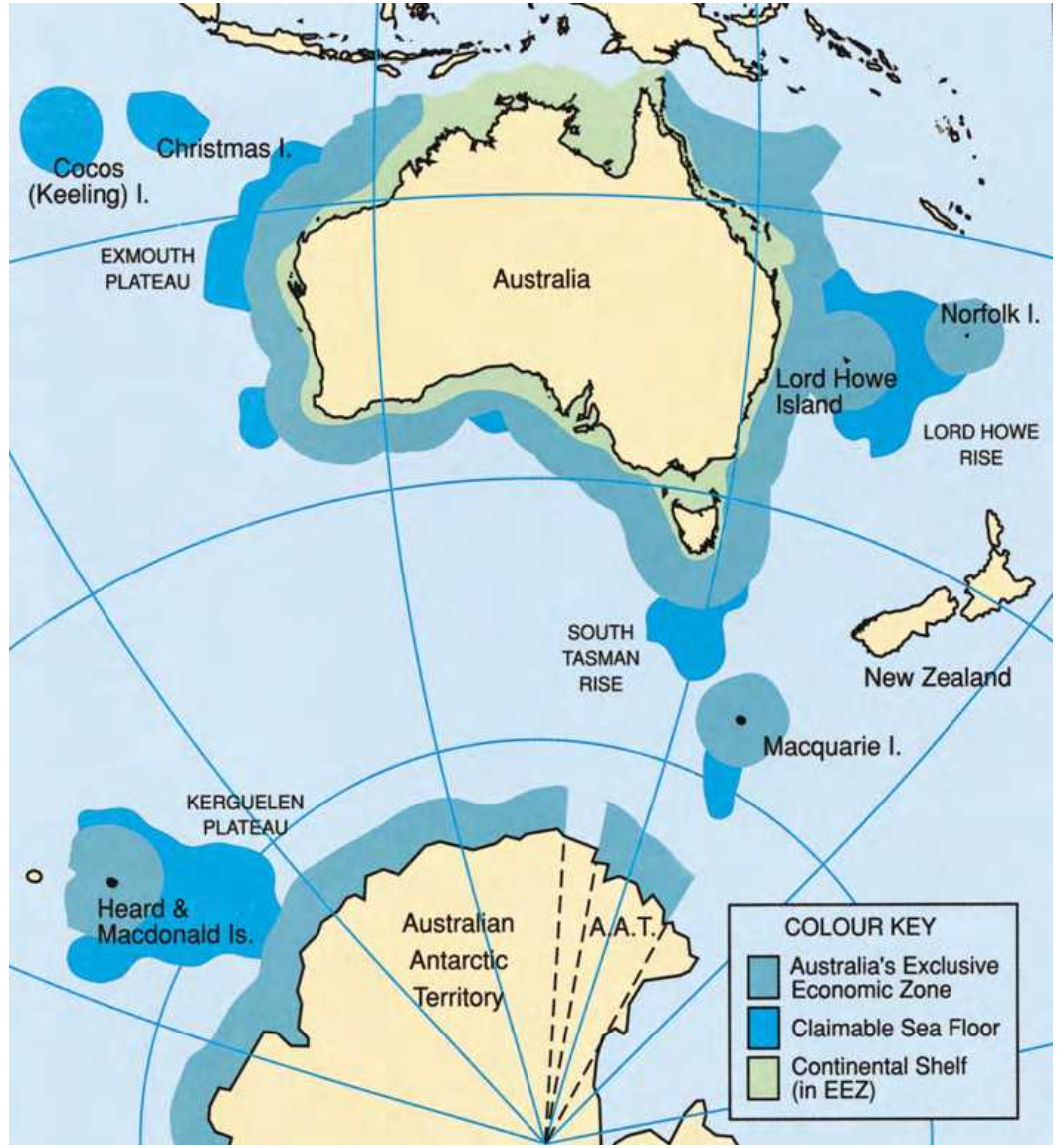


Continental rise and EEZ

Illustration Geoscience Australia

As a result we can draw maps of our EEZ.

Note, our EEZ includes waters off Antarctica and off other offshore islands.



Australia EEC

Illustration Geoscience Australia

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

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/

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

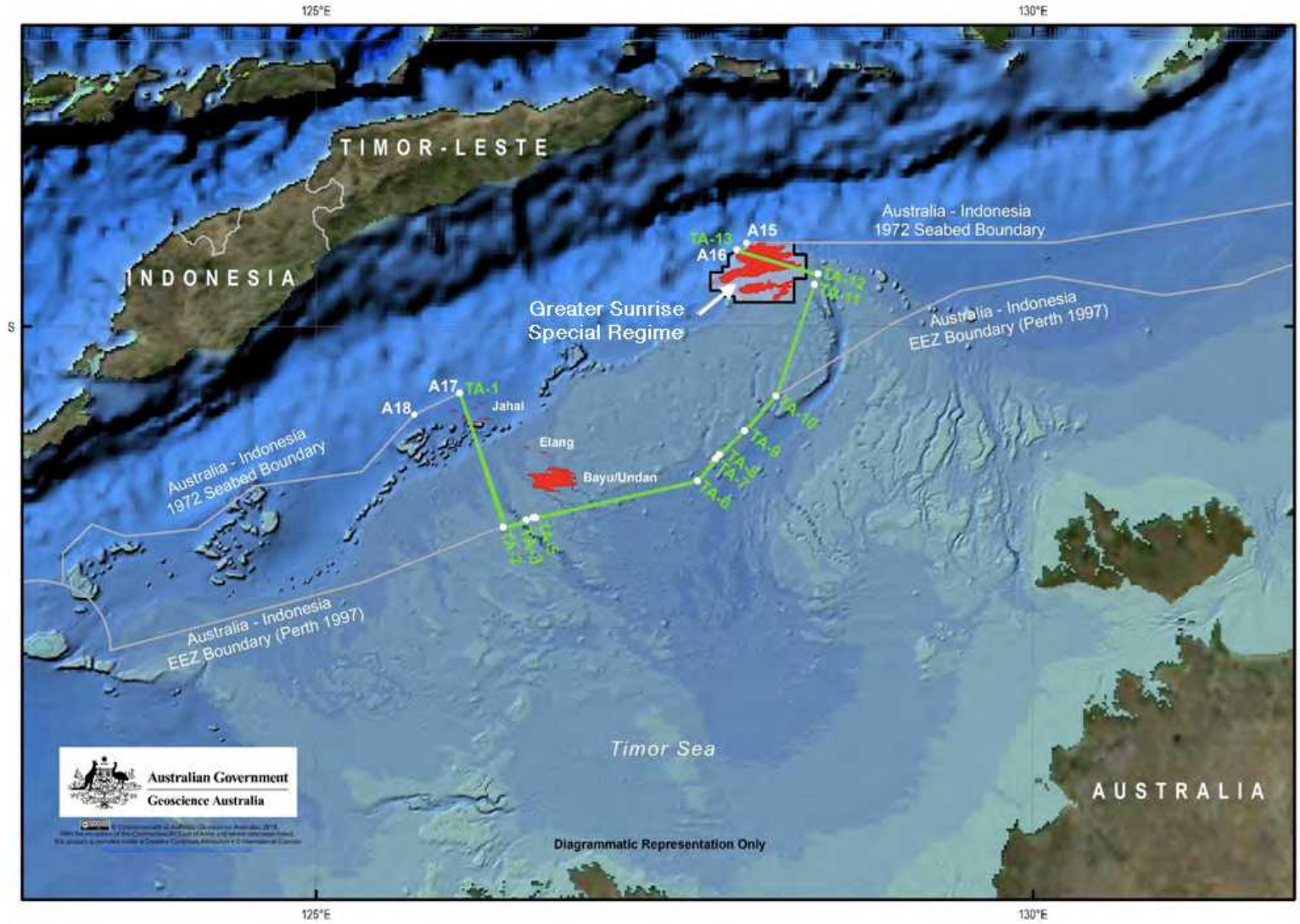
Gas is then delivered to our homes

Crown gas truck

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

To safeguard our resources treaties are drawn up between nations.

For example the Timor Sea oil and gas Treaty.

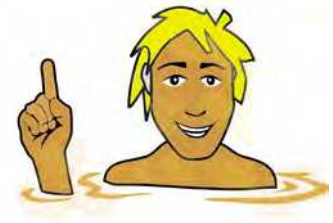


Timor Sea agreement

Illustration Geoscience Australia

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.



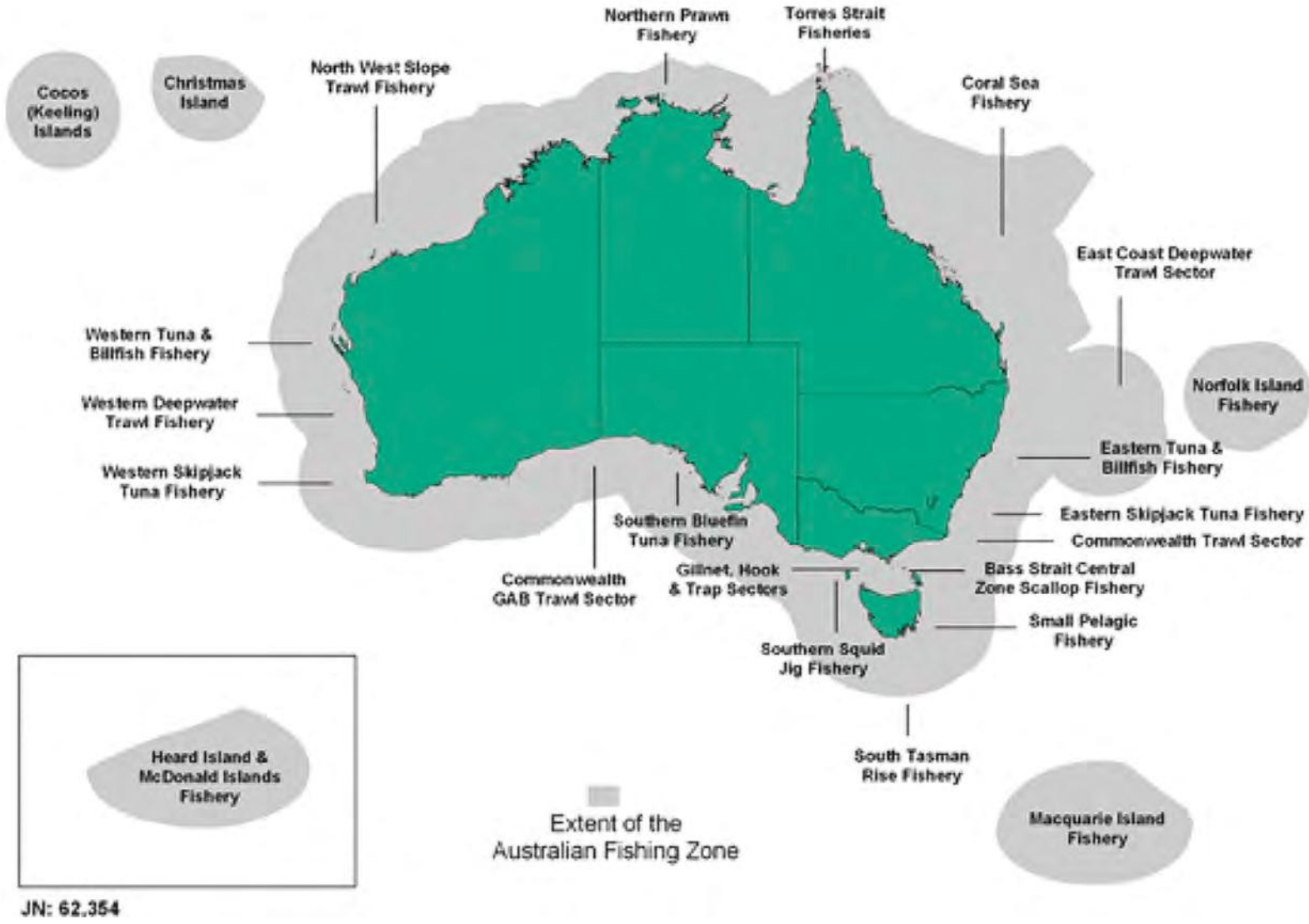
Food resources and security

Australians love seafood with good profit margins when supply is maintained

Seafood for sale

Photo Fisheries Queensland

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

Australian has prawn industries in each state.

Australian prawn industry map

Source AFMA

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)

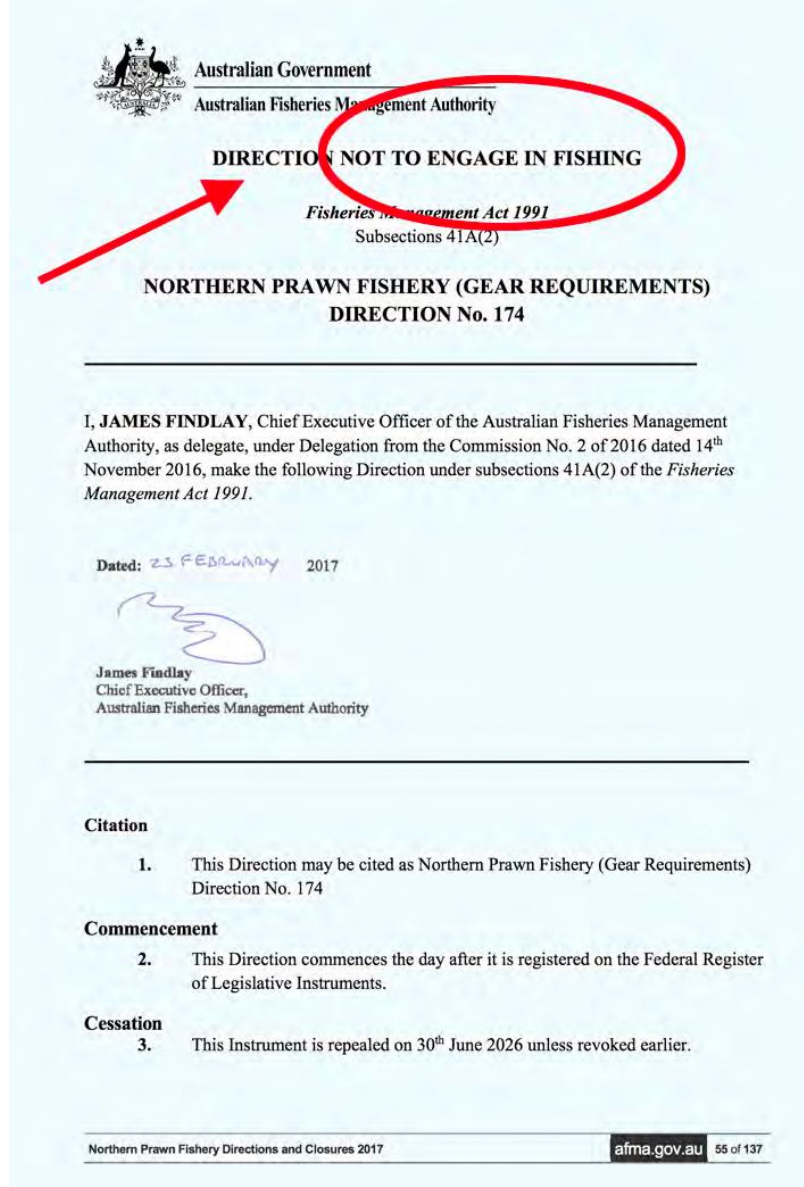
[1] Australian fisheries & aquaculture statistics 2015

Prawn fishery values by State

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

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

For example seasonal closure directives.



Australian Government
Australian Fisheries Management Authority

DIRECTION NOT TO ENGAGE IN FISHING

Fisheries Management Act 1991
Subsections 41A(2)

NORTHERN PRAWN FISHERY (GEAR REQUIREMENTS) DIRECTION No. 174

I, **JAMES FINDLAY**, Chief Executive Officer of the Australian Fisheries Management Authority, as delegate, under Delegation from the Commission No. 2 of 2016 dated 14th November 2016, make the following Direction under subsections 41A(2) of the *Fisheries Management Act 1991*.

Dated: 23 FEBRUARY 2017

James Findlay
Chief Executive Officer,
Australian Fisheries Management Authority

Citation

1. This Direction may be cited as Northern Prawn Fishery (Gear Requirements) Direction No. 174

Commencement

2. This Direction commences the day after it is registered on the Federal Register of Legislative Instruments.

Cessation

3. This Instrument is repealed on 30th June 2026 unless revoked earlier.

Direction not to engage in fishing
http://www.afma.gov.au/wp-content/uploads/2017/03/Final-NPF-Directions-and-Closures-2017.pdf

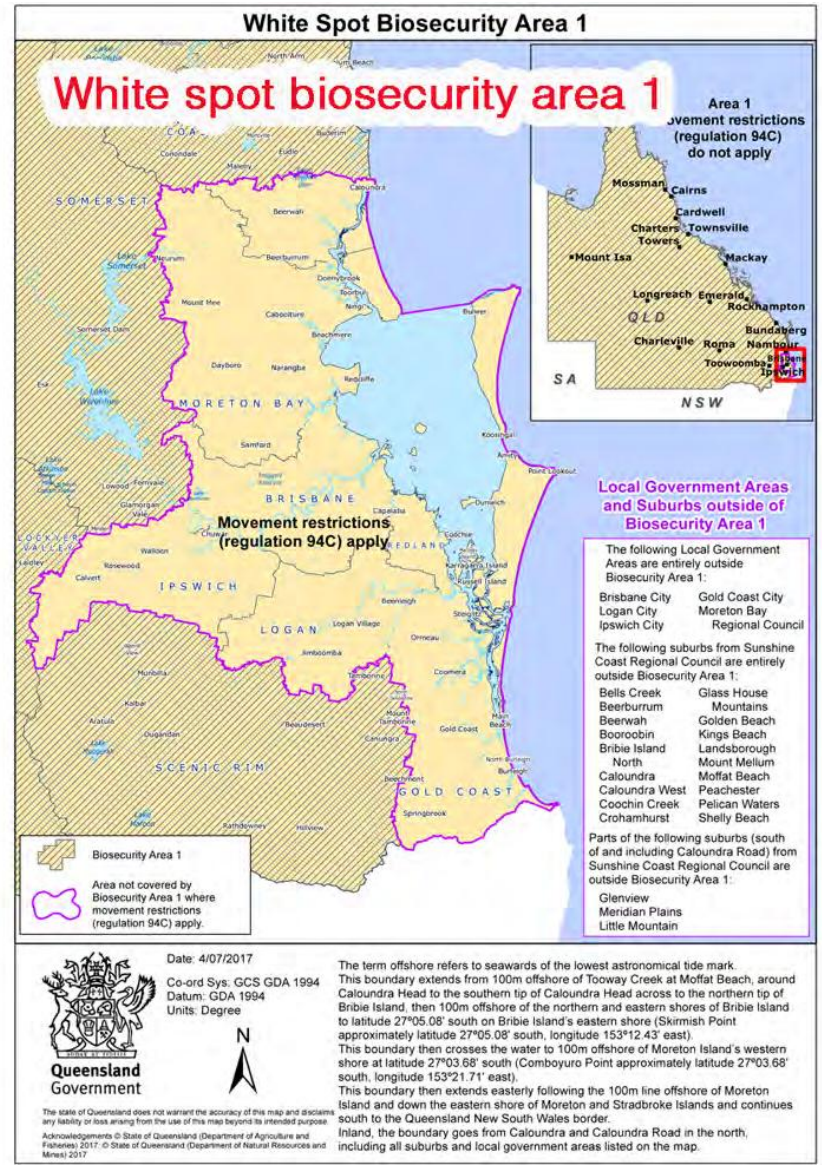
Biosecurity

Disease can also decimate prawn aquaculture industries

Prawn white spot disease

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

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



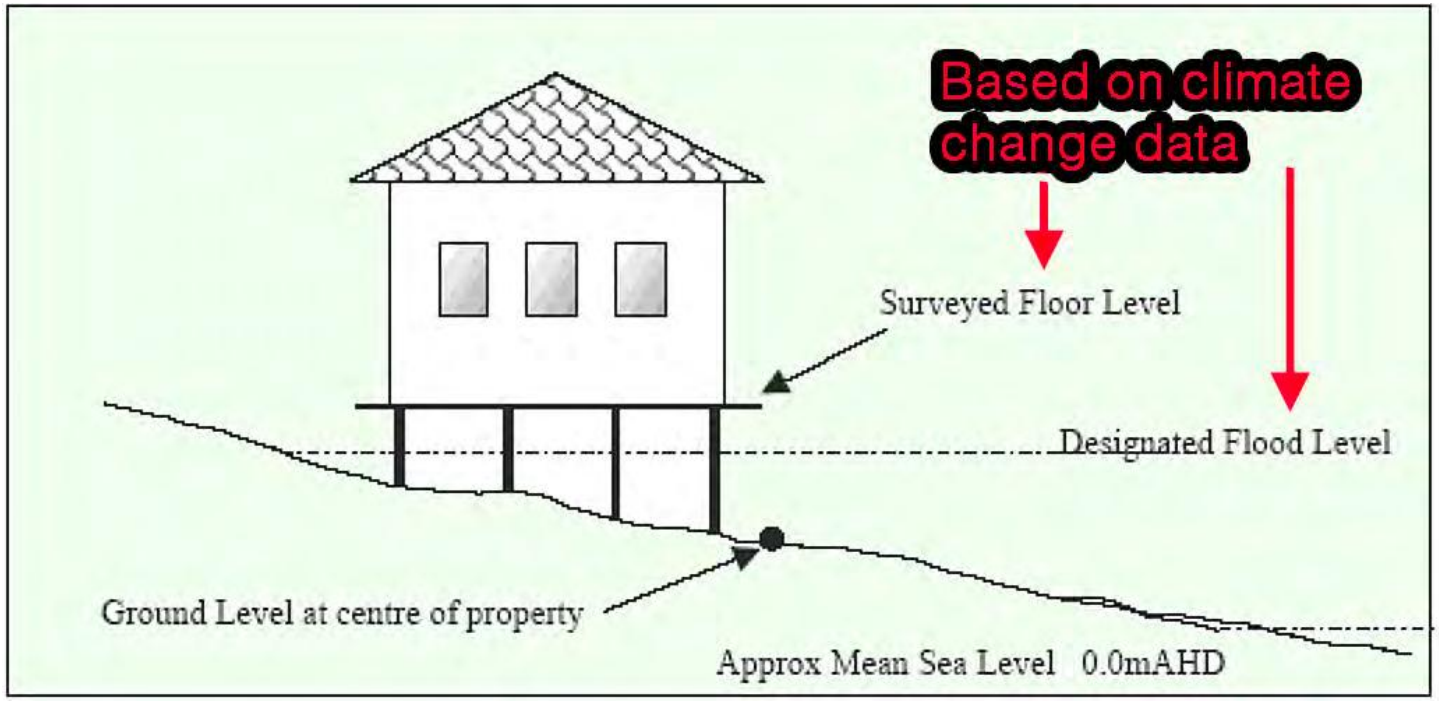
White spot biosecurity area

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

Climate change

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

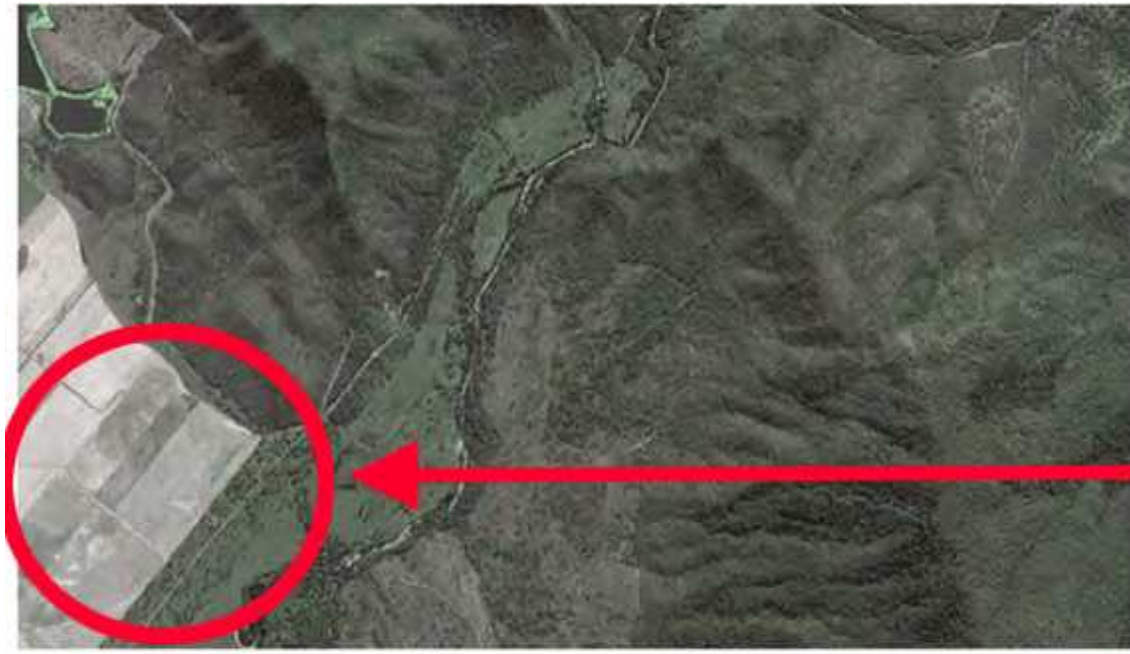
Decisions have been made by councils now to require building surveyed floor levels to take into account sea level rise.



Surveyed level for buildings

Illustration Gold Coast City Council

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

Question

Write three sentences to describe how marine resource management decisions affected by the following issues?

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

Ch 4 Coastlines

T012 Shaping coastlines

T013 Tidal movements

T014 Sand movement

T015 Wave definitions

T016 Material movements

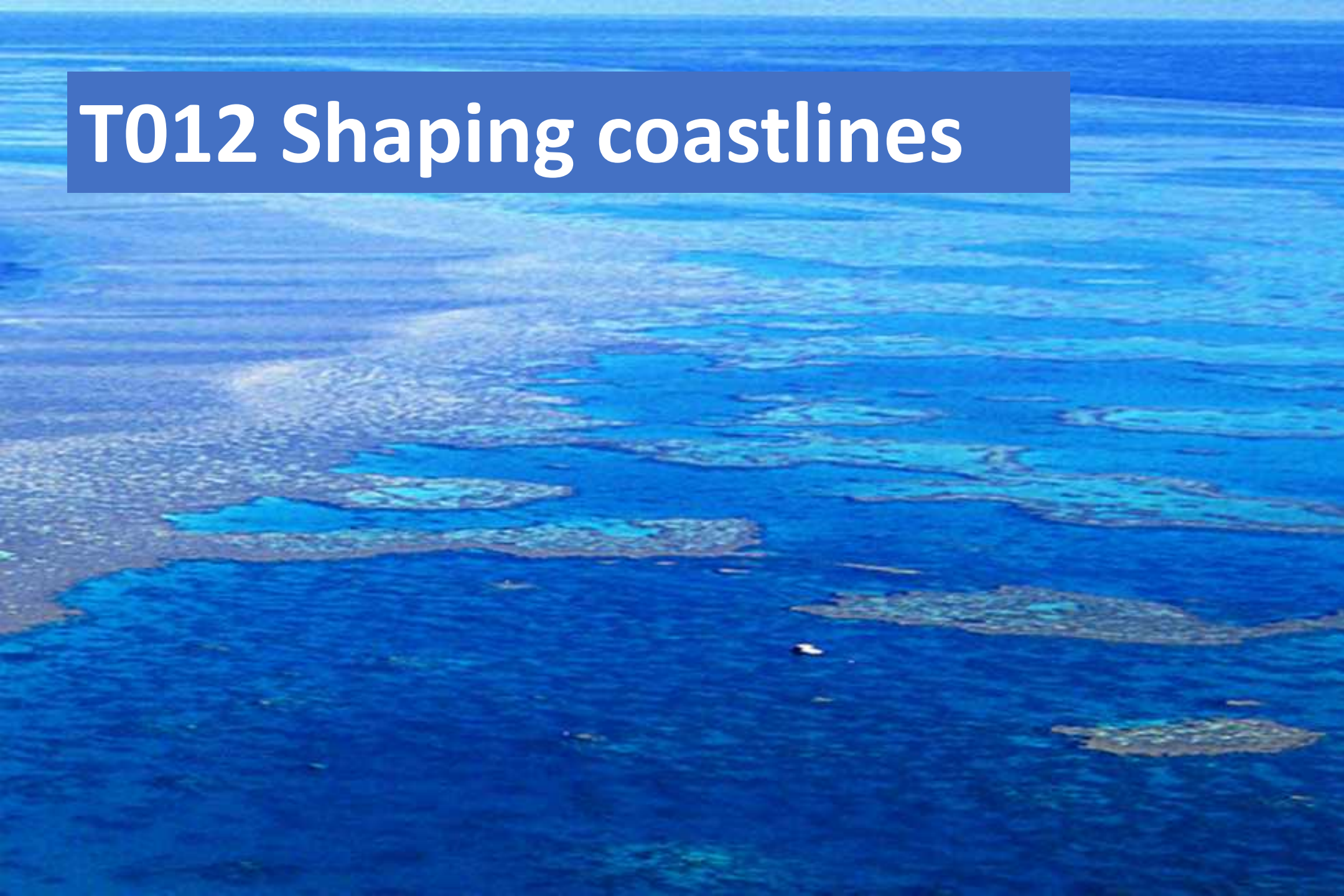
T017 Coastal erosion

T018 Weather patterns

T019 Wave formation

T020 Wave properties

T012 Shaping coastlines



Syllabus statement

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

identify that coastlines are shaped by a number of factors, including tectonic plate movements, shifts in climate patterns and sea level change, weather patterns, and movement of sediments and water (e.g. waves and currents).

Identify

- Locate, recognise and name;

- establish or indicate who or what someone or something is;

- provide an answer from a number of possibilities;

- recognise and state a distinguishing factor or feature.

Question

Identify and give examples of how following have shaped the Australian coastline.

A. Tectonic plate movements,

B. Shifts in climate patterns and sea level change

C. Weather patterns

D. Movement of sediments and water

Tectonic plate movements

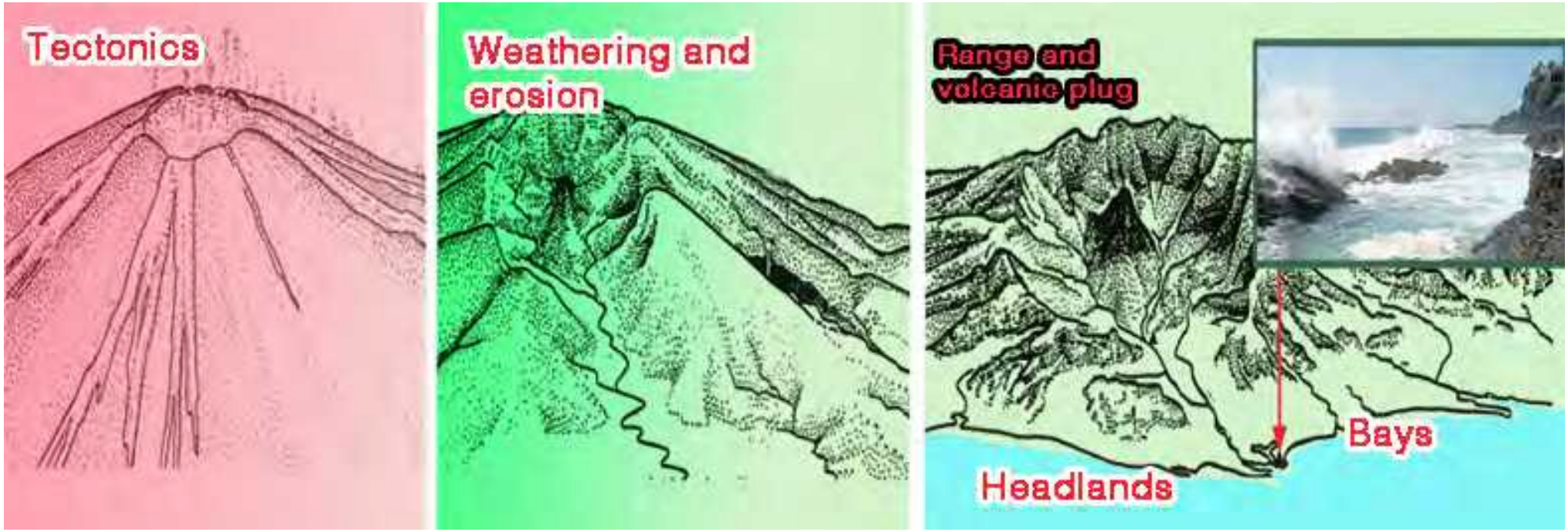
Anticlines in Western Australia show that sandstone has been folded by tectonic plate movements into an arch like structure with igneous rocks at the core.

Nares Point WA

Photo Bob Moffatt

In Queensland molten lava from numerous eruptions along the Great Dividing Range, spread in all directions, some flows reaching the present coastline.

Erosion and weathering then left behind a series of volcanic plugs, rocky headlands and bays.



Great Dividing Range volcanic landscape

Adapted from South East Queensland Geology Society

Slow cooling of thick lava resulted in shrinkage and cracking into a variety of rock types and many slid and rolled to the water's edge. These can be seen as large basalt boulders.

Basalt boulders Qld Coastline

Photo Bob Moffatt

Sediments also were formed millions of years ago and we folded and mixed with igneous rocks by great forces of subduction.

Snapper rocks tectonics

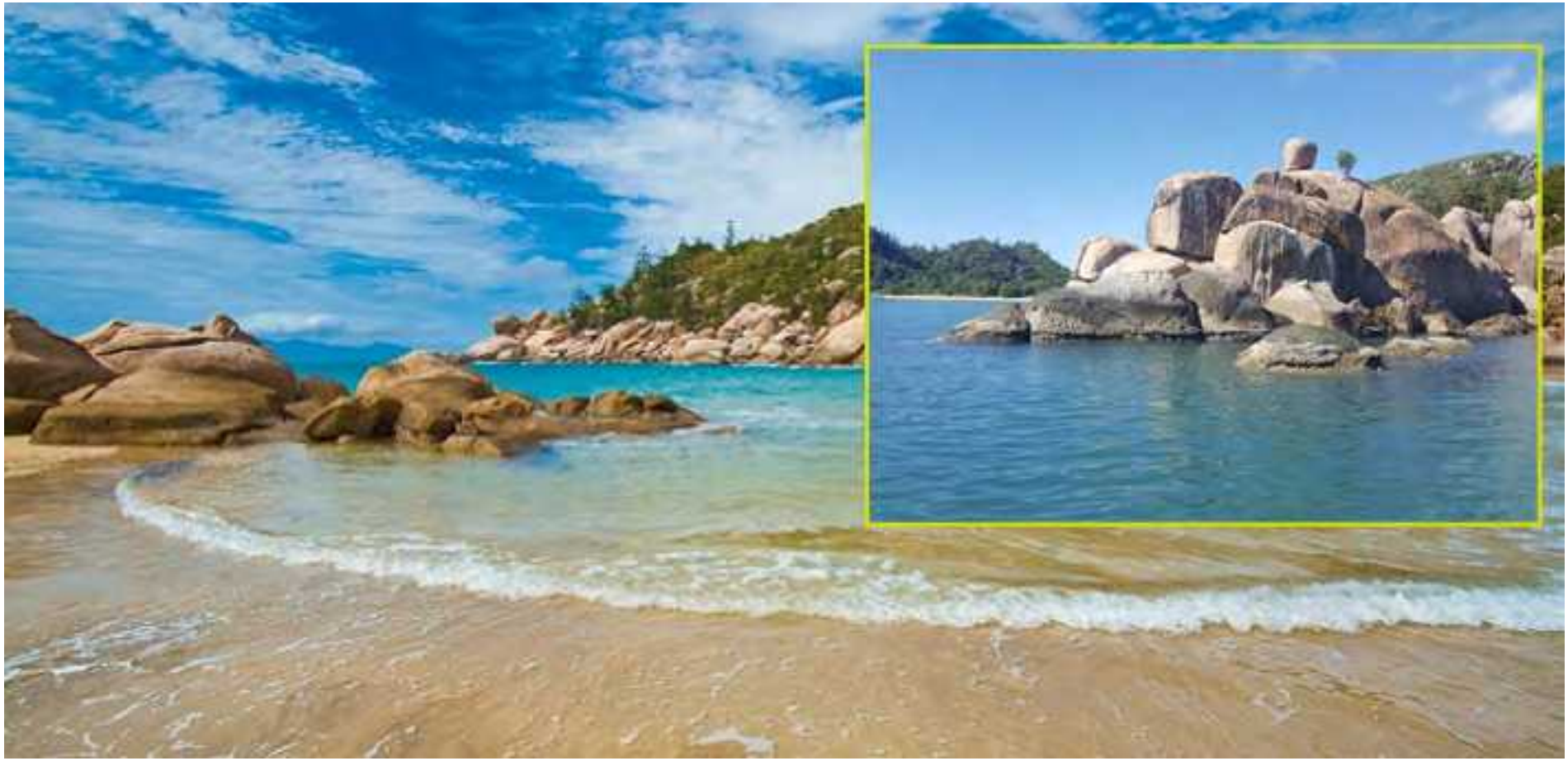
Photo Bob Moffatt

Offshore islands in Queensland such as Magnetic Island formed when molten granite was pushed to the Earth's surface with volcanic force. Over time the overlying volcanic rocks weathered away.

Magnetic Island

Photo Tourism Queensland

The underlying granite mass has decomposed along fracture lines, creating today's extraordinary landscape of rounded domes and boulders (tors), many of which are larger than a house and spectacularly perched.



Magnetic Island

Photo Tourism Queensland

Shifts in climate patterns and sea level change

All of the continental islands in Queensland were once hilltops on an extended coastal plain.

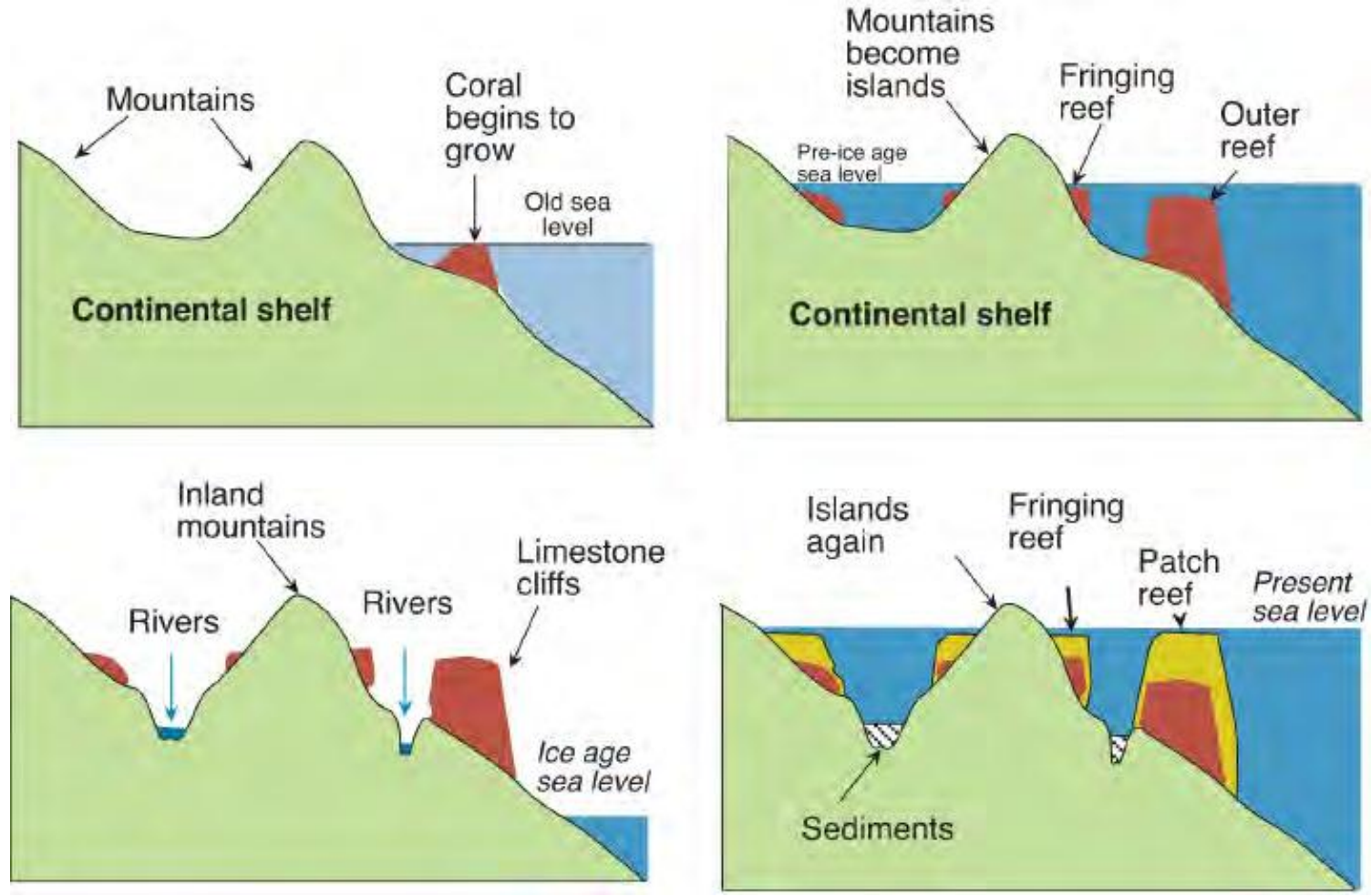
Rising sea level isolated these hilltops to make them islands.

White sandy beaches, rocky headlands and coral reefs fringe most of these islands.

Great Kepple Island

By Stuart Edwards - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3219905

Queensland coral cays, fringing and ribbon reefs also formed as the result of sea level rise.



Reef development

Illustration Bob Moffatt

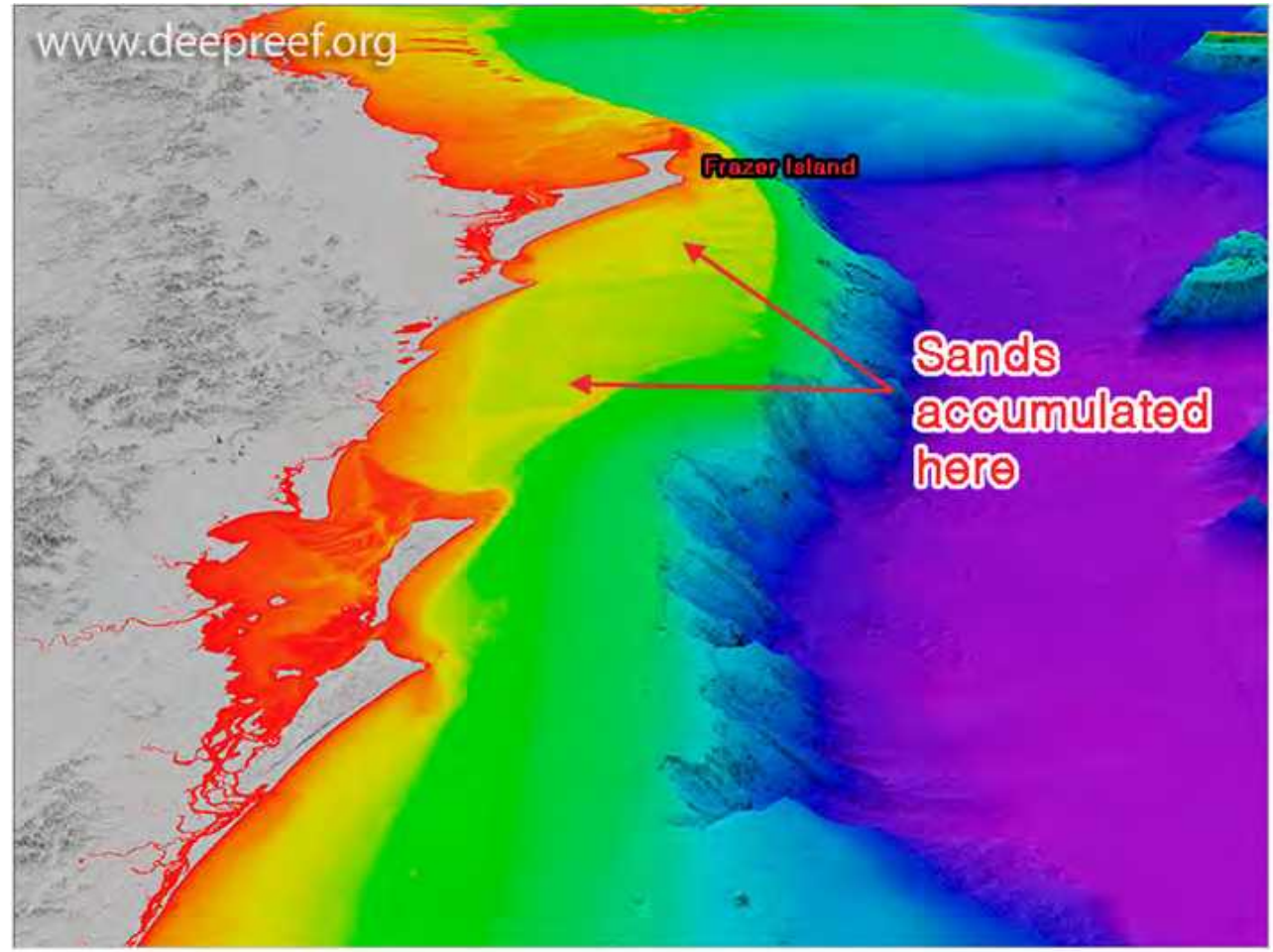
The live coral is a thin veneer on ancient coral growths.

North west island – a patch reef, Lizard Island - fringing reef

North West Island (photo Bob Moffatt) and Lizard Island (photo Great Barrier Reef Marine Park Authority) Copyright reproduced with permission

Millions of years ago Antarctica had mountain ranges that rival the modern-day Himalayas.

These mountain ranges were eroded with the resulting sands being accumulated on the continental shelf where Fraser Island now lies.



Frazer Island and continental shelf

Periodic changes in the Earth's temperature created changes in sea levels.

Sand from the exposed continental shelf during these ice ages was blown up into these massive sand dunes.

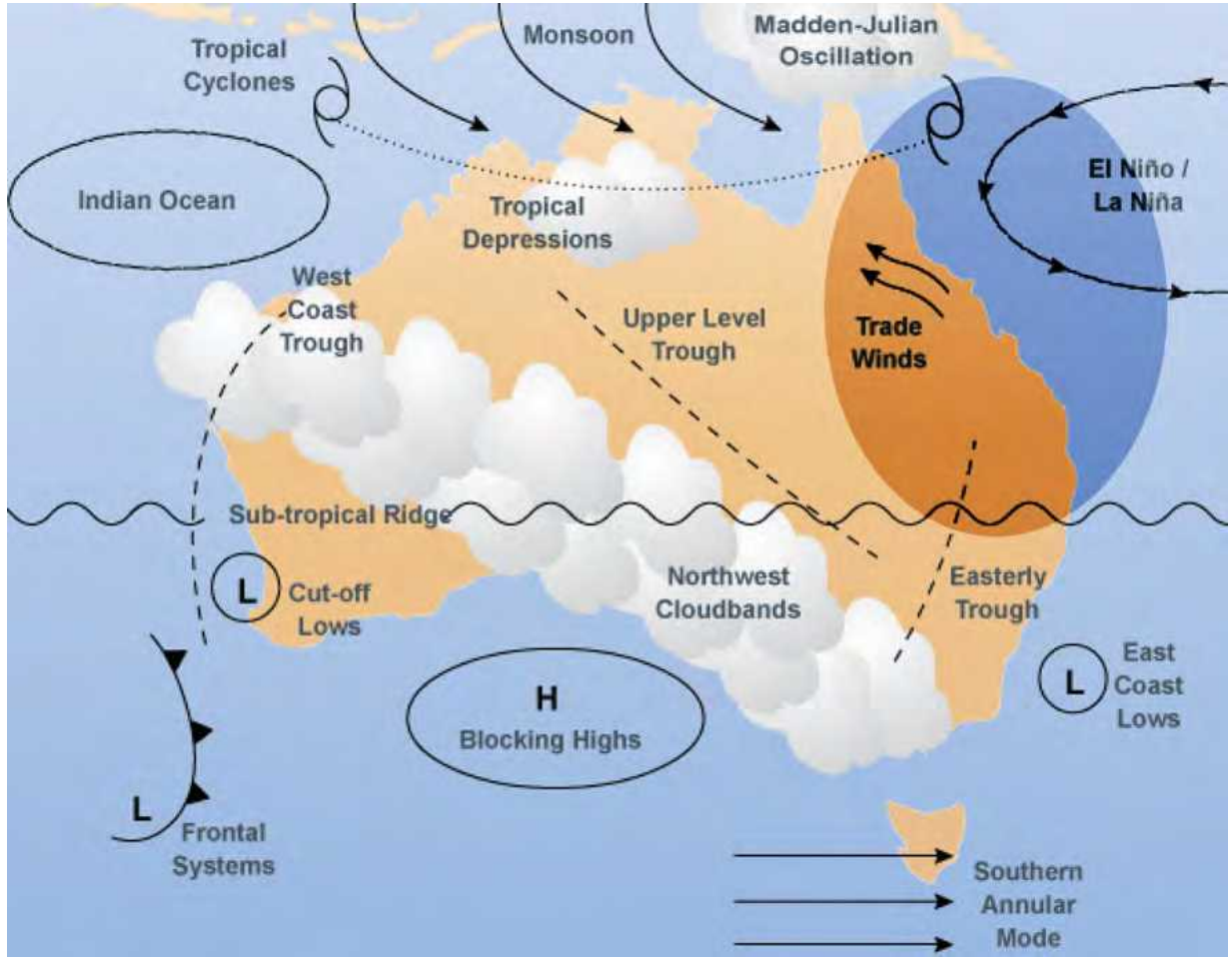
Frazer Island sand dunes

Photo Bob Moffatt

Weather patterns and weathering

Weather patterns constantly move sand from place to place on beaches.

The prevailing south east trade winds move sand northwards continually changing coastal bars and beaches.



Qld trade winds

Illustration Australian Government Department of Agriculture

These trade winds keep coral cays at the North West end of reefs.

North West and Heron Island map

Illustration Bob Moffatt

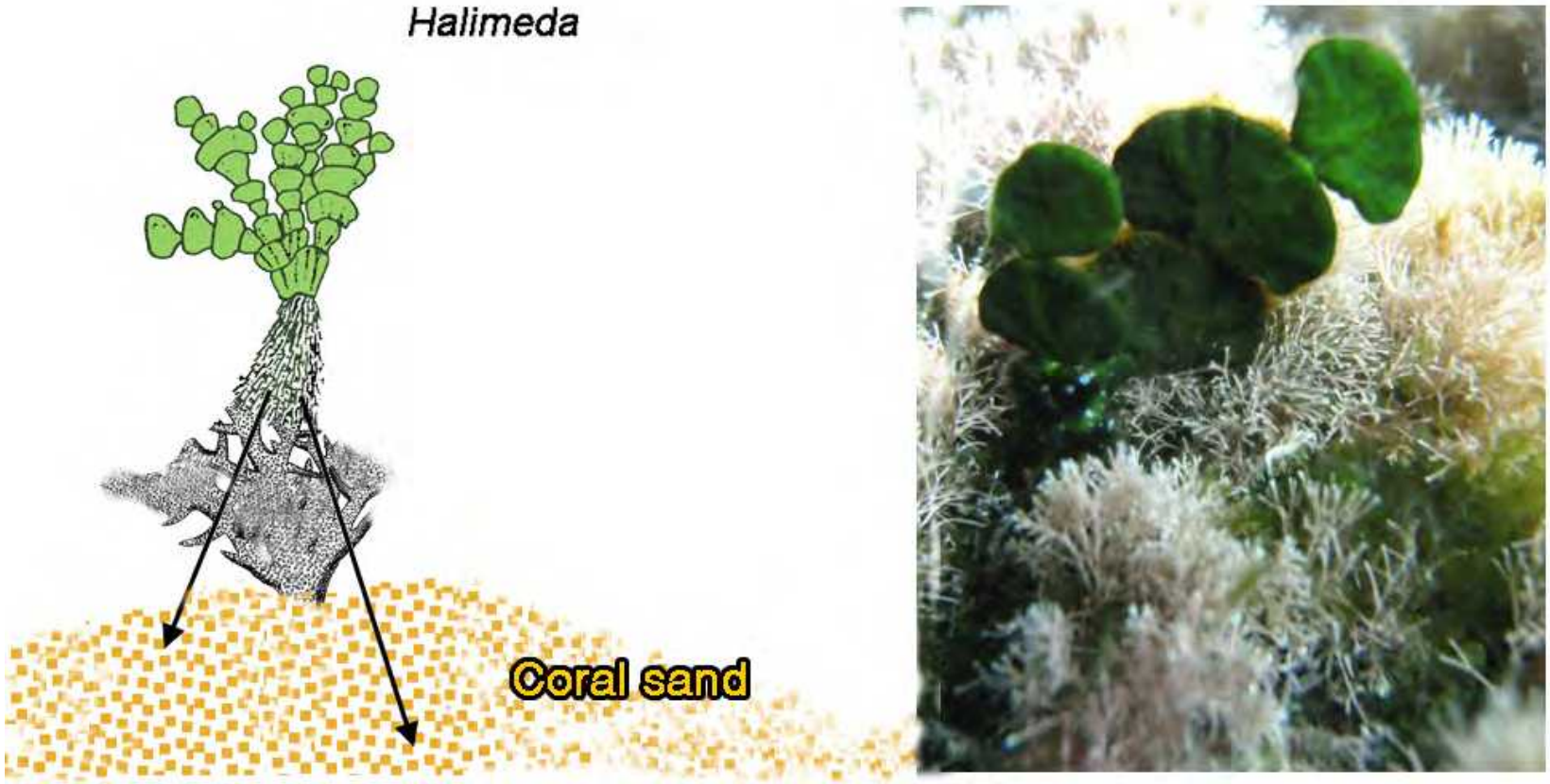
In mechanical weathering, waves, wind and coastal currents are continually reshaping the coastline.

Waves create wave cut platforms which can be seen all along the Queensland coastline.

Wave cut platform Noosa

Photo Bob Moffatt

Chemical weathering is caused by chemical reactions (chiefly with water and substances dissolved in it.



Halimedia

By Alberto Romeoalbertoromeo@neomedia.ithttp://www.romeofotosub.it - Own work (personal work), CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=4660367For example the reef algae Halimedia disintegrates coral into sand.

Wind and rain also breaks boulders and shapes coastlines.

For example weathered siltstone and columnar basalt lava flow.

Siltstone and granite headlands

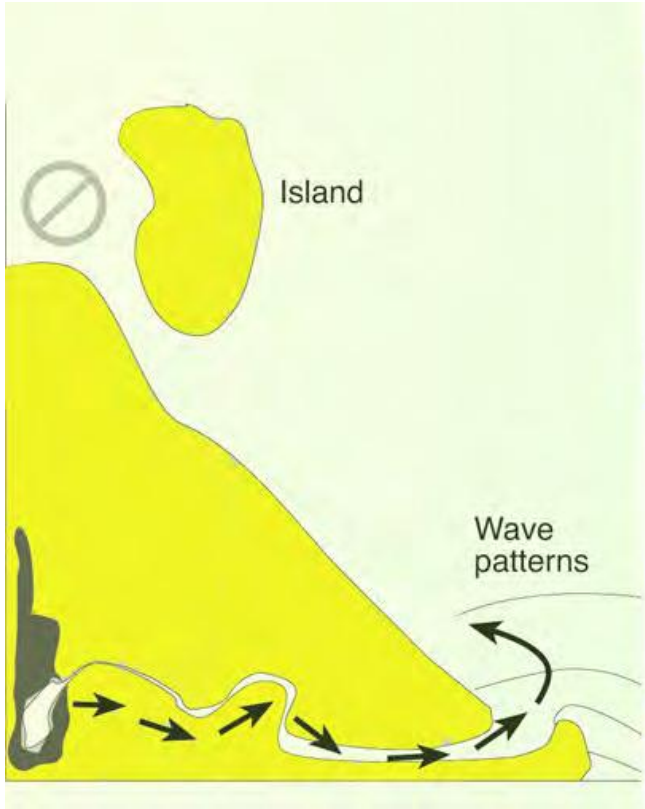
Moving glaciers also causes massive weathering of mountain ranges, for example the fiords of New Zealand.

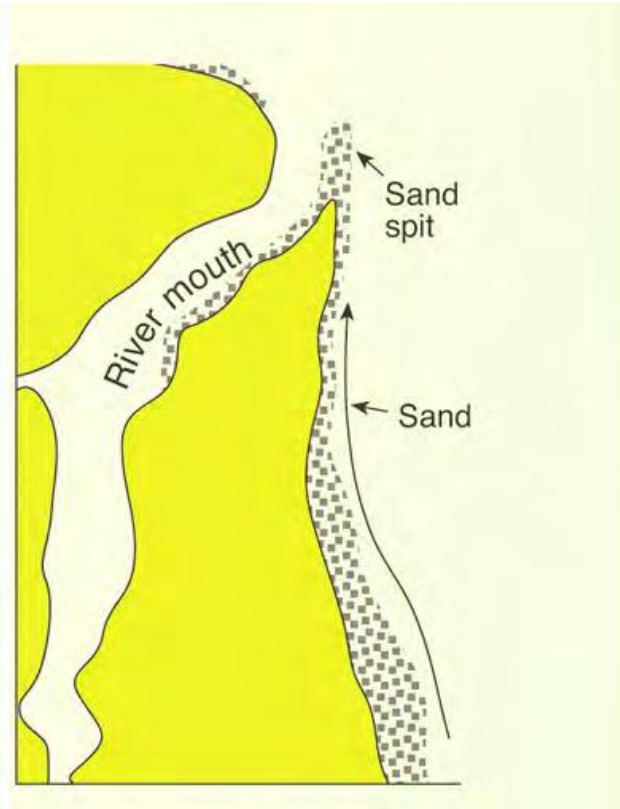
NZ Glacier and fiord

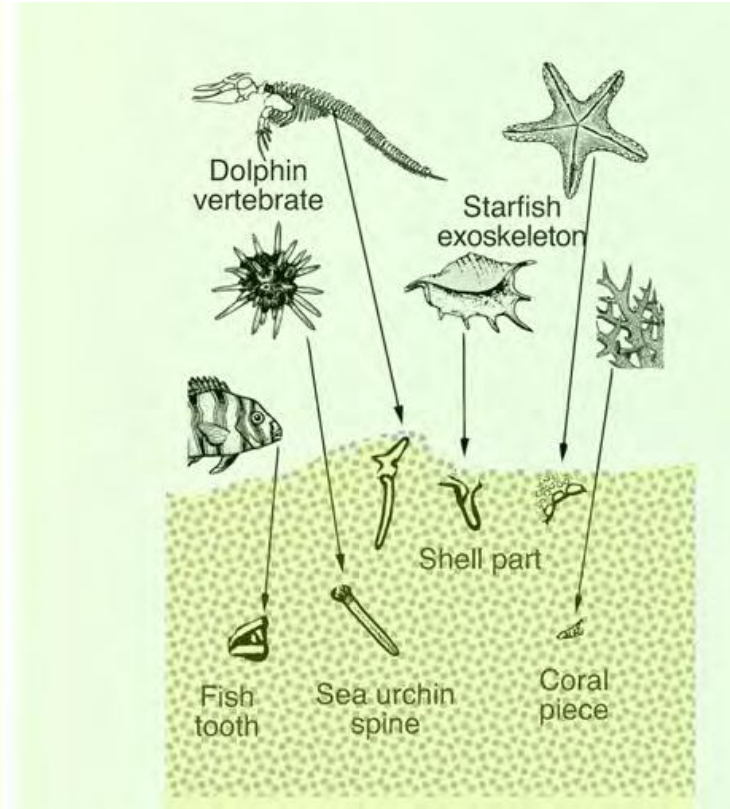
Photo Bob Moffatt

Movements of sediments and water

Sediments can be made from weathered rock, animal remains or behaviours.







Ways sand can form

Illustration Bob Moffatt

Weathered rocks in mountain ranges roll down rivers gradually forming sand.

This type of sand is called non-carbonate sand and contains minerals.

Non-carbonate sands are made from the eroded rocks

Photos Left QUT, Sam Smith, reproduced with permission L, Bob Moffatt R

Non-carbonate sands accumulate on all beaches in Queensland

Water movement causes a beach

Photo Bob Moffatt

Movement of sediment is greatest in high wave energy areas such as the Gold and Sunshine Coasts, but also occurs on all Queensland beaches.

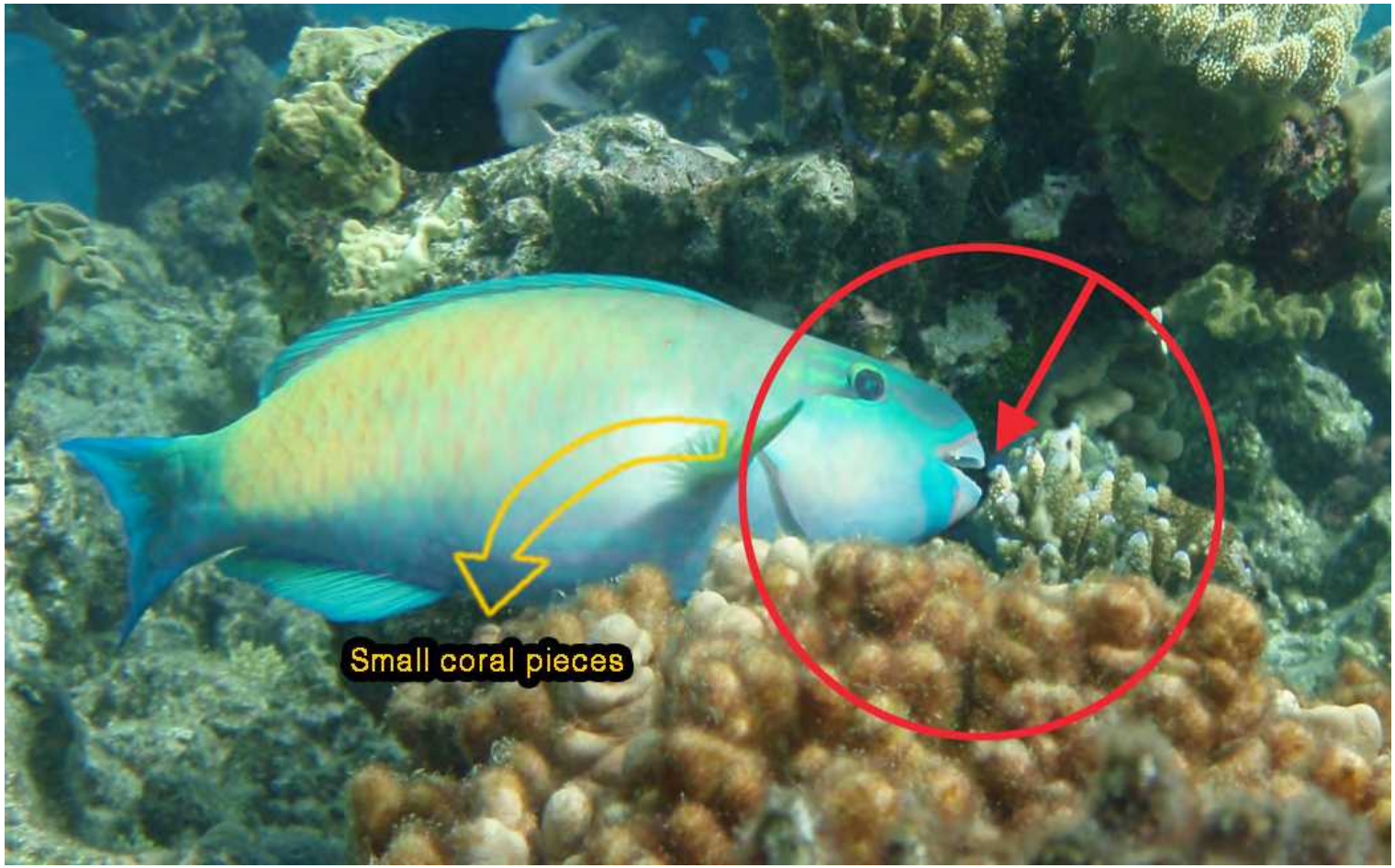
Beaches low energy Bagara left and High Noosa Right

Wind also blows sand along beaches, offshore and into sand dunes.

Onshore winds blow sand into dunes

Photo Bob Moffatt

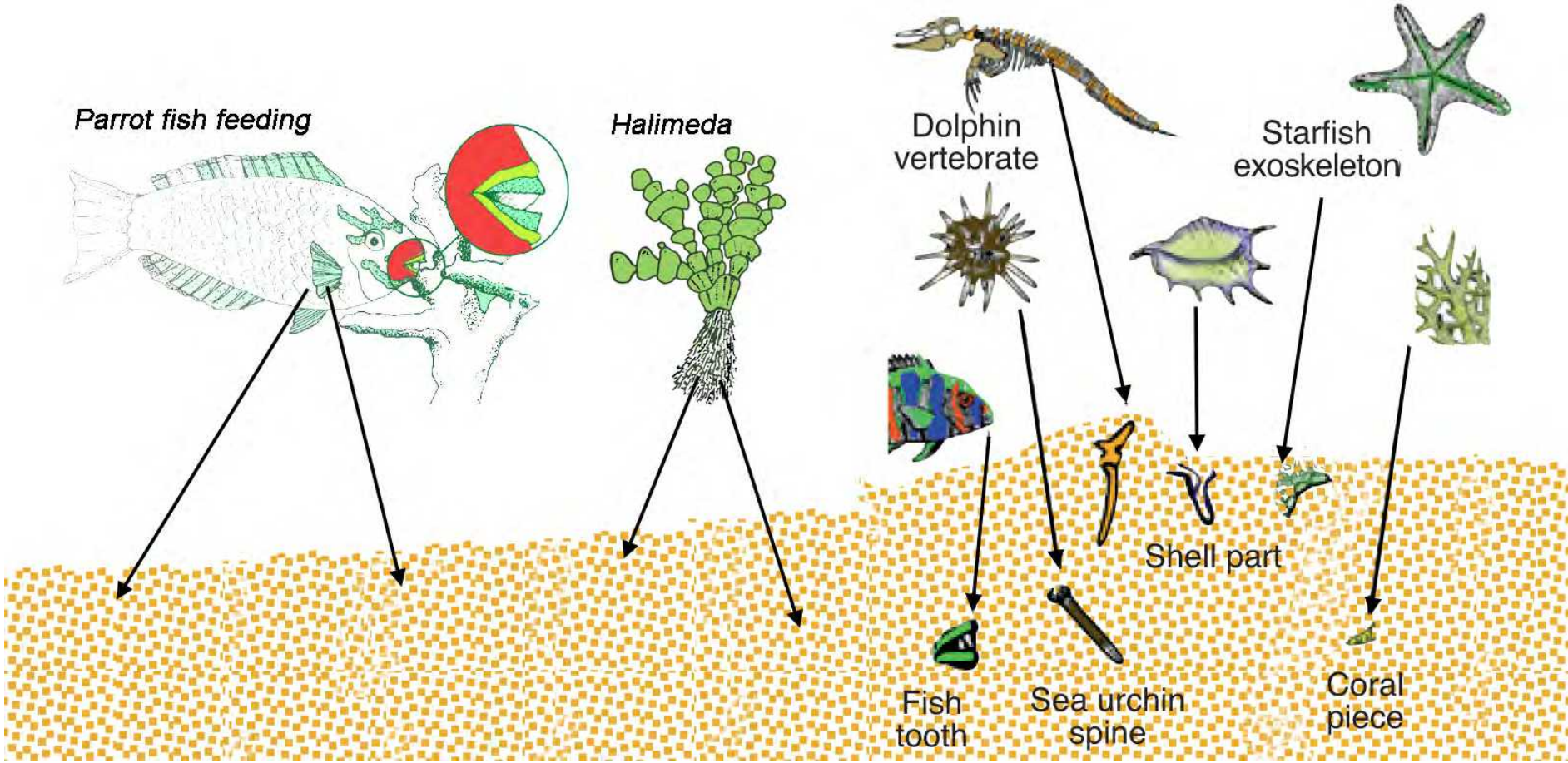
Sediments can also be made from animal remains or behaviours.



Parrot fish eats coral

Photo Bob Moffatt

Sand from animal remains or behaviour is called carbonate sand and can be seen on offshore islands and reefs.



Carbonate sand formation

Illustrations Bob Moffatt, Steven Byers

This sand can accumulate on beaches providing a barrier to erosion.

Lady Elliott Is and beach

Photo Bob Moffatt

Question

Identify and give examples of how following have shaped the Australian coastline.

A. Tectonic plate movements,

B. Shifts in climate patterns and sea level change

C. Weather patterns

D. Movement of sediments and water

T013 Tidal movements

Syllabus statement

At the end of this topic you should be able to … **recognise** tidal movement in terms of gravitational pull, current strengths and wave actions.

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.

Question

Recall how tides are created by

A. Gravitation pull

B. Current strength and

C. Wave action

Gravitation pull

Tides are the periodic rise and fall of the water on the earth's surface and are actually one big wave caused primarily by the gravitational pull of the moon.

The Earth spins into this wave and causes the water at the edge of continents to rise and fall on a regular basis.

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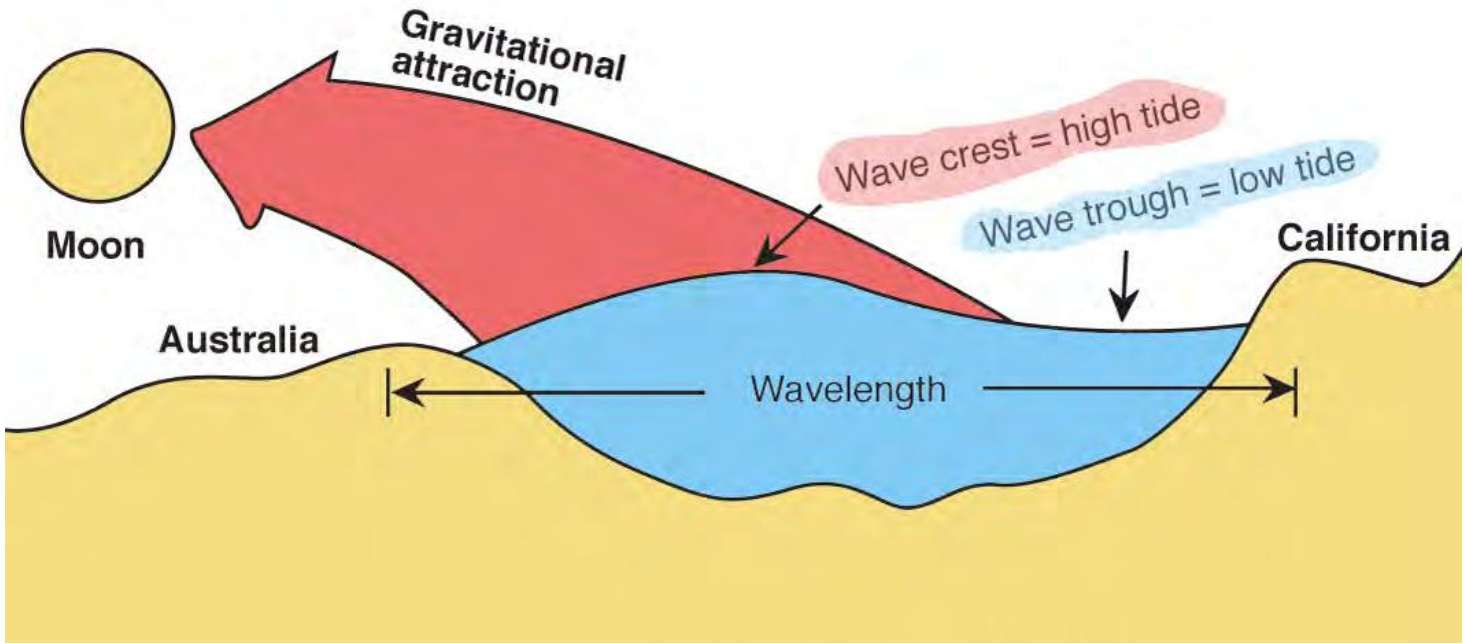
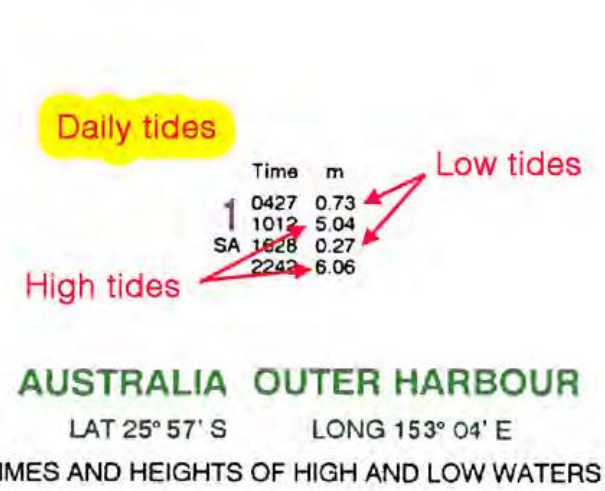
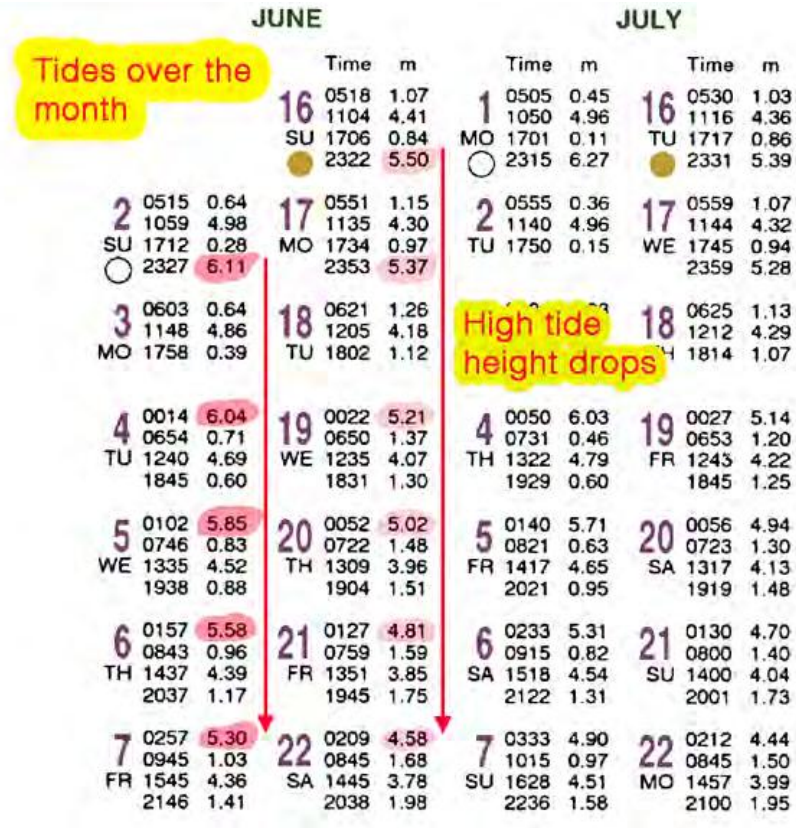


Tides are one big wave

Illustration Bob Moffatt

This gravitational attraction causes two main types of tide - daily and monthly with big variations around the Australian coastline.





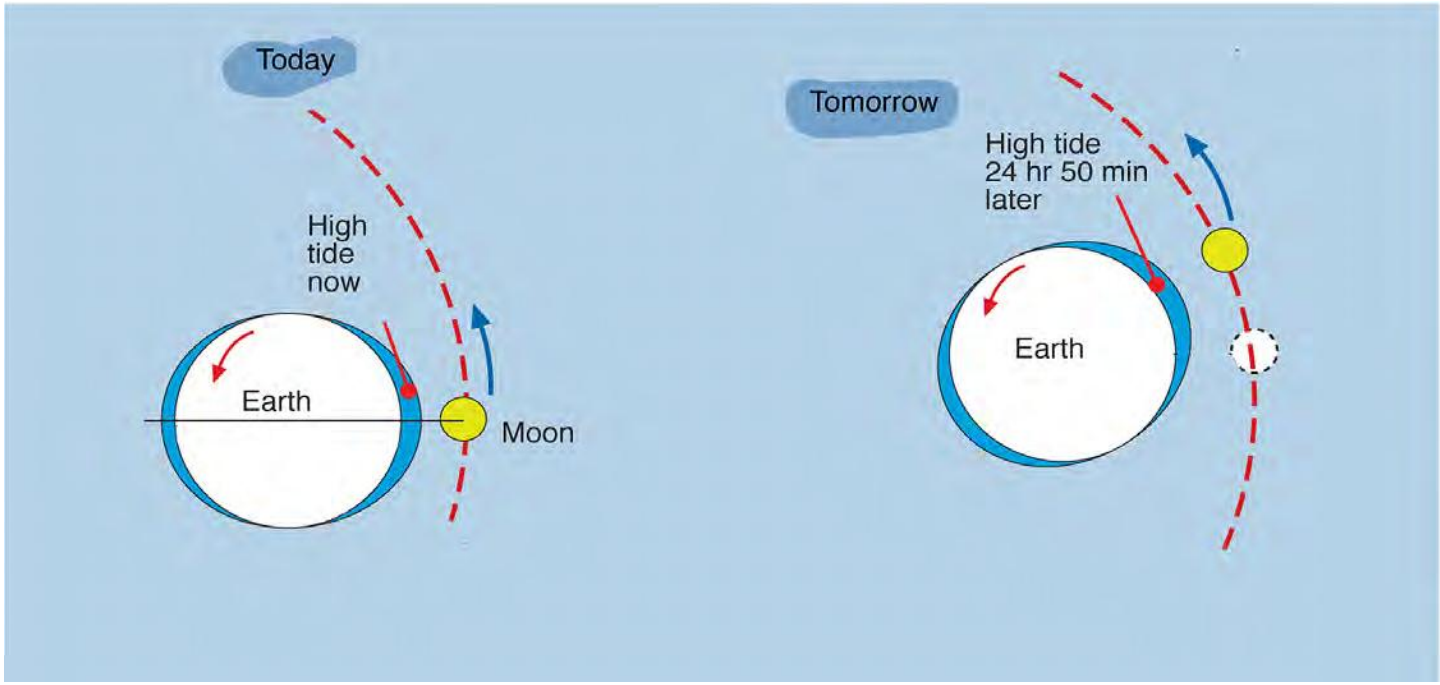
Tides tables day and month comparison

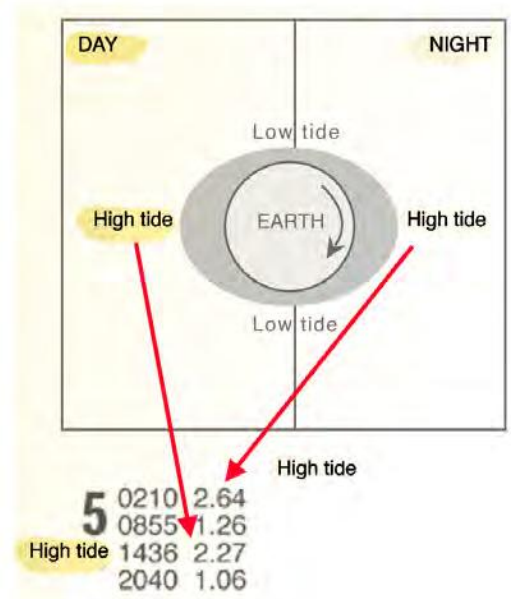
Illustration Bob Moffatt

Daily tides are caused by the position of the moon and the rotation of the earth.

There are five hours and fifty two minutes between tides.

A high tide occurs when we spin into the tidal bulge.
An low tide is when we spin out of it.





Daily tides
Illustration Bob Moffatt

When the tide comes in it is said to be flooding.

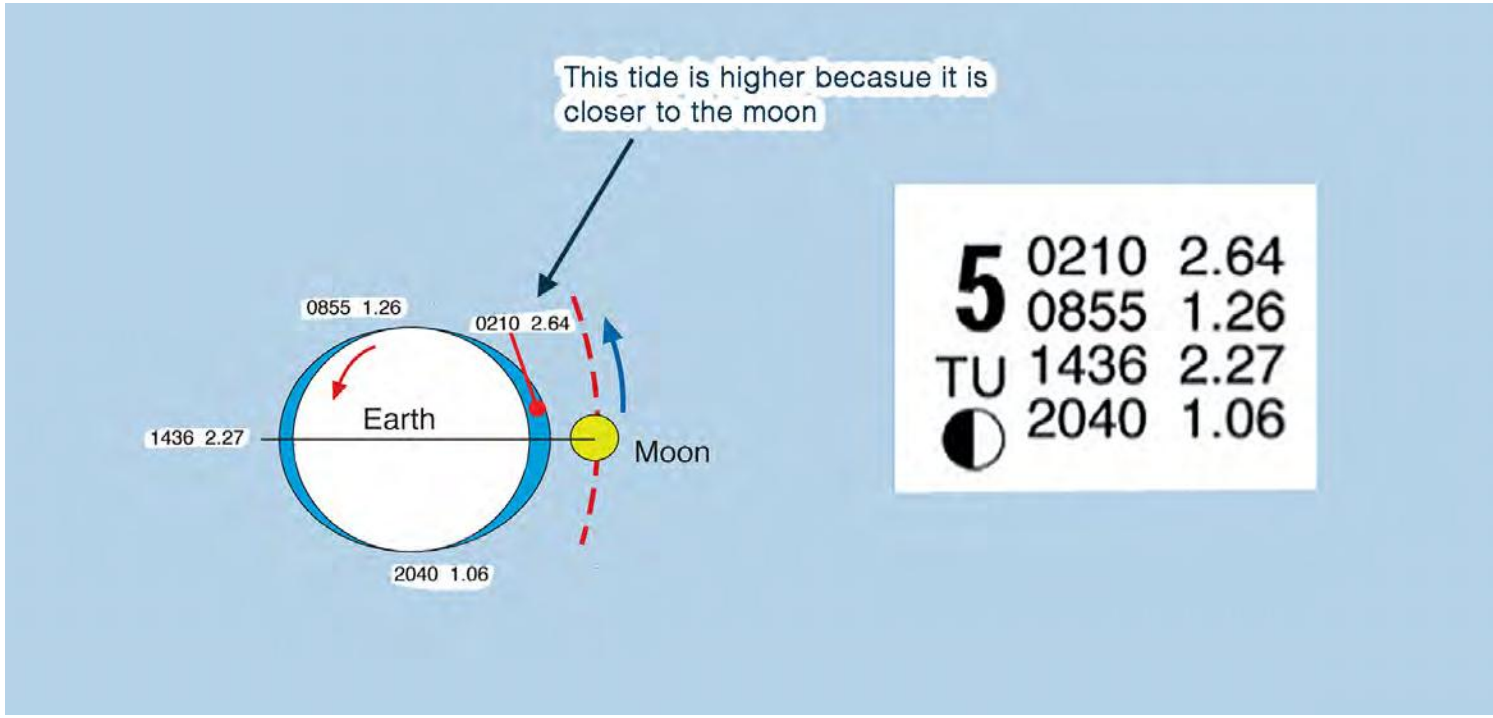
When it goes out it is said to be ebbing.

Tides flooding and ebbing

Photos Bob Moffatt

This difference in height occurs because the Earth spins through two different heights of tide and is called the tidal range.

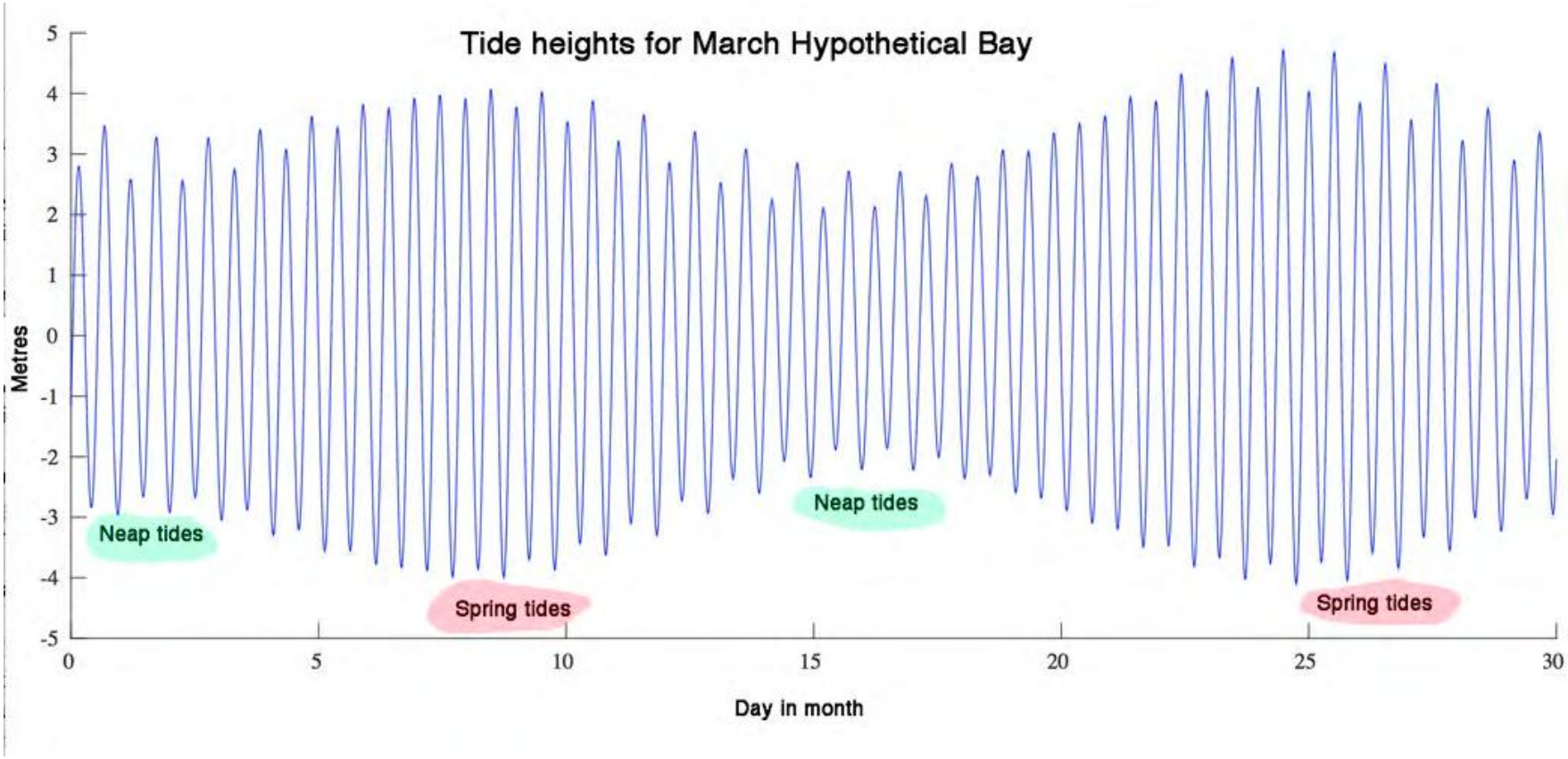
One height is higher because the point above the tide is directly below the moon. The other height is caused by the earth's centrifugal force and is slightly lower.



Daily tides

Illustration Bob Moffatt

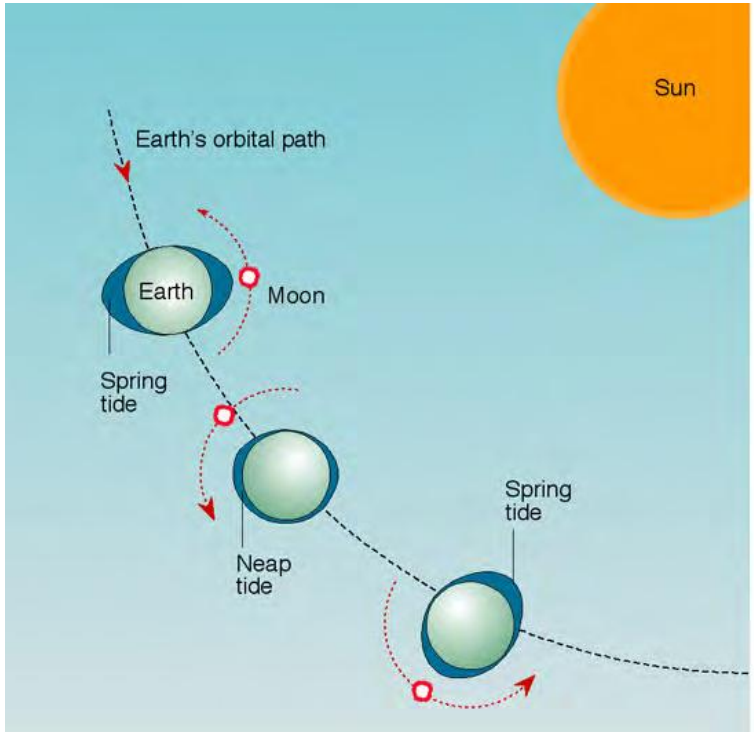
Tides also vary over the month. If you plot the tides over a month you will noticed a change in tide heights.
There are two spring tides and in the month.



Tide graph over a month
Illustration Bob Moffatt

Spring tides occur where the gravitational pull of the Sun and the Moon are combined and the tides are at their highest (high highs and low lows).

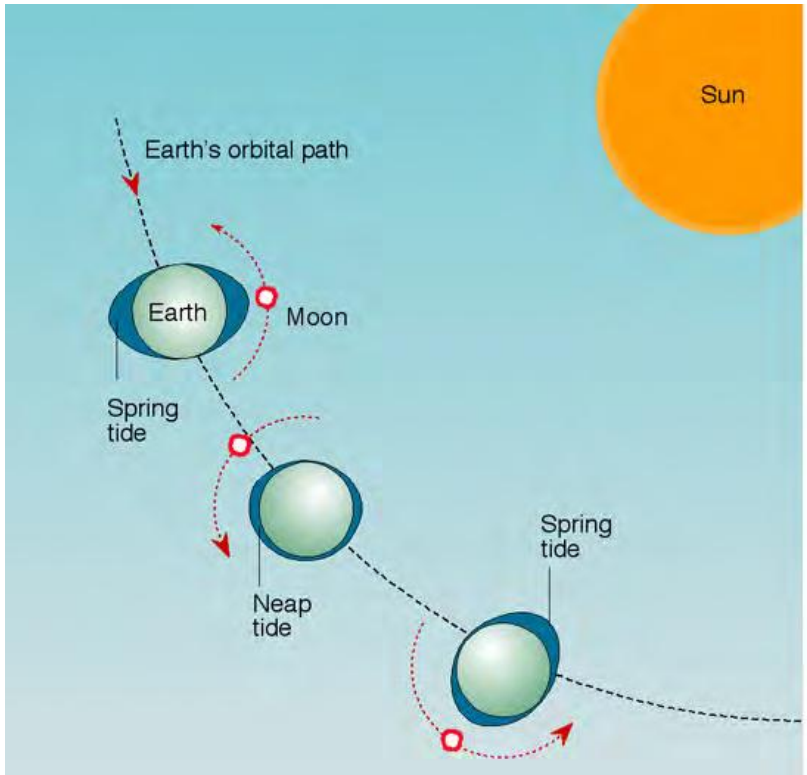
These tides occur when the Moon is in full or new Moon phases.

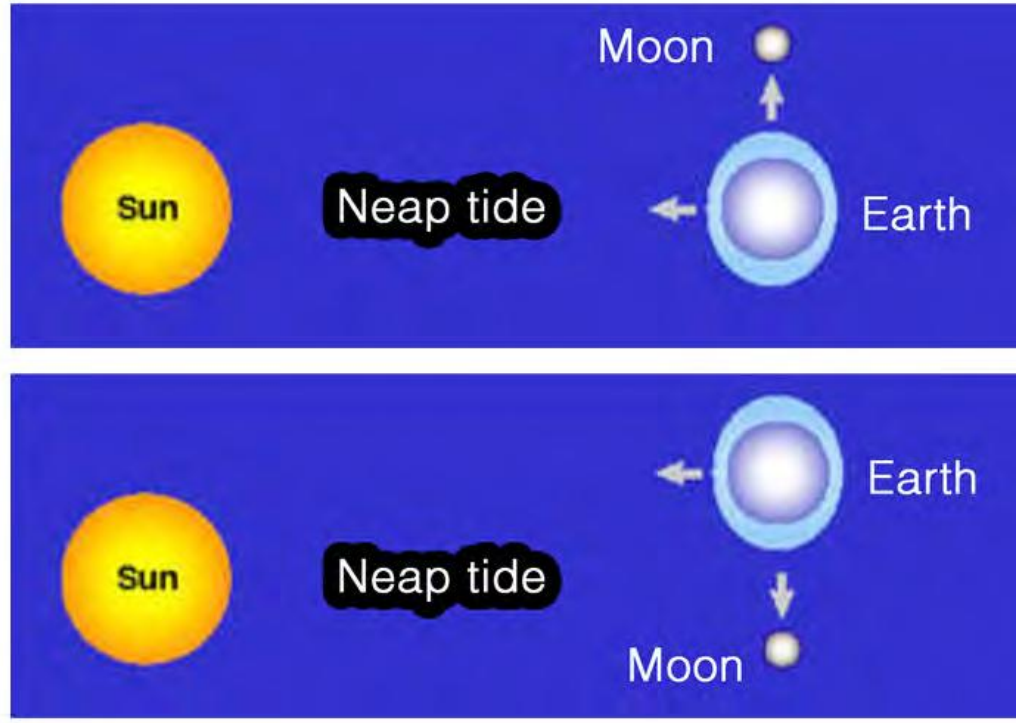


Spring tides

Illustration Bob Moffatt

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. These are smaller tidal ranges (low highs and high lows).



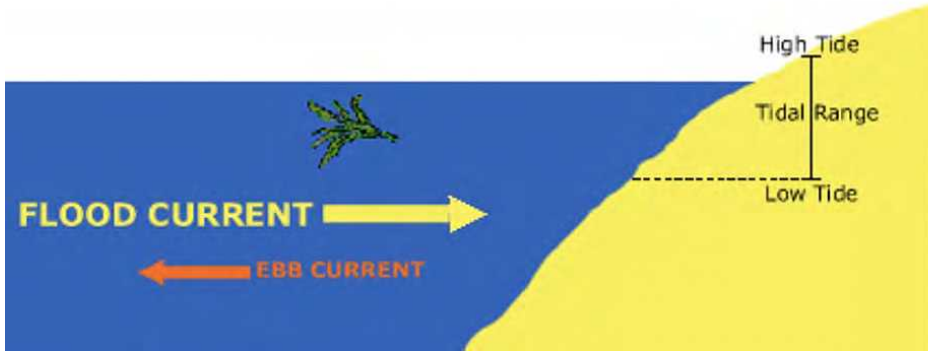


Neap tides

Illustration Bob Moffatt

Flooding and ebbing tides create currents.

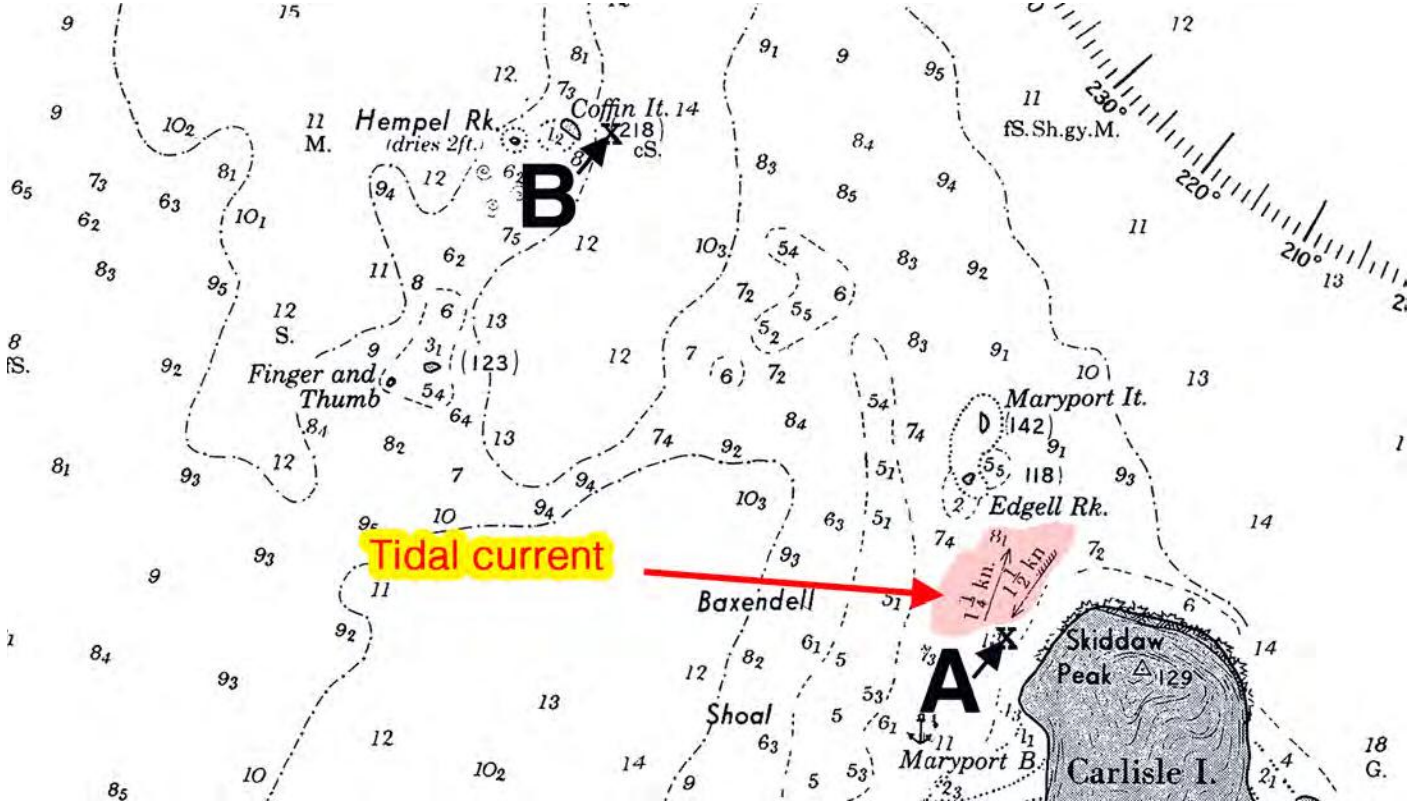
You can read more at
https://oceanservice.noaa.gov/education/tutorial_currents/02tidal1.html



Tide flood and ebb currents
https://oceanservice.noaa.gov/education/tutorial_currents/02tidal1.html

Current strength

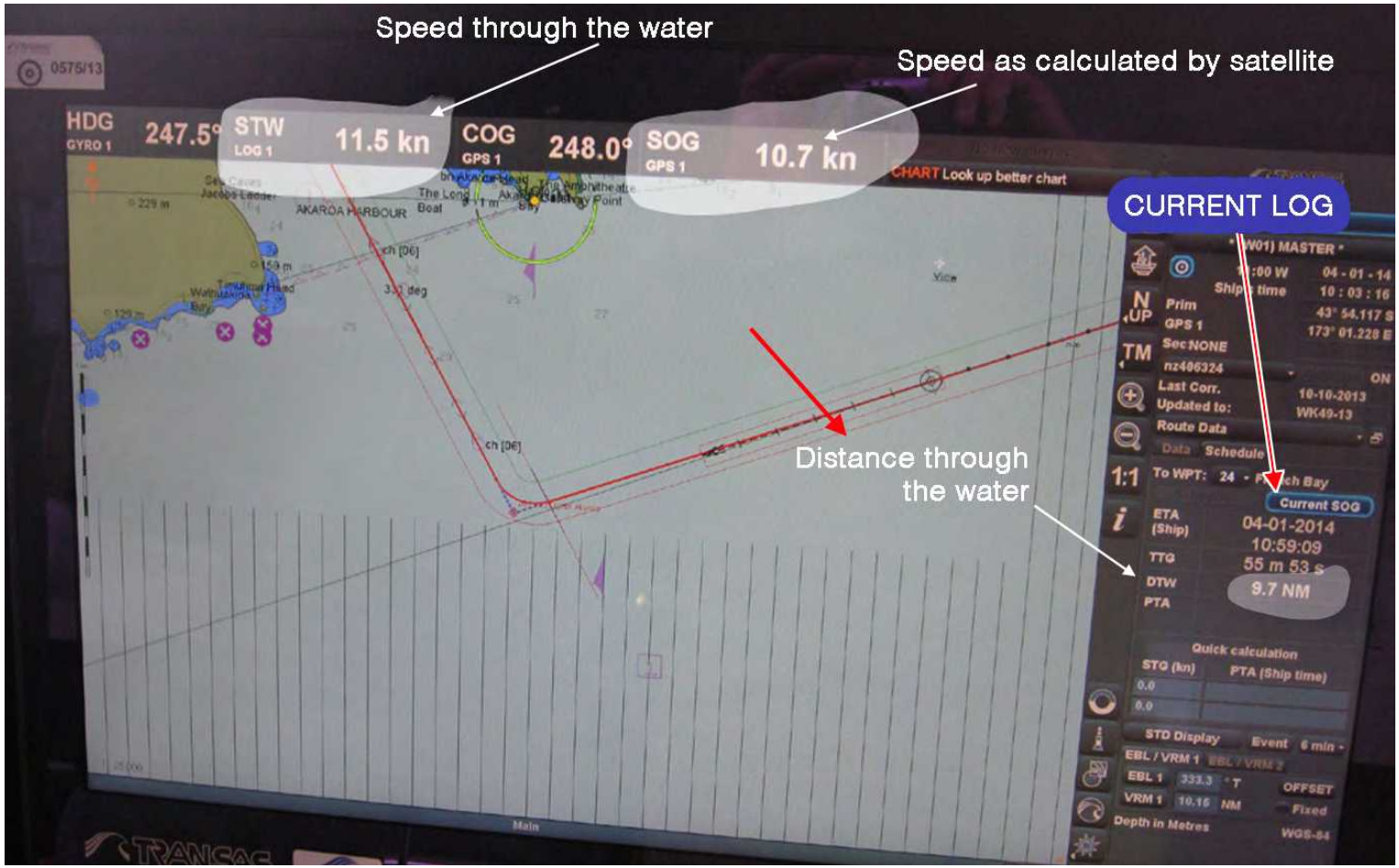
In areas with large tidal ranges or experiencing storms, currents form and flood and neap tides can flow in many different directions due to the ocean topography.



Hillsborough Chart tidal current

Credit: Hydrographer for the Navy

This can effect a ships speed through the water and accurate constant readings need to be taken when entering ports.



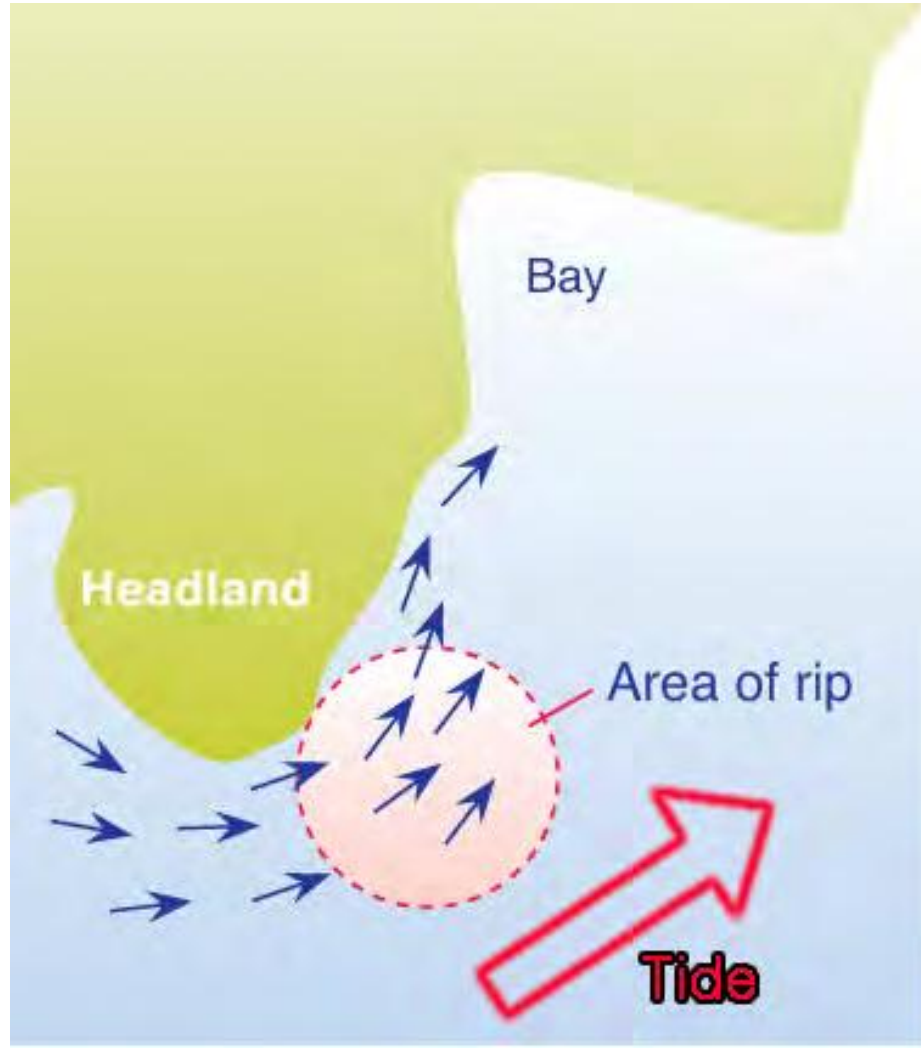
Effect of tidal currents on navigation

Photo 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.

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

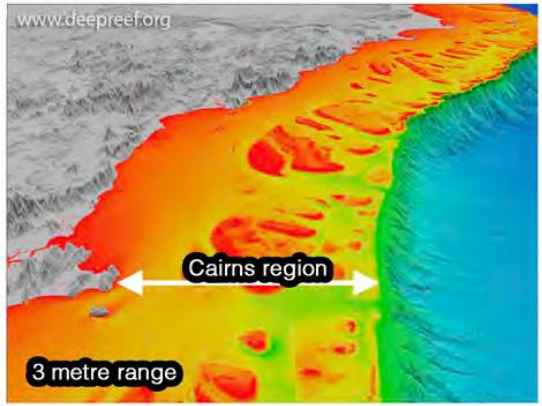


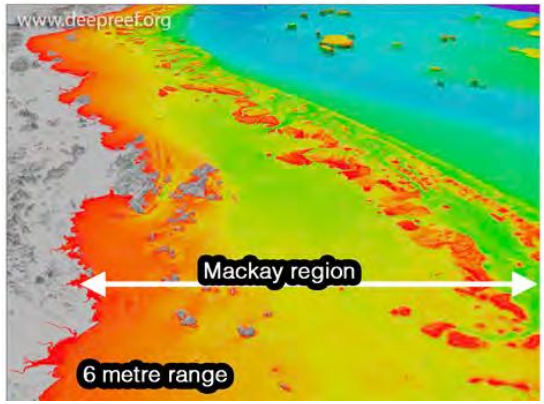
Headland rips and tides

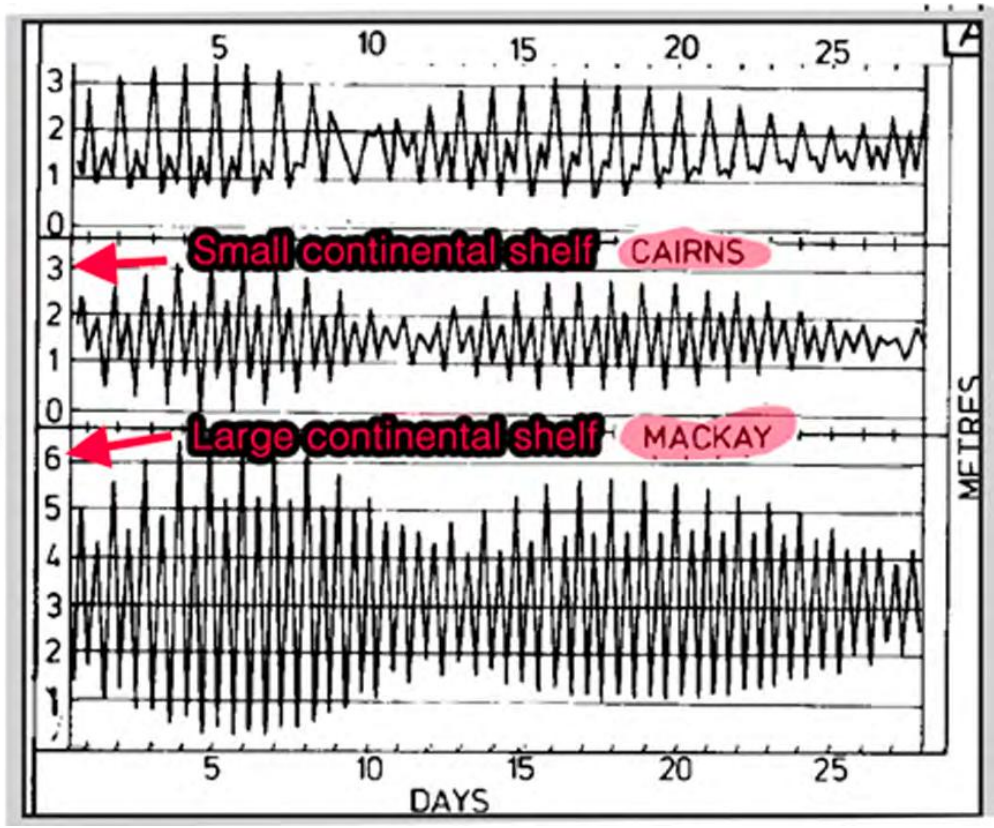
Illustration Bob Moffatt

Wave action

In Queensland, the tidal range can play a big factor in tidal stream creation, as the tide wave moves over different areas of the continental shelf.



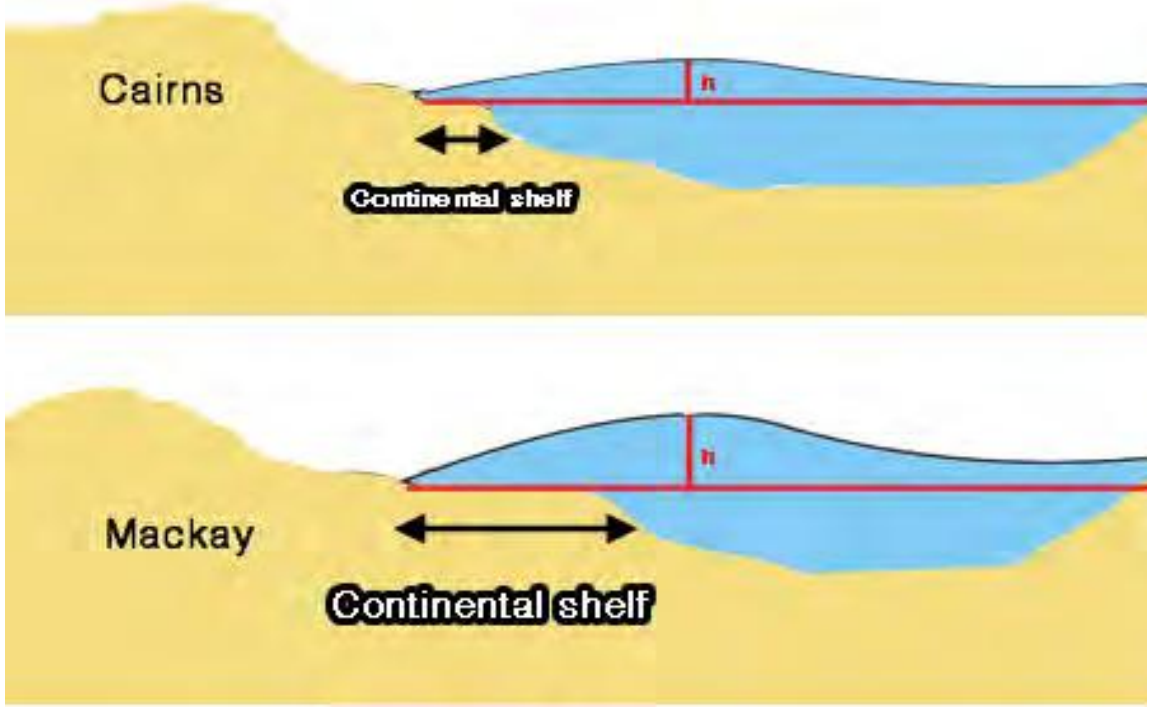




Tide comparisons Cairns Mackay

https://www.deepreef.org/bathymetry/65-3dgbr-bathy.htmlBeaman, R.J., 2010. Project 3D-GBR: A high-resolution depth model for the Great Barrier Reef and Coral Sea. Marine and Tropical Sciences Research Facility (MTSRF) Project 2.5i.1a Final Report, MTSRF, Cairns, Australia, pp. 13 plus Appendix 1. Tides graphs Bureau of Meteorology

The tidal range in Mackay is much greater than that of Cairns because of the larger length of the adjacent continental shelf.



Cairns – Mackay tide comparison

Illustration Bob Moffatt

You can read more at

Tides and the continental shelf
https://www.americanscientist.org/sites/americanscientist.org/files/2005428111736_306.pdf

Large waves in storms can cause tidal (storm surges) surges.

This is because the sea level rises due to lower pressure of the cyclone above or near the shore.

Storm surge and tides
http://www.bom.gov.au/cyclone/about/stormsurge.shtml

You can read more at
http://www.bom.gov.au/cyclone/about/stormsurge.shtml

Question

How does each of the following affect tides?

A. Gravitation pull

B. Current strength and

C. Wave action

Use diagrams to illustrate your answer.

T014 Sand movements

Syllabus statement

At the end of this topic you should be able to

Define

sand budget and longshore drift.

Define

- give the meaning of a word, phrase, concept or physical quantity;

- state meaning and identify or describe qualities.

Question

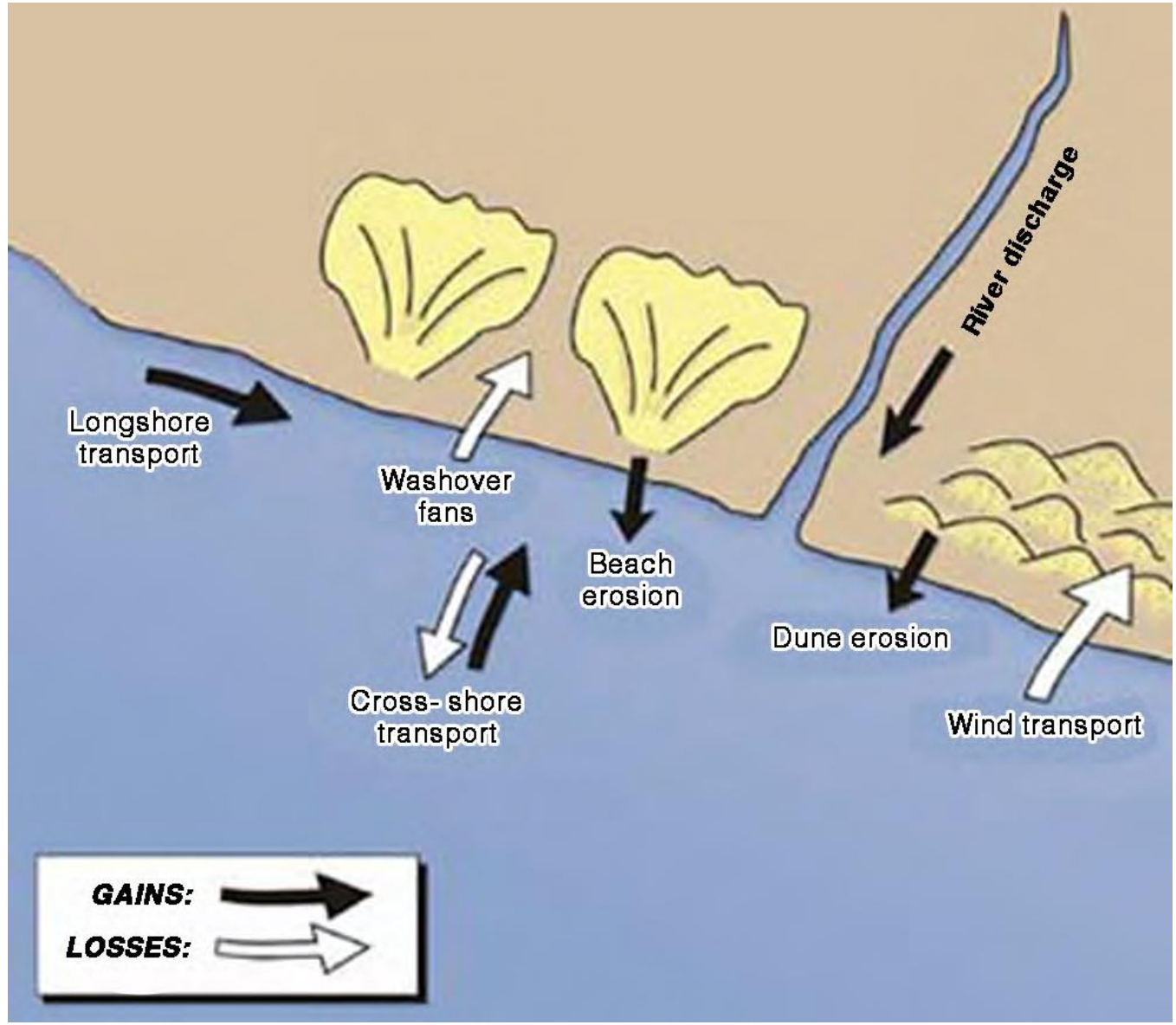
State meaning of following terms and giving examples of where they occur on our coastline

A. Sand budget

B. Longshore drift

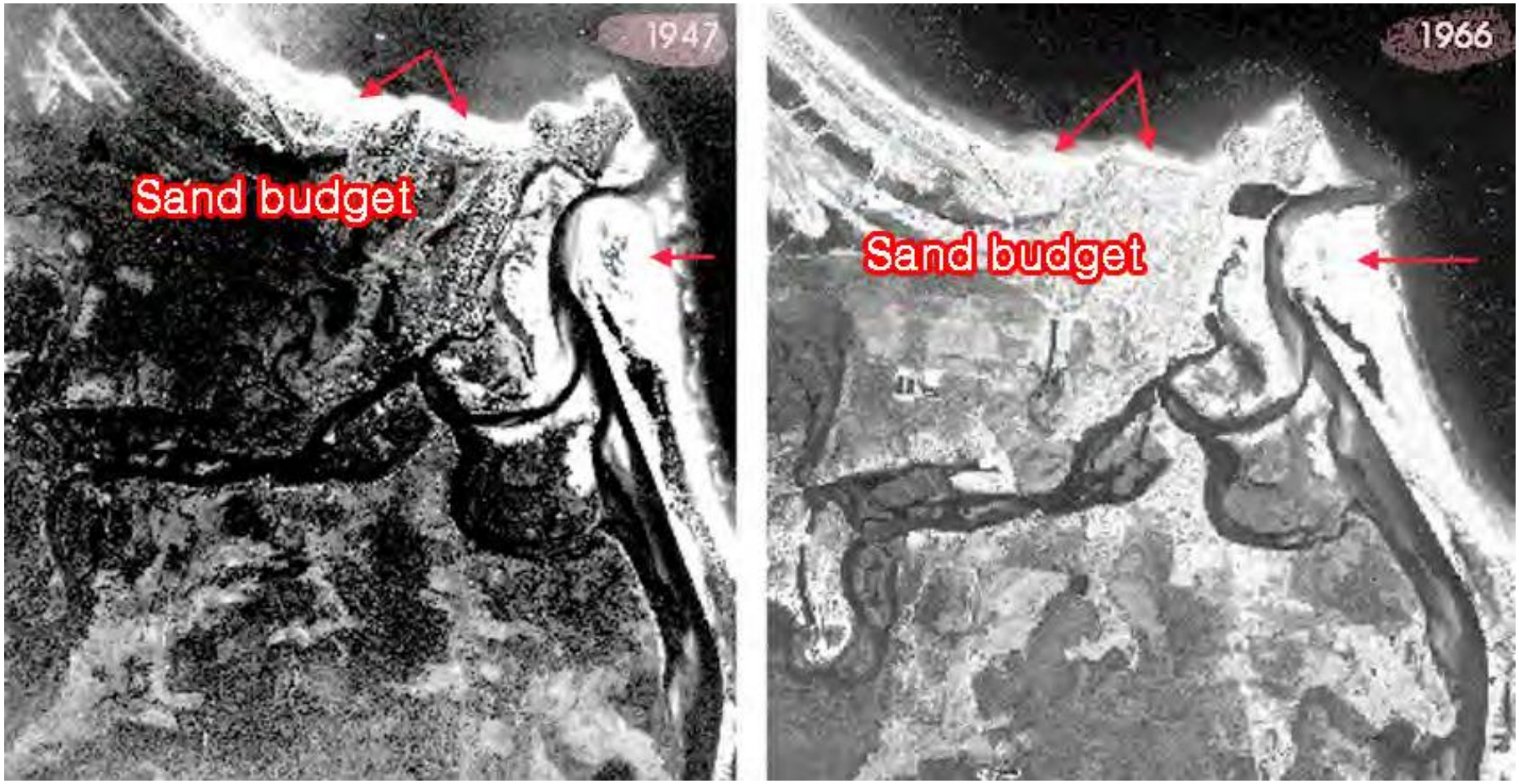
Sand budget

A sedimentary (or sand) budget is a coastal management tool used to analyze and describe the different sediment inputs (sources) and outputs (sinks) along our coastline.



Sand budget

Budgets are used to predict changes in any particular coastline over time.



Southern Gold Coast 1947 1969

Photos Geoscience Australia

Within a coastal environment the rate of change of sediment is dependent on the amount of sediment brought into the system versus the amount of sediment that leaves the system.

Sand entering and leaving

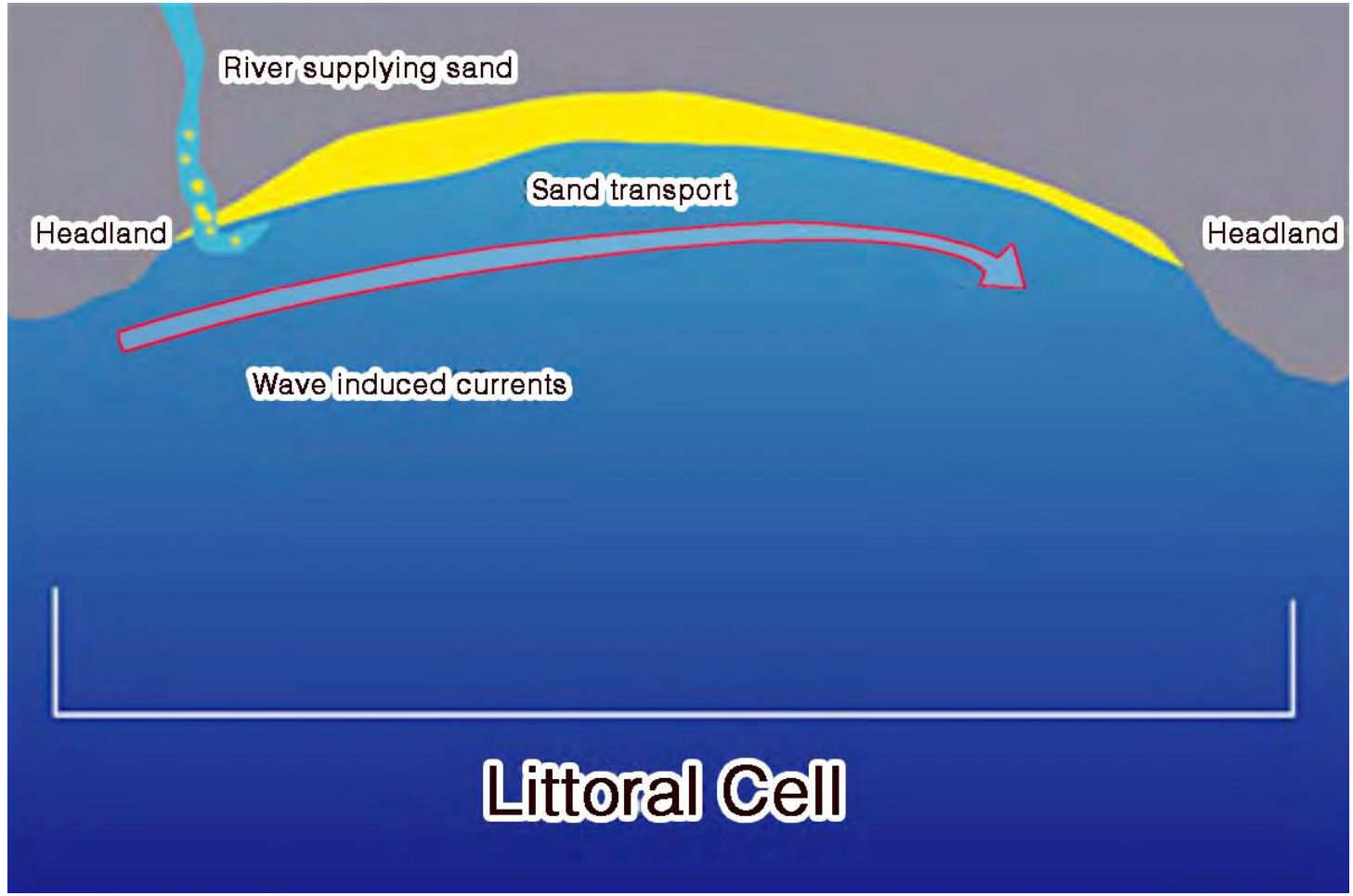
Photo Geoscience Australia

These inputs and outputs of sediment then equate to the total balance of the system and more than often reflect the amounts of erosion or accretion affecting the shape of the coastline.

Sand dune erosion and accretion

Photo Bob Moffatt

To assess the sedimentary budget the coast has to be divided into two separate morphologies, commonly known as littoral cells and compartments.



Littoral cell

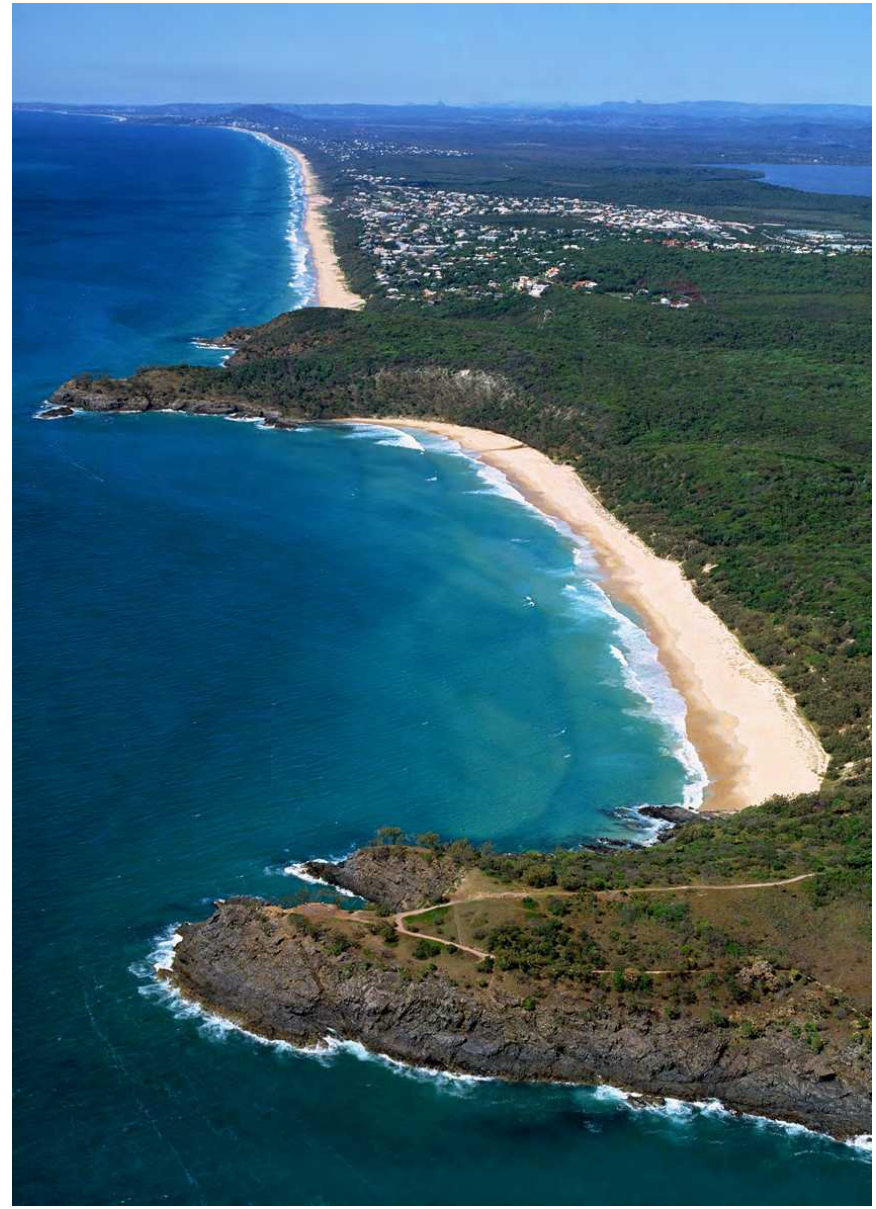
Illustration Bob Moffatt and NOAA

Littoral cells can either be free or fixed and can occupy a hierarchy of scales, from individual rip cells to entire beaches.

Currumbin estuary with sand cells

Photo Murray Waite and Viewfinder

Sediment compartments can usually be defined as two rocky barriers which mark the ends of a beach and have a fixed sediment budget, although usually leaky to some extant.



Alexander Bay Noosa

Photo Murray Waite and Viewfinder

There are various types of natural sources and sinks within a coastal system.

Sediment sources can include river transport.

Rivers as a sediment source

Photo Bob Moffatt

Sediment sources can include sea cliff erosion.

12 Apostles

Photo Tourism Victoria

Sediment sources can include longshore drift into an area.

Longshore drift - sediment source

Photo Bob Moffatt

Sediment sinks can include longshore drift of sediment away from an area and sediment deposition into an estuary.

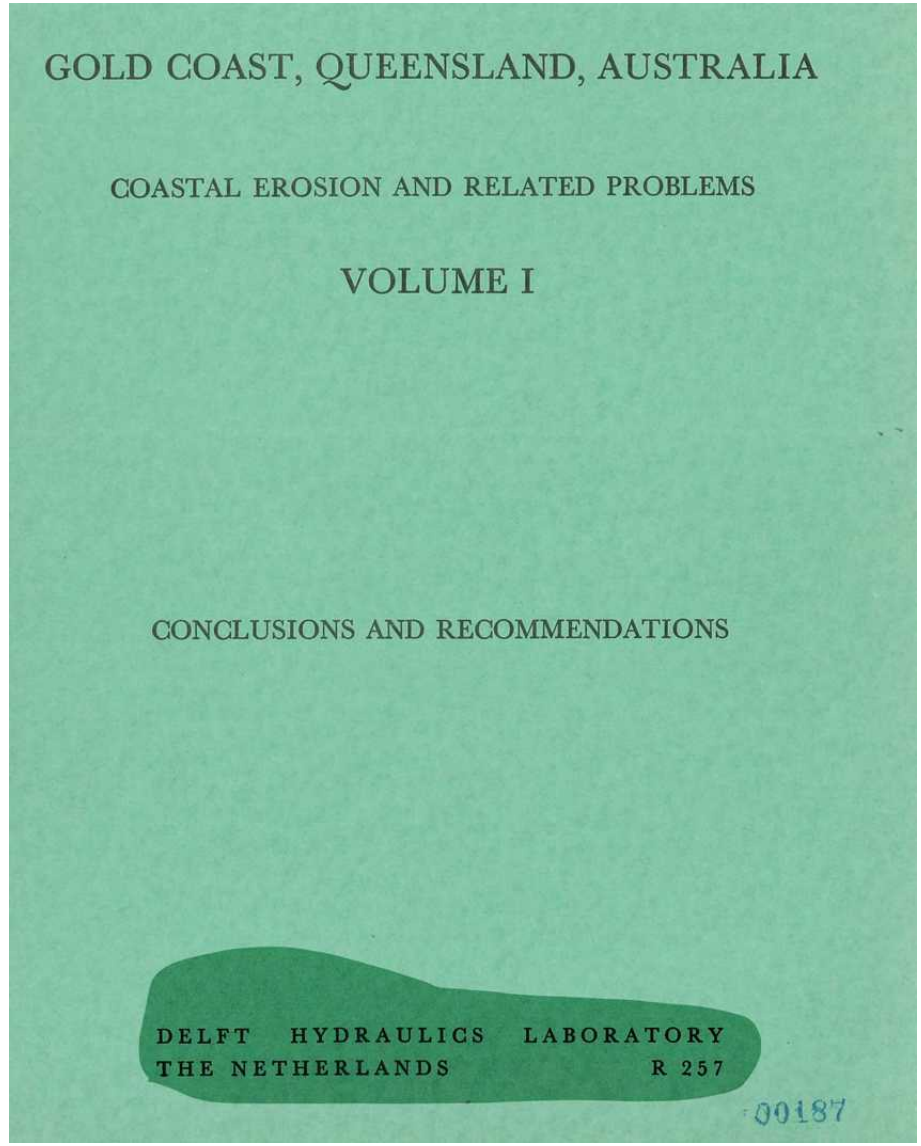
Sediment sinks Bustard Head

Photo Bob Moffatt

In one Australian State, studies have shown that 500,000 cubic metres of sand move in the sand system each year.

The amounts will vary and depend on the energy that the beach experiences.

High-energy beach systems will move more sand than low energy sand systems.



Delft report cover

http://www.goldcoast.qld.gov.au/documents/bf/coastal-erosion-related-problems-vol1.pdf

Anthropogenic activities can also influence sedimentary budgets.

In particular, engineering solutions such as building groynes or development including building of houses on sand dunes.

Kirra beach 2008, 1994

Photos Bob Moffatt

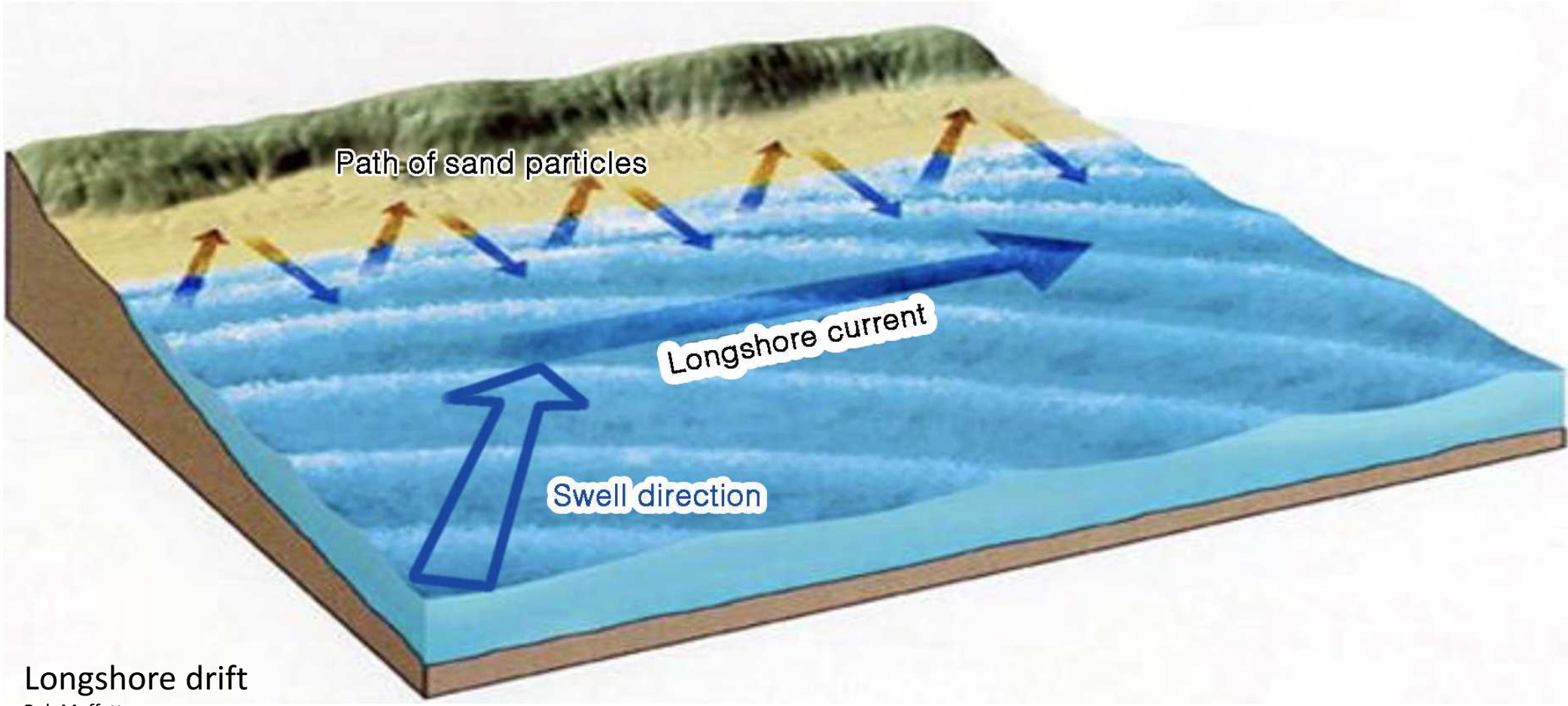
In contrast beach nourishment can increase sediment source.

Dredge Kirra
Photo Bob Moffatt

You can read the full article at
https://en.wikipedia.org/wiki/Sedimentary_budget

Longshore drift

Longshore drift is a geological process that consists of the transportation of sediments (clay, silt, sand and shingle) along a coast parallel to the shoreline, which is dependent on oblique incoming wave swell direction.

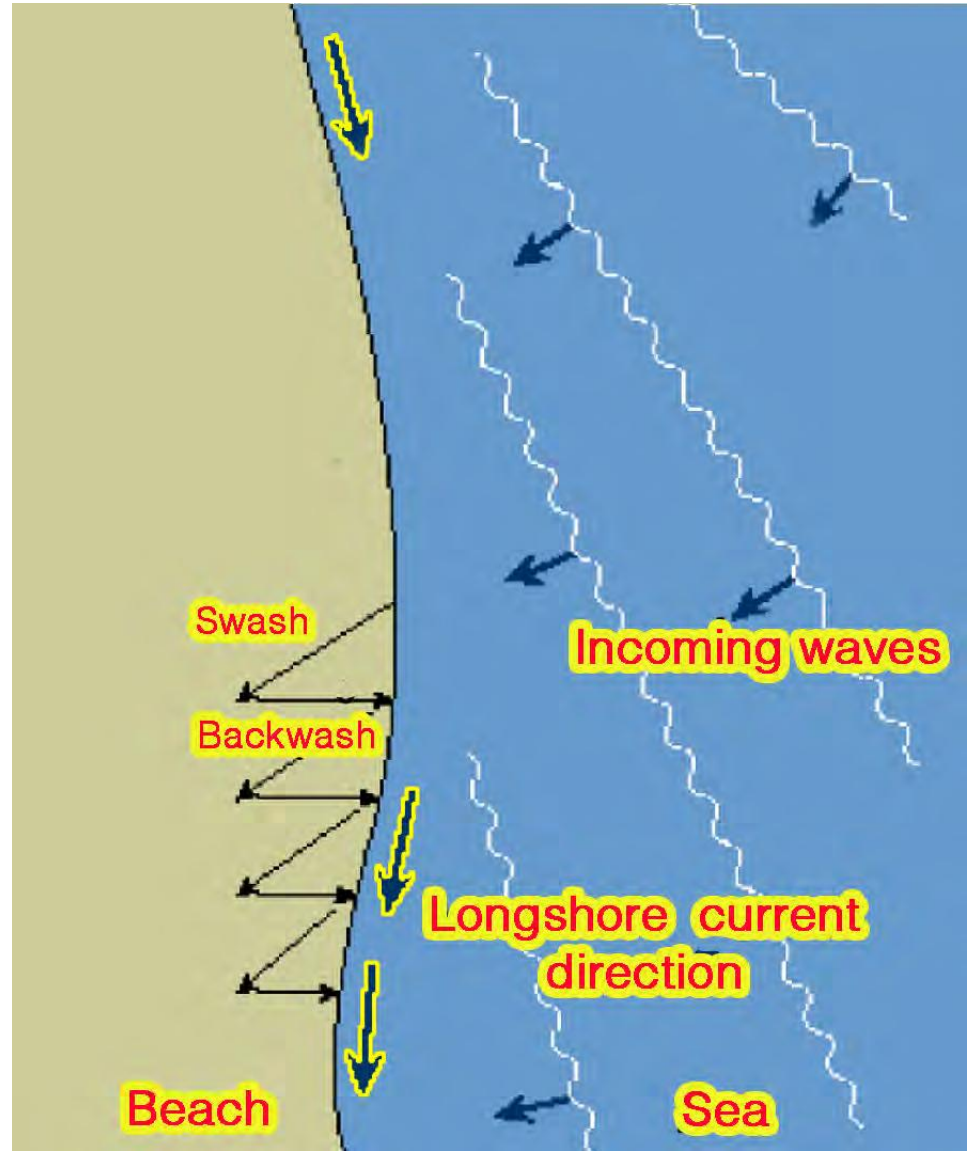


Longshore drift

Bob Moffatt

Oblique incoming wind squeezes water along the coast, and so generates a water current which moves parallel to the coast.

Longshore drift is simply the sediment moved by the longshore current.



Longshore drift

By USGS/USGov, modified by Eurico Zimbres - http://commons.wikimedia.org/wiki/Image:Longshore.gif, Public Domain, https://commons.wikimedia.org/w/index.php?curid=826142

This current and sediment movement occur within the surf zone.

Surf zone

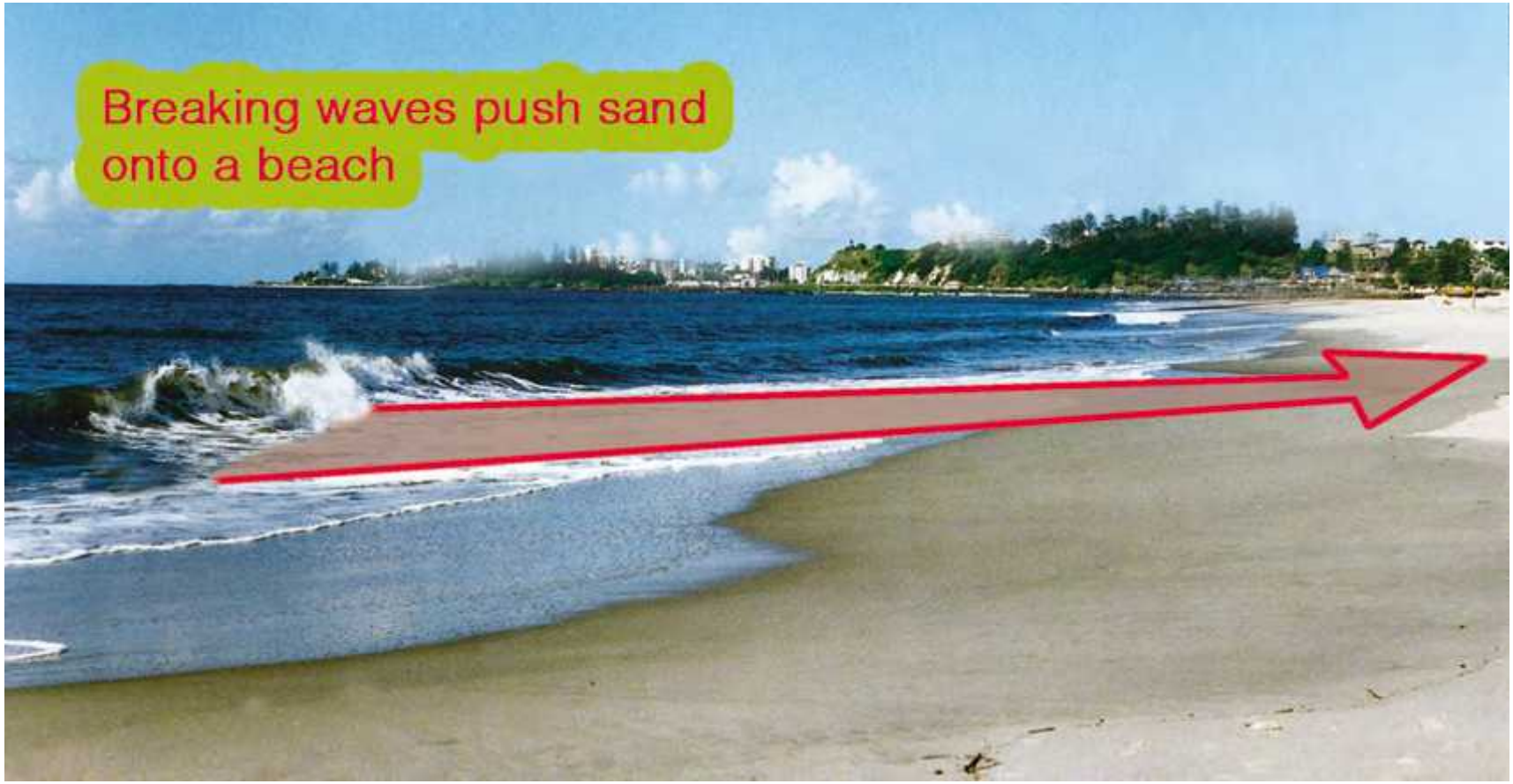
Photo Bob Moffatt

Beach sand is also moved on windy days, ending up on the opposite side of the wind's direction.

Sand blows along a beach

Photo Bob Moffatt

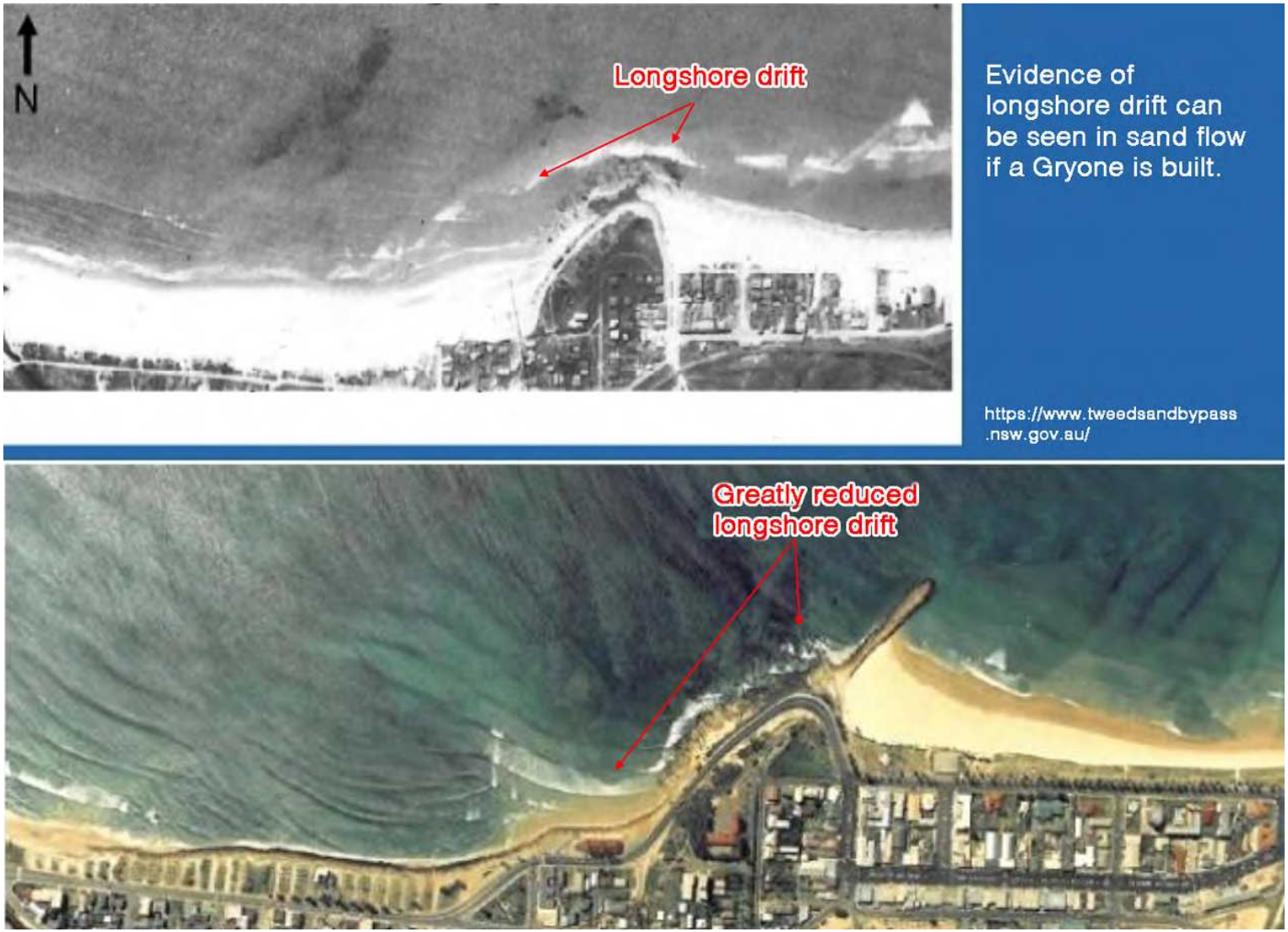
Breaking surf sends water up the beach (swash) at an oblique angle and gravity then drains the water back to the sea.



Breaking wave pushes sand onto a beach
Photo Bob Moffatt

You can read the full article at
https://en.wikipedia.org/wiki/Longshore_drift

Evidence of longshore drift movement of sand has be seen at Kirra on the Gold Coast when a groyne was built.



Evidence for longshore drift

Photos NSW Illustration Bob Moffatt
https://www.tweedsandbypass.nsw.gov.au/

Questions

What do the terms sand budget and longshore drift mean?

Give examples of each from your local beach.

T015 Wave definitions

Syllabus statement

At the end of this topic you should be able to … **define** refraction, reflection and diffraction.

Define

- give the meaning of a word, phrase, concept or physical quantity;

- state meaning and identify or describe qualities.

Question

Define the following terms giving examples of their relevance to coastal planning and recreation.

A. Refraction

B. Reflection

C. Diffraction

Syllabus definitions

Refraction a property of wave interference whereby the wave changes direction after passing from one medium to another (i.e. deep to shallow water).

Reflection a property of wave interference whereby the wave changes direction after bouncing off a barrier.

Diffraction a property of wave interference whereby the wave changes direction after passing through an opening or around a barrier.

Explanation

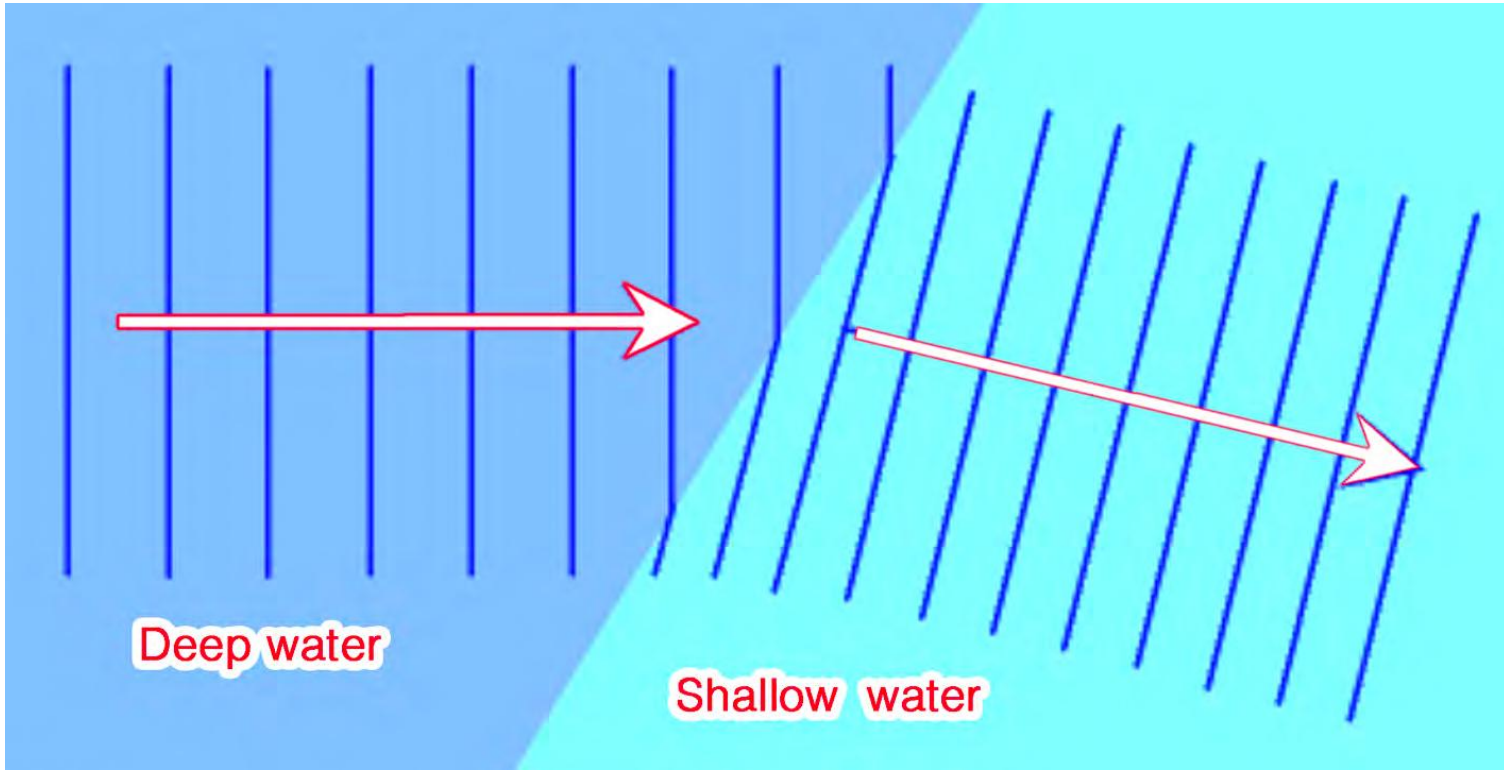
Refraction in the ocean is the change in direction of waves that occurs when waves travel from deep to shallow water.

Reflection of ocean waves is the change in direction of a wavefront as it strikes something in the water and so that the wavefront returns to the water.

Diffraction of ocean waves is the bending of waves around obstacles and openings

Refraction

As waves pass into shallow water they slow down, increase in wave height and decrease in wavelength.



Waves from deep to shallow water

Illustration Bob Moffatt

This effect is called refraction and occurs around headlands.

Waves refract around a headland

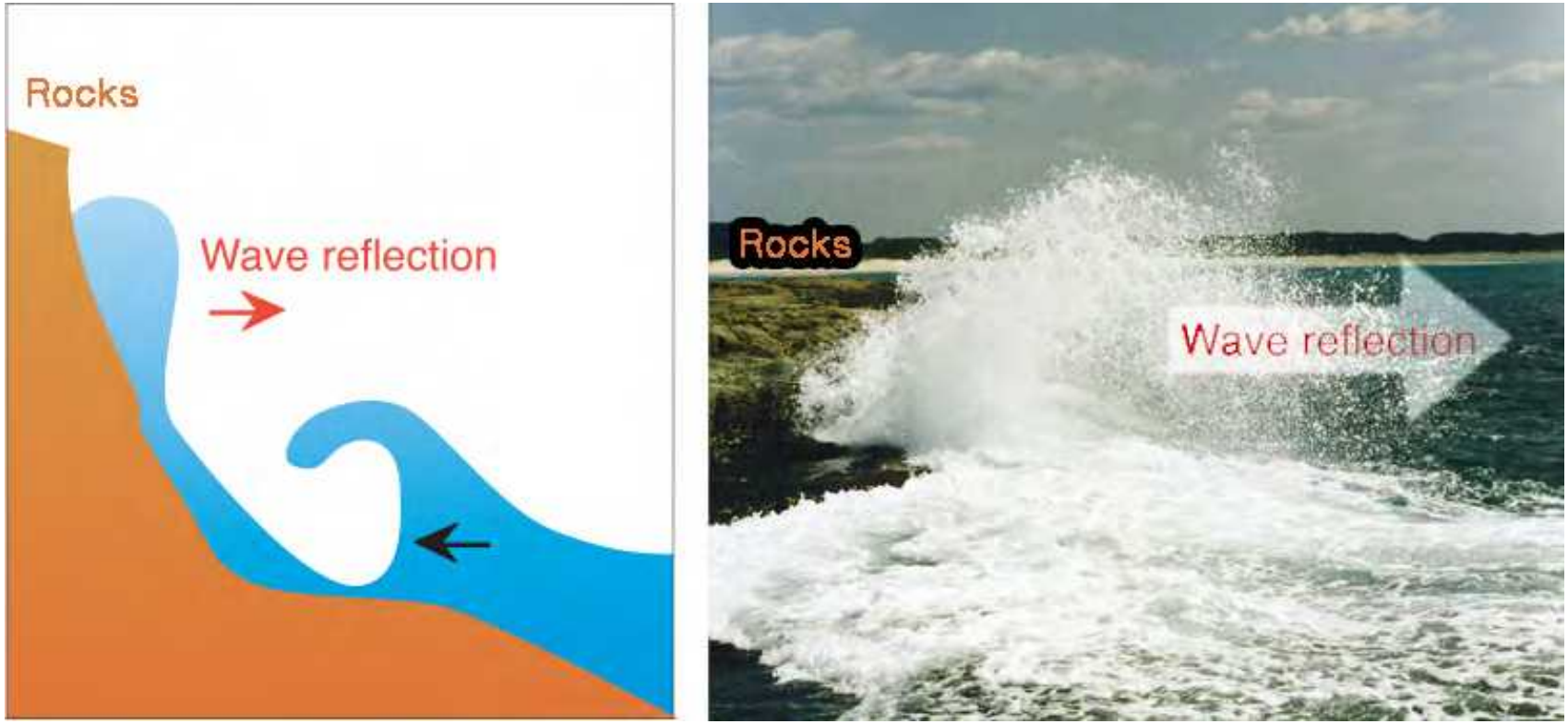
Photo Bob Moffatt

Waves refract around a headland

Photo Geoff Jensen

Reflection

A wave which bounces straight back on itself after striking an object straight on is called a reflected wave.



Wave reflection

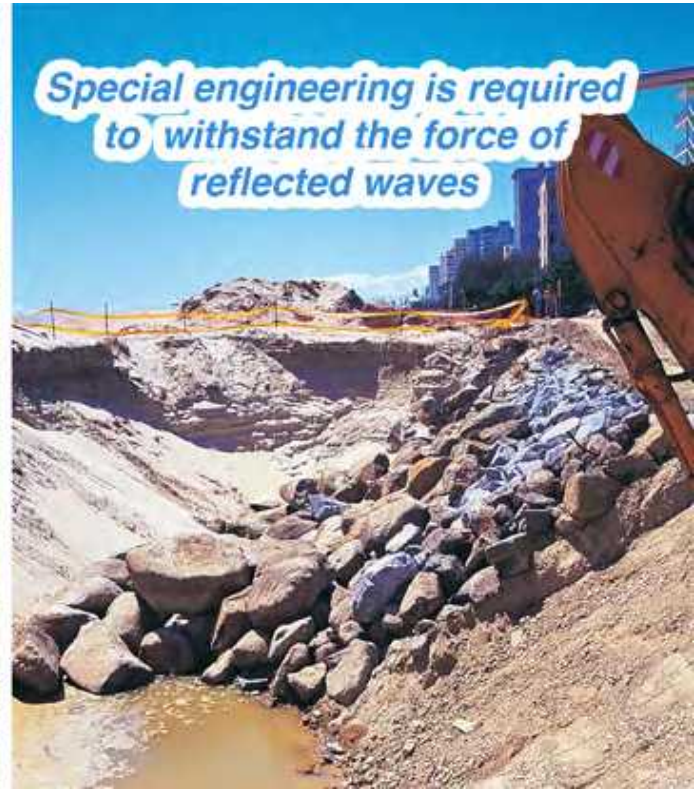
Photo and illustration Bob Moffatt

Large storm waves travelling from deep water striking headlands expend a tremendous amount of energy on the structures they hit.

Storm waves reflect

Photo Tim Ryan

Boulder walls constructed to protect essential services along beach fronts such as power cables and water pipes need special engineering to withstand these forces.



Boulder walls and reflected waves

Photo Bob Moffatt

This reflection often results in the shaping of headlands to form wave cut platforms.

Bells Beach in Victoria, is an example of a platform cut by reflected waves.

Bells Beach

Photo Joli photography

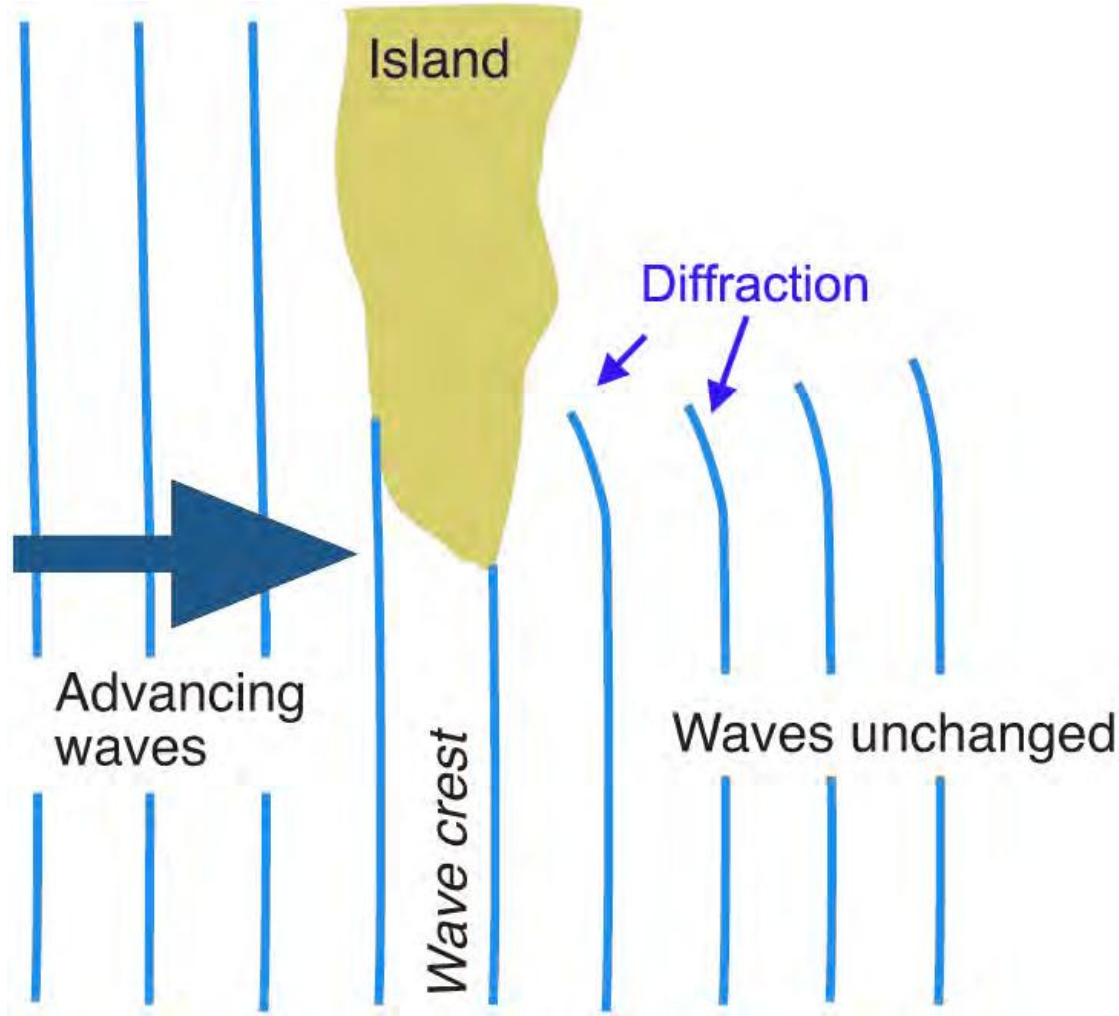
Diffraction

The apparent bending of waves around a sharp point or the spreading out of waves in a bay is called diffraction.

Wave diffraction examples

Photos Bob Moffatt

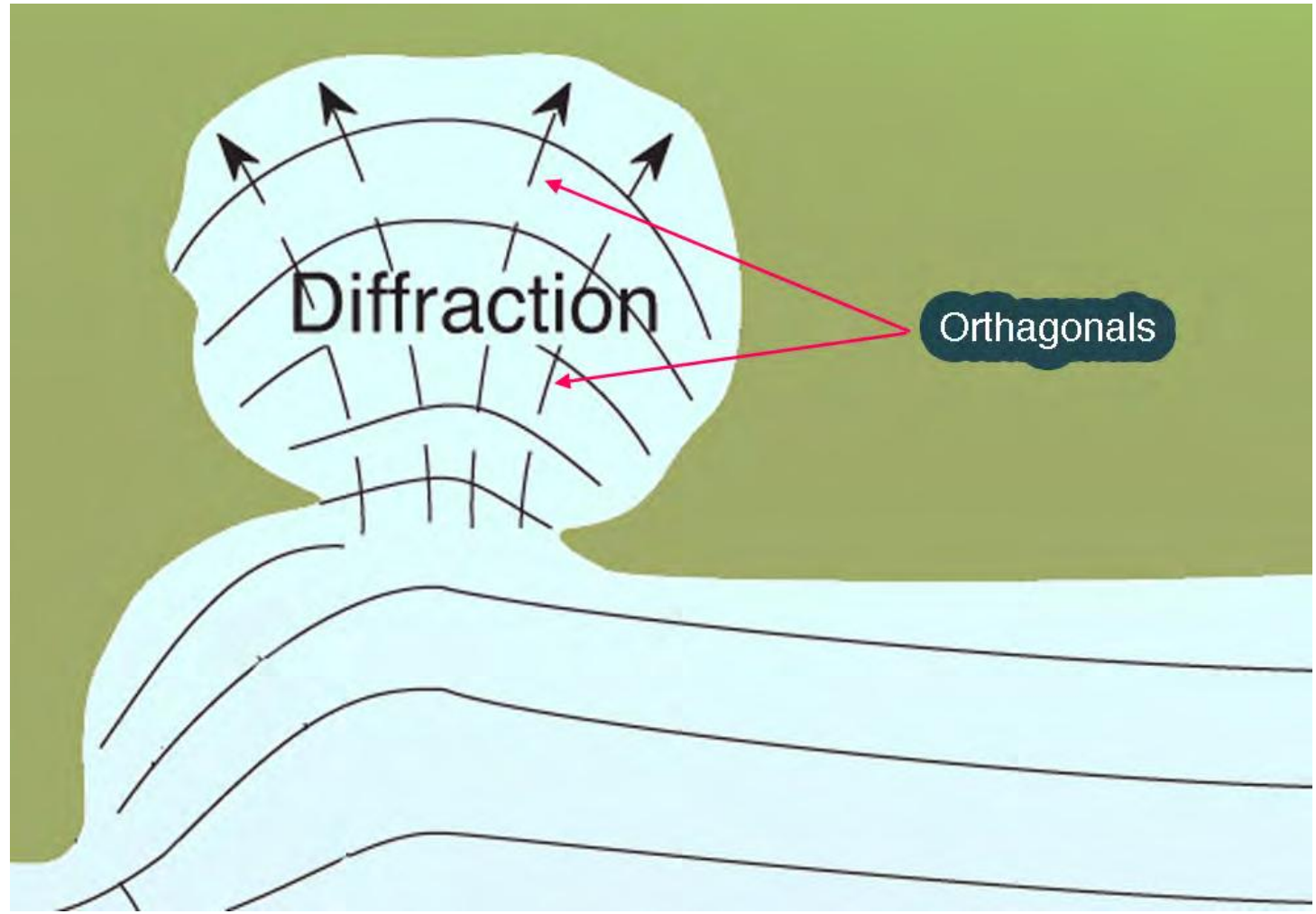
The wave turns due to changes in the wave height along the crest.



Wave diffraction

Illustration Bob Moffatt

The direction of spread by drawing lines at right angles to the wave crest, called **orthogonals**.



Orthogonals

Illustration Bob Moffatt

These orthogonals help coastal engineers plan boat harbour designs, rock walls, foreshore developments and beaches.

Boat harbour

Photo Bob Moffatt

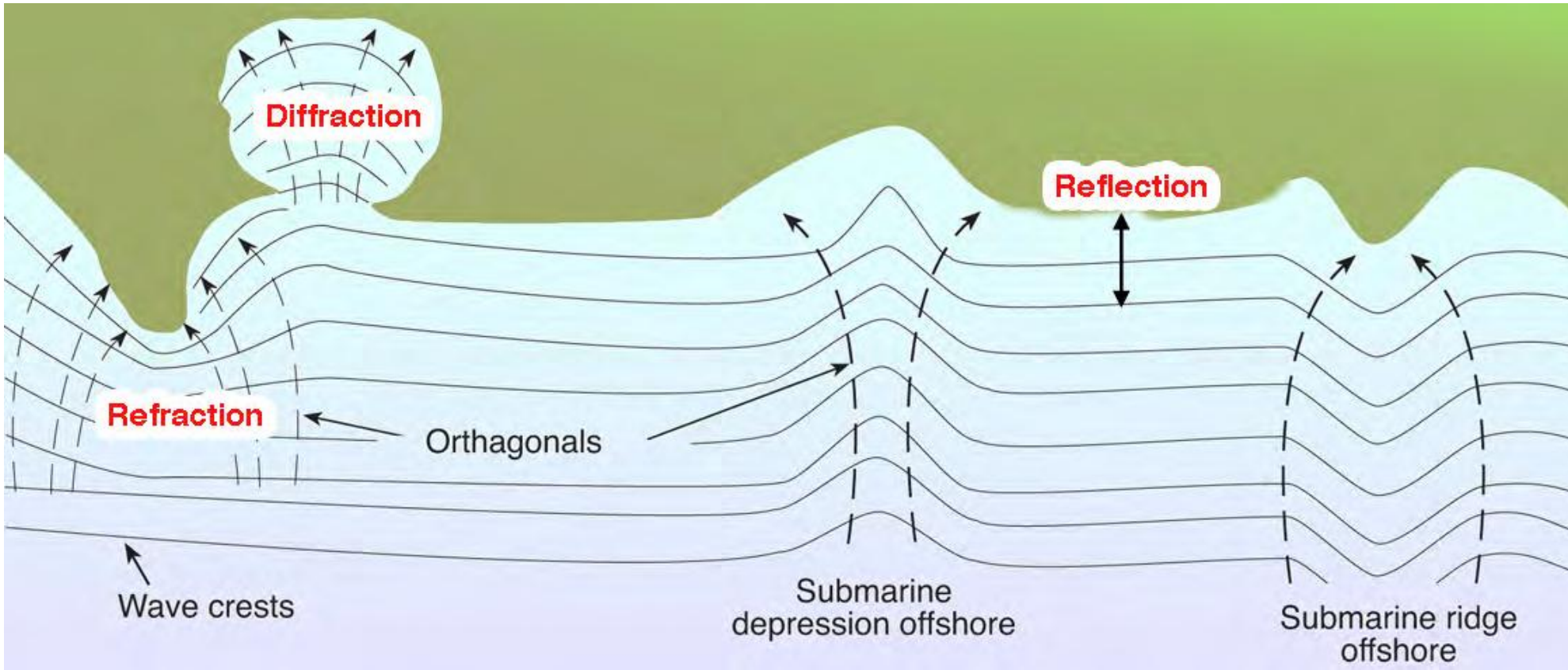
A safe berth should have very little wave action and hence the rates of diffraction need to be as small as possible.

You don’t want waves in a marina when embarking

Photo Bob Moffatt

Question 1:

Redraw this diagram in your notebook



Definitions summary

Illustration Bob Moffatt

Question 2:

The write a definitions for diffraction, reflection and refraction and list places on your local coastline where they occur.

T016 Material movements

Syllabus statement

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

Describe

the factors of wave action, wind and longshore drift

in

the management of the movement of water, nutrients, sand, sediment and pollutants (e.g. oil spills, debris)

Describe

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

Objective

Describe how waves, tides, longshore drift and wind manage the movement of the following along our coastline

A. Water

B. Nutrients

C. Sand

D. Sediment

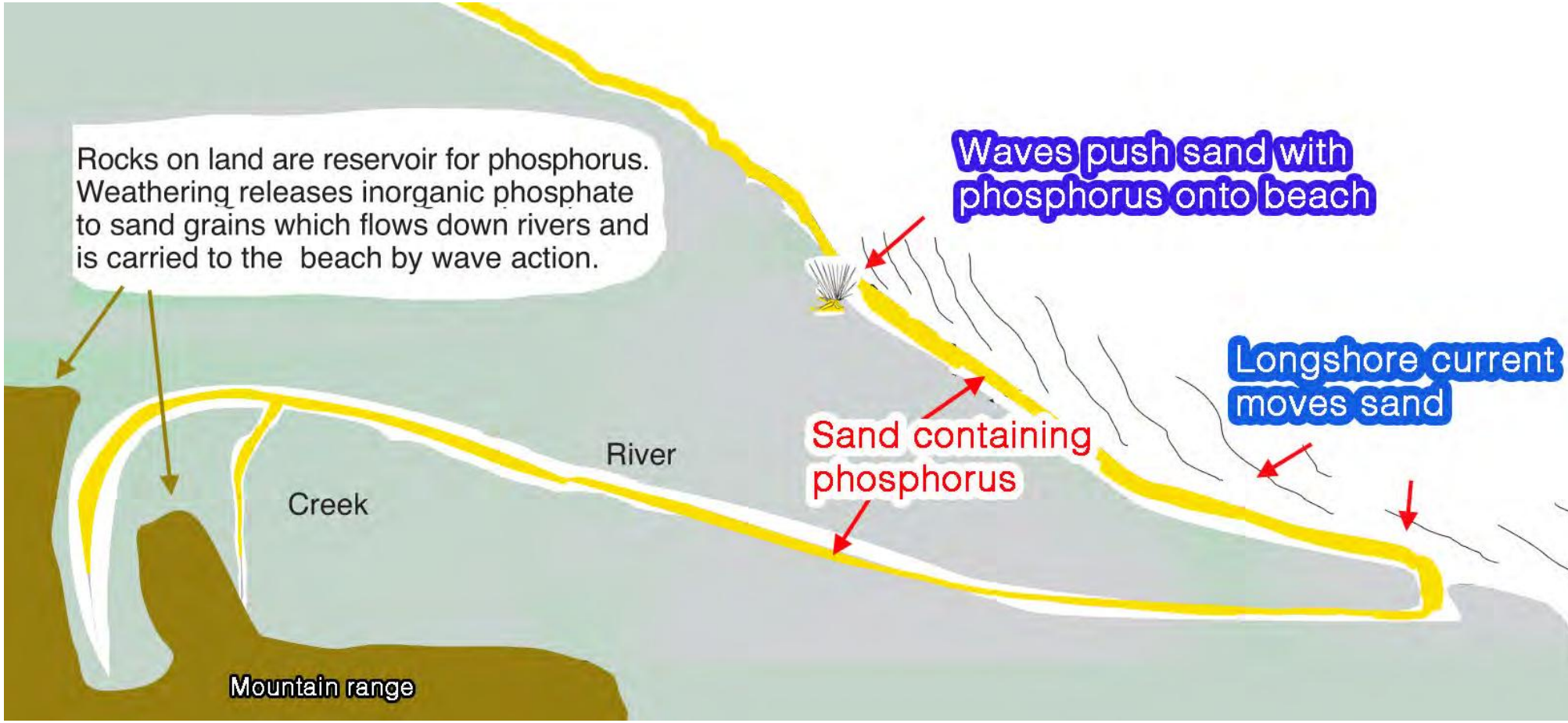
E. Pollution

Question

Summarise your account in a table.

Factor	Management of water movement	Management of nutrient movement	Management of sand movement	Management of sediment movement	Management of pollution movement
Wave action					
Longshore drift					
Wind					
Tides					

Many materials start in mountain ranges and are washed to the sea by river.
Big boulders are made smaller and end up as sand.
Minerals such as phosphorus are also washed down rivers.



Phosphorus and sand enters a beach system

Illustration Bob Moffatt

Wind can cause water to lump up if it blows onto the beach (called onshore)

Onshore surf conditions.

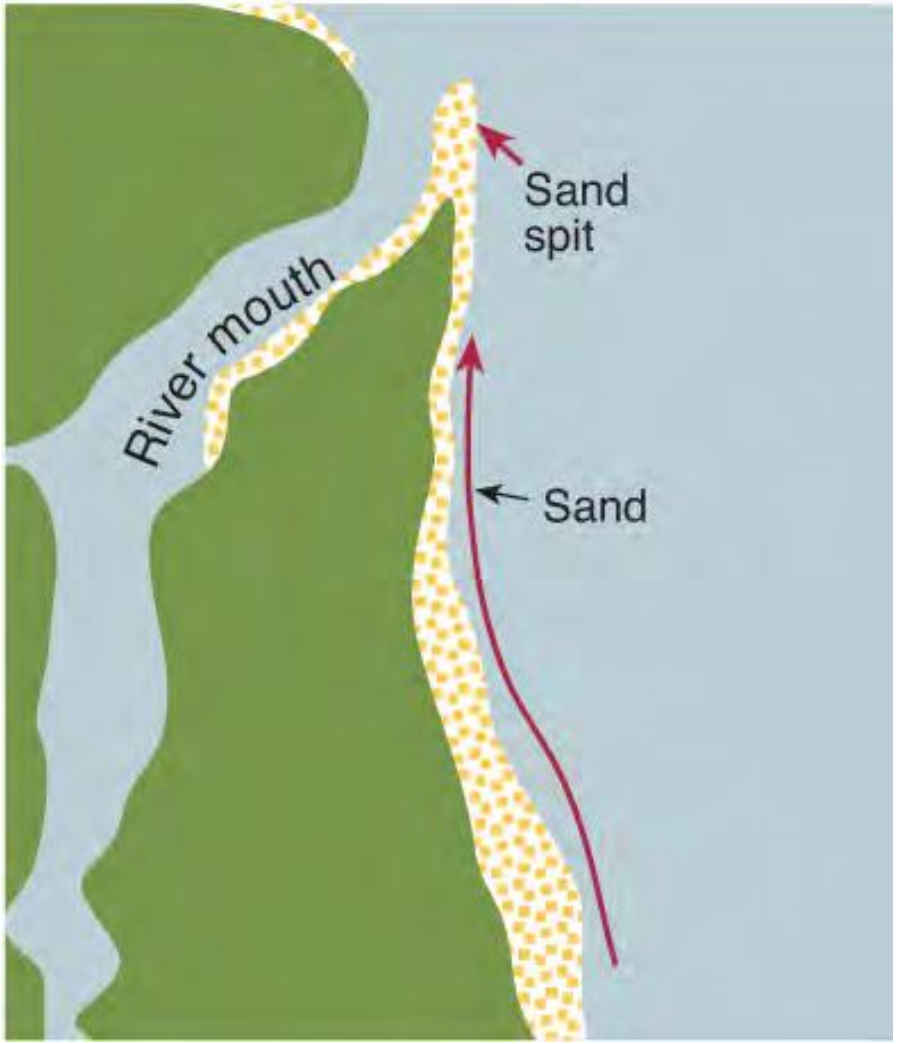
Photo: Bob Moffatt

Wind can cause water to smooth out if it blows away from the beach (called offshore)

Offshore surf conditions.

Photo: Bob Moffatt

Longshore drift moves sand along the coastline into spits and into estuaries.



Photos: Bob Moffatt and Qld Fisheries

Waves move water into an estuary

Photo: Bob Moffatt

Tides move water in and out of an estuary

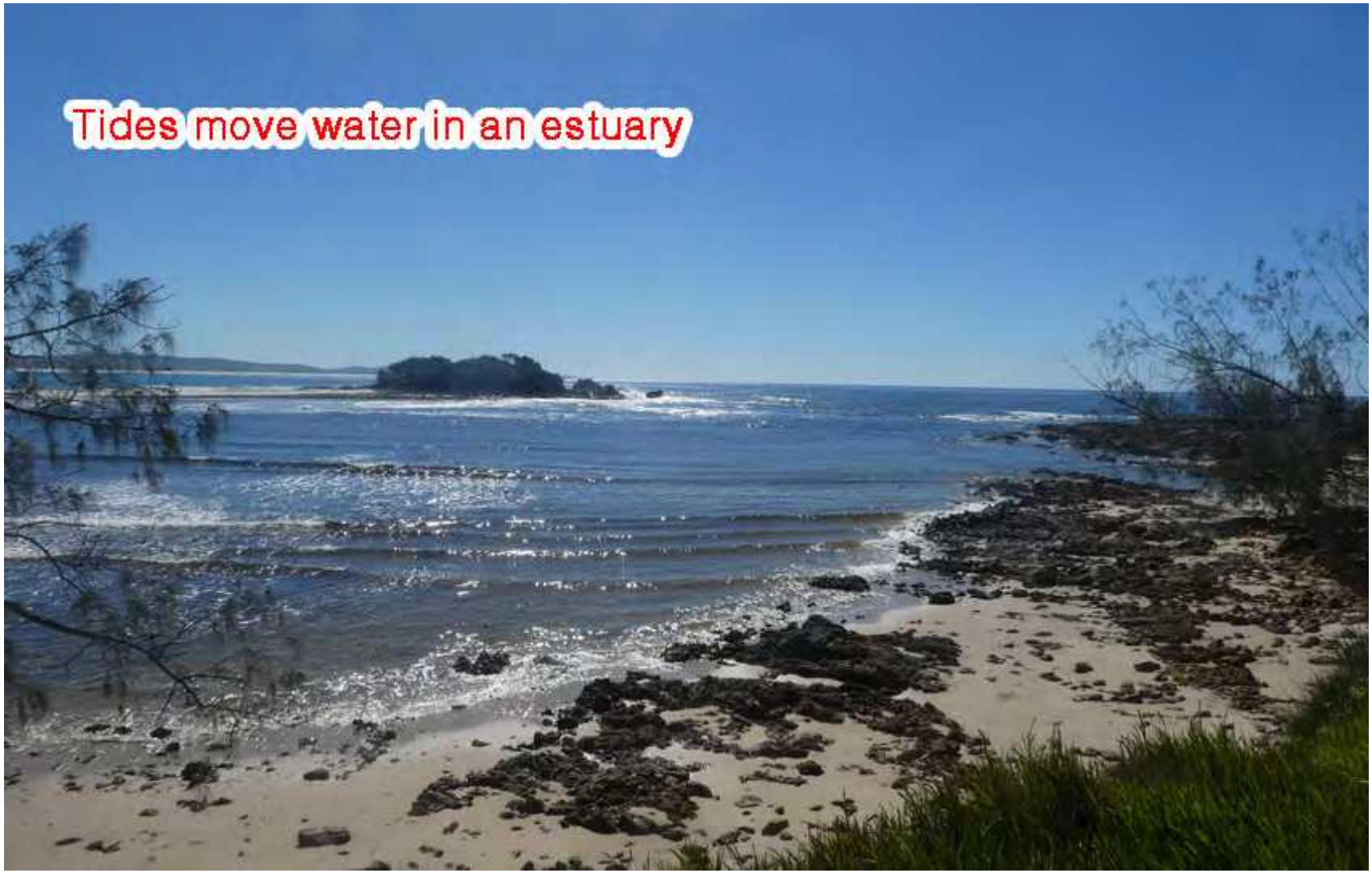
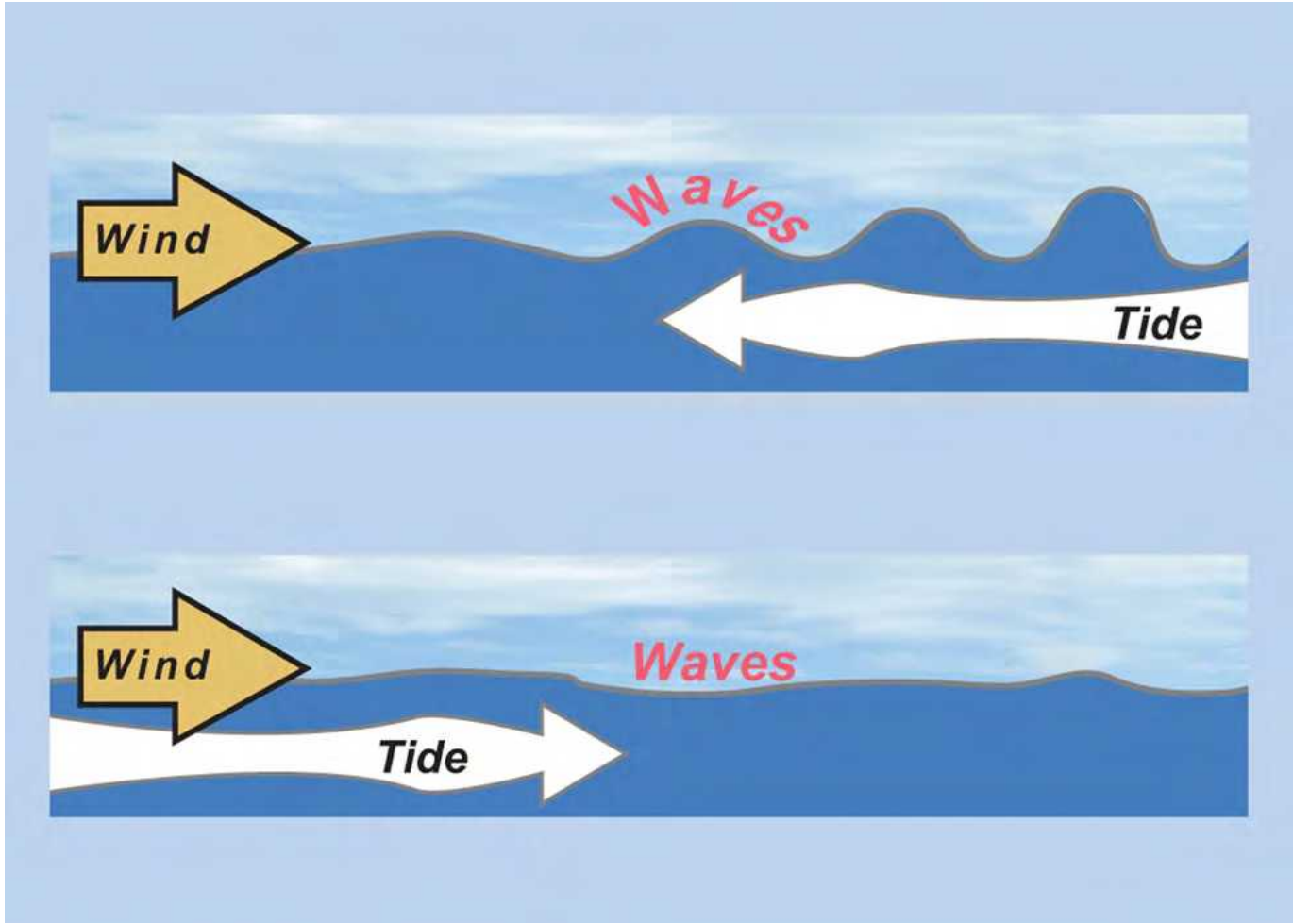


Photo: Bob Moffatt

When wind blows over these tides water to lumps up slowing nutrient movement

When wind blows with tides it flattens out waves making nutrients on the surface blow quicker.



Wind over tide

Bob Moffatt

Waves break over rocks bringing plankton (nutrients) for rock pool life (eg barnacles).

Waves move water into rock pools

Bob Moffatt

Planktonic larvae is food for barnacles as waves break over the rocks.

Barnacles feed on nutrients

Photo: Deep Voyage

Waves also move water into a reef lagoon bringing nutrients to reef organisms.

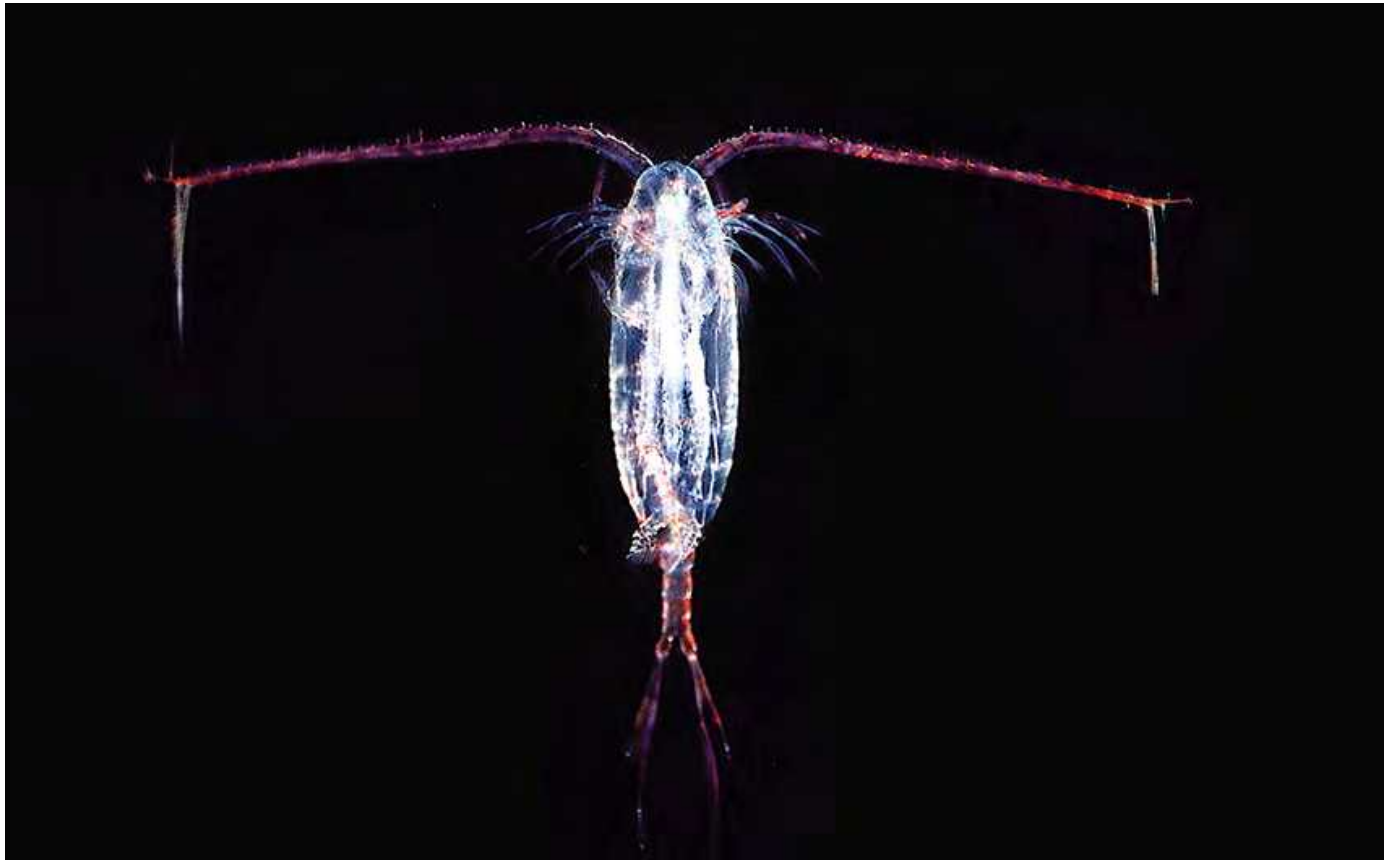
Waves move water into a reef lagoon.

Photo: Bob Moffatt

Longshore drift carries water and moves sediment along the coastline.

Longshore drift currents.
Photo: Bob Moffatt

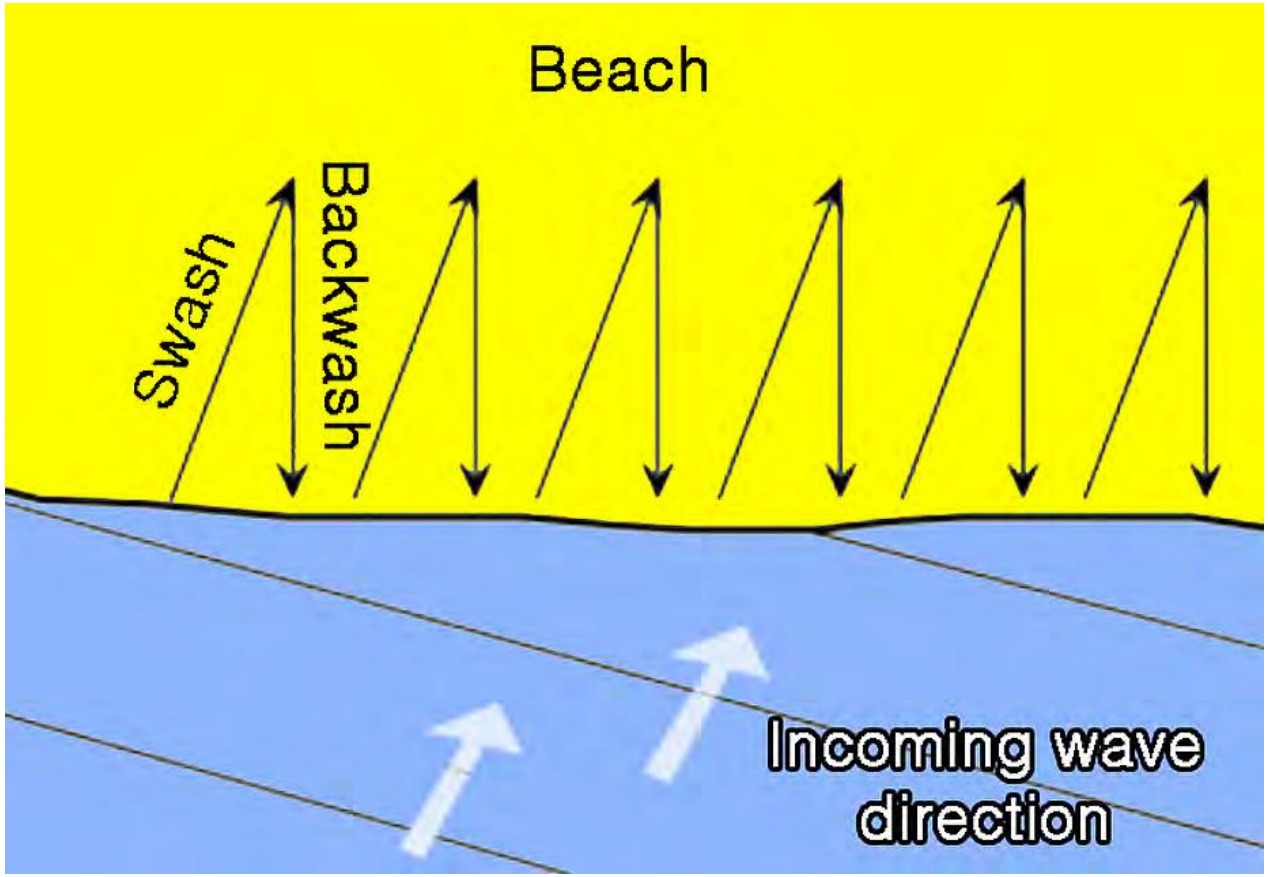
Longshore drift also moves planktonic larvae (nutrients) from one ecosystem to another.



Calanoid copepod

Photo ANARE

Wave direction moves sediment on a beach. Longshore drift transports sand along a beach at an angle gradually moving in the direction of the waves.



Movement of sediment on a beach.

Illustration: Bob Moffatt

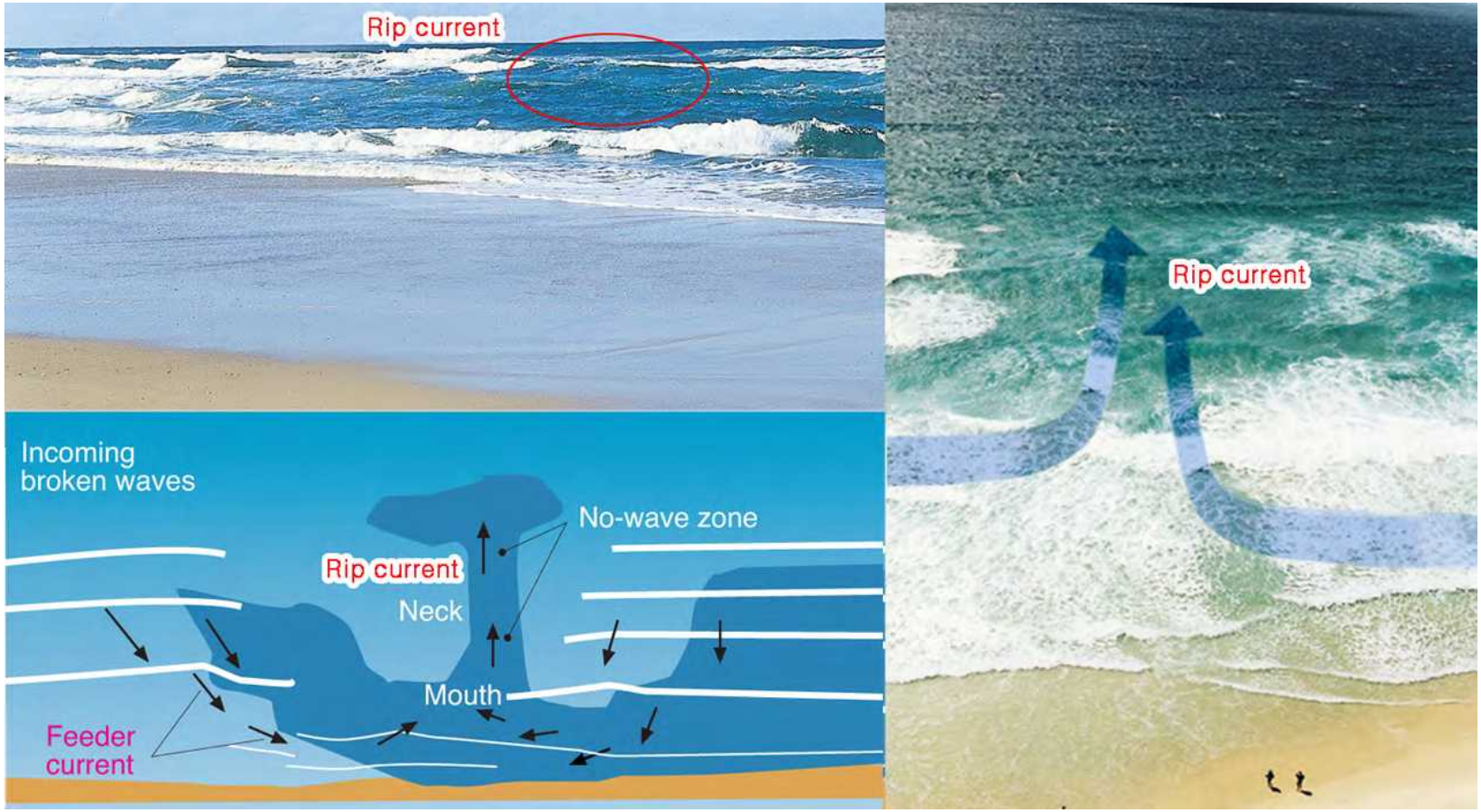
Long shore drift moves sediments past headlands and into bays where sand is dropped in littoral cells

Photo Murray Waite

Sand sink river mouth

Photo Murray Waite

Waves and Longshore drift can move <u>water</u> in rips in different directions into rips.



Rip current

Photos and illustration: Bob Moffatt

Sediment

Big waves move sand off the beach

Waves erode beach

Photo: Bob Moffatt

Waves can erode sediment from cliffs.

Waves erode cliffs

Photo: Tourism Victoria

Longshore drift can carry these sediments at different rates:

a. Bigger grains are found in the surf zone
b. Smaller grains are found offshore. The further sediments are found offshore the less likely they are to be influenced by longshore drift.

Sediment movement compared close and offshore.
Photo: Bob Moffatt

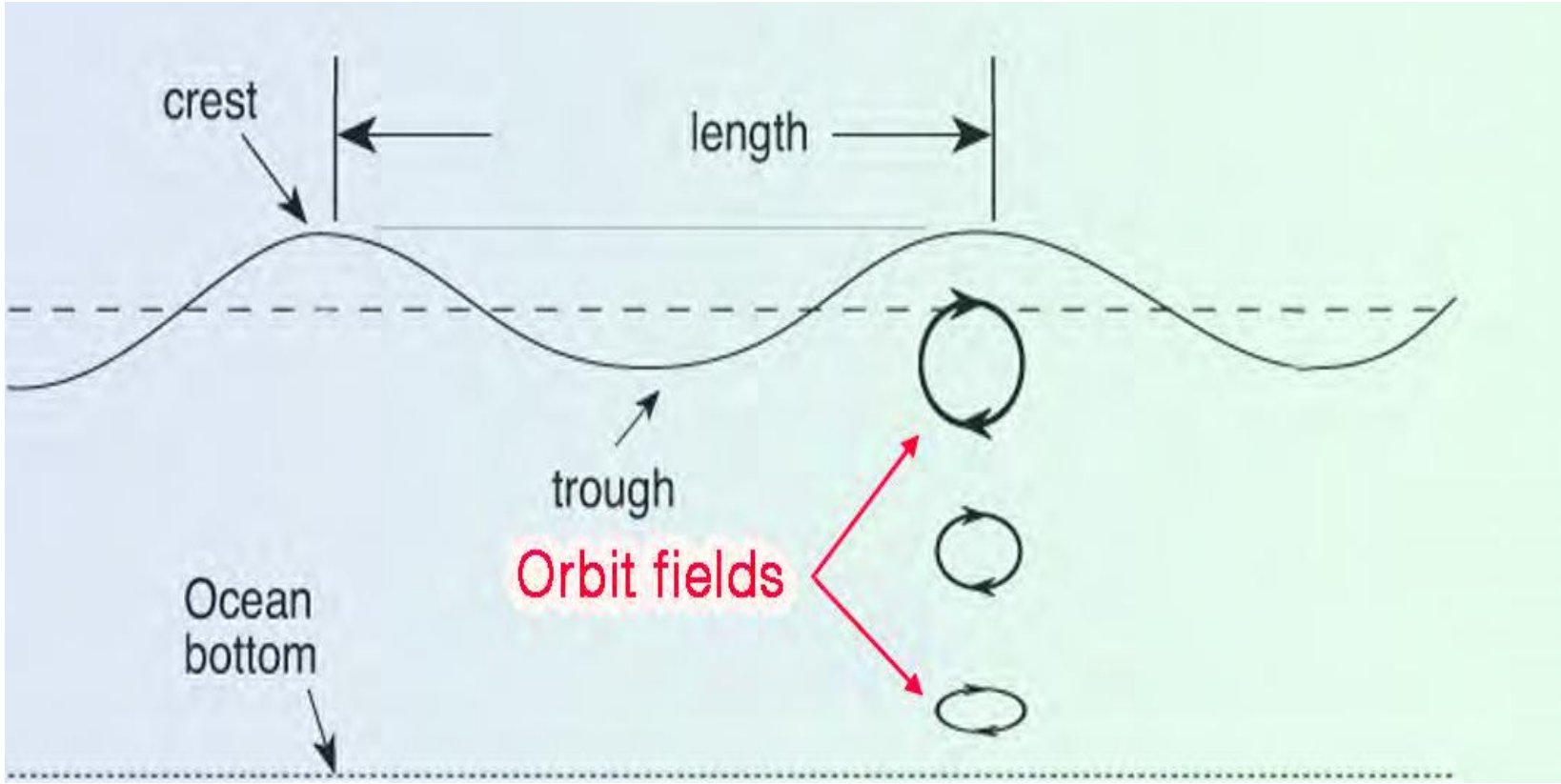
Longshore drift can disperse nutrients along the coastline for many kilometers. For example the drift can move mangrove seeds which die and provide food for microorganisms on a beach.

Photo Bob Moffatt

Longshore drift can also disperse algae blooms dispersing reproductive cells and larvae.

Photo: Bob Moffatt

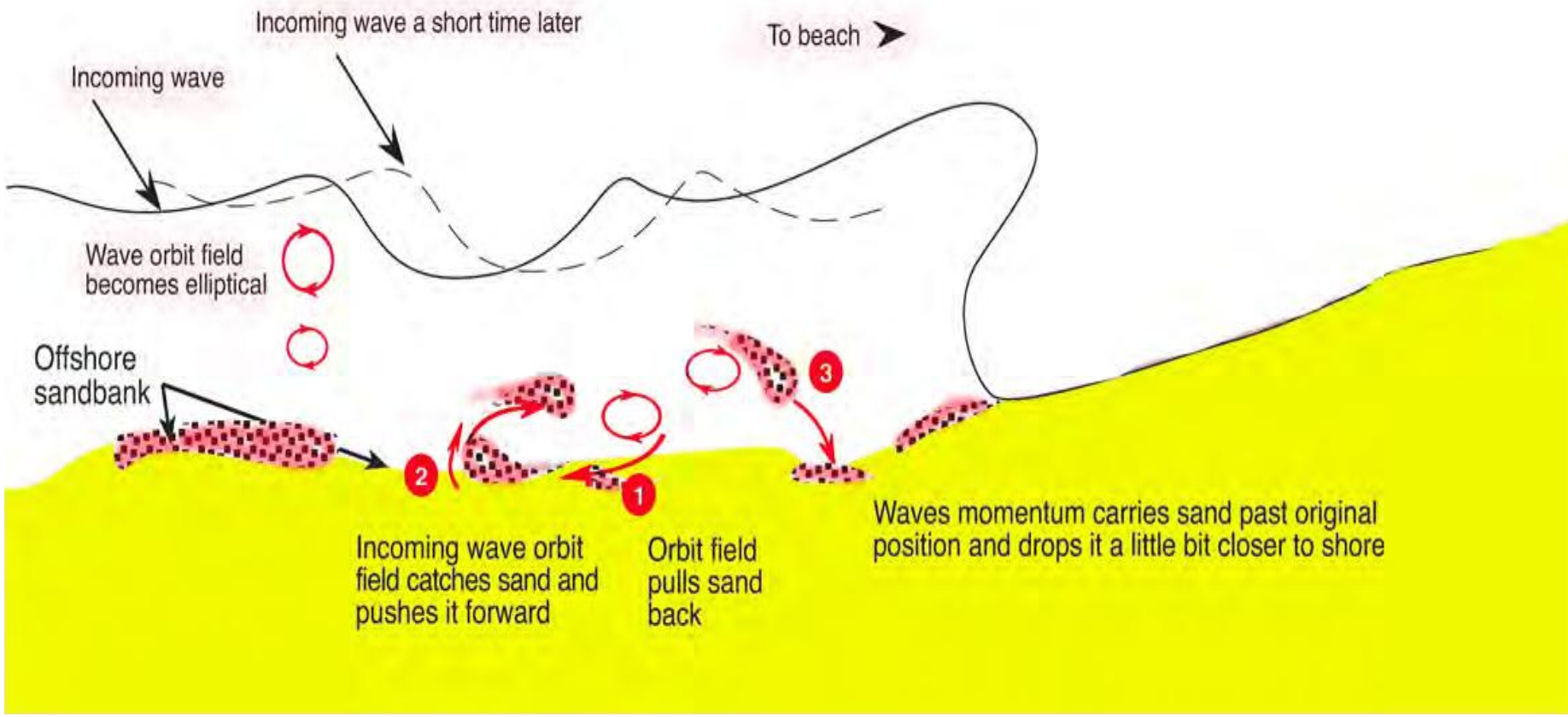
As waves move towards the beach their orbit fields interact with the sea floor.



Orbit fields

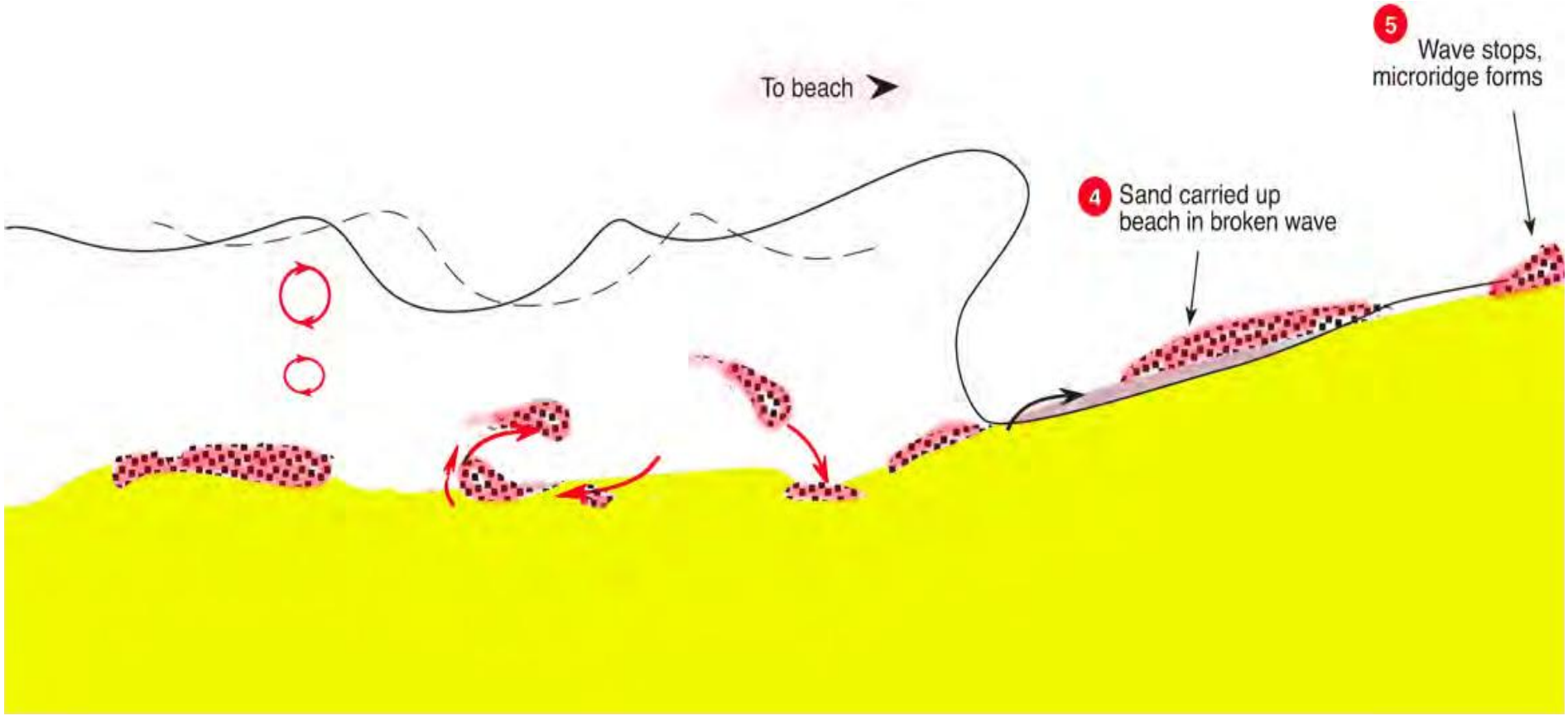
Illustration: Bob Moffatt

The orbit field pulls the sand back.
The incoming wave orbit field catches the sand and pushes it forward.



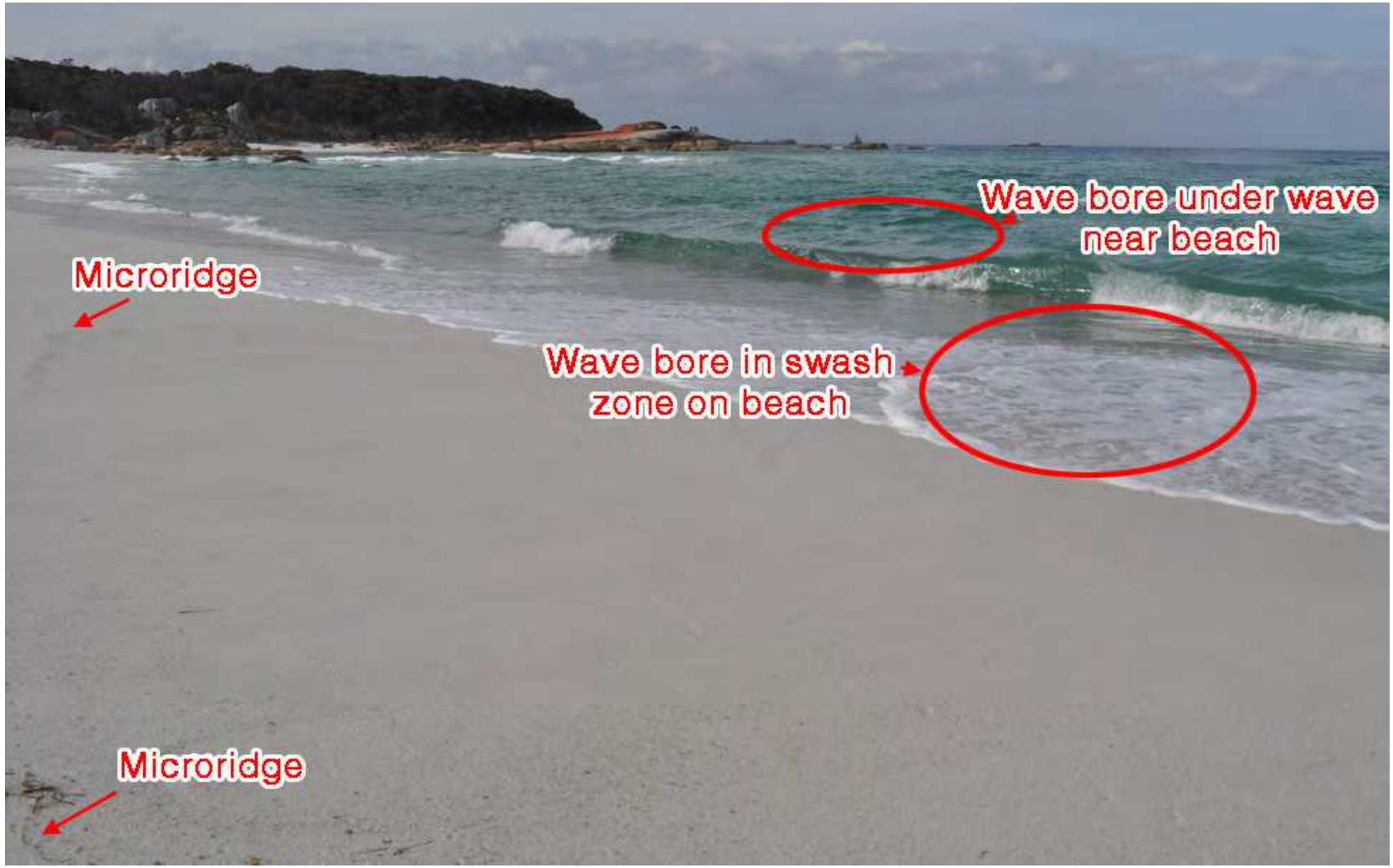
Bob Moffatt

In calm wave conditions the orbit fields carry on to push sand past its original position



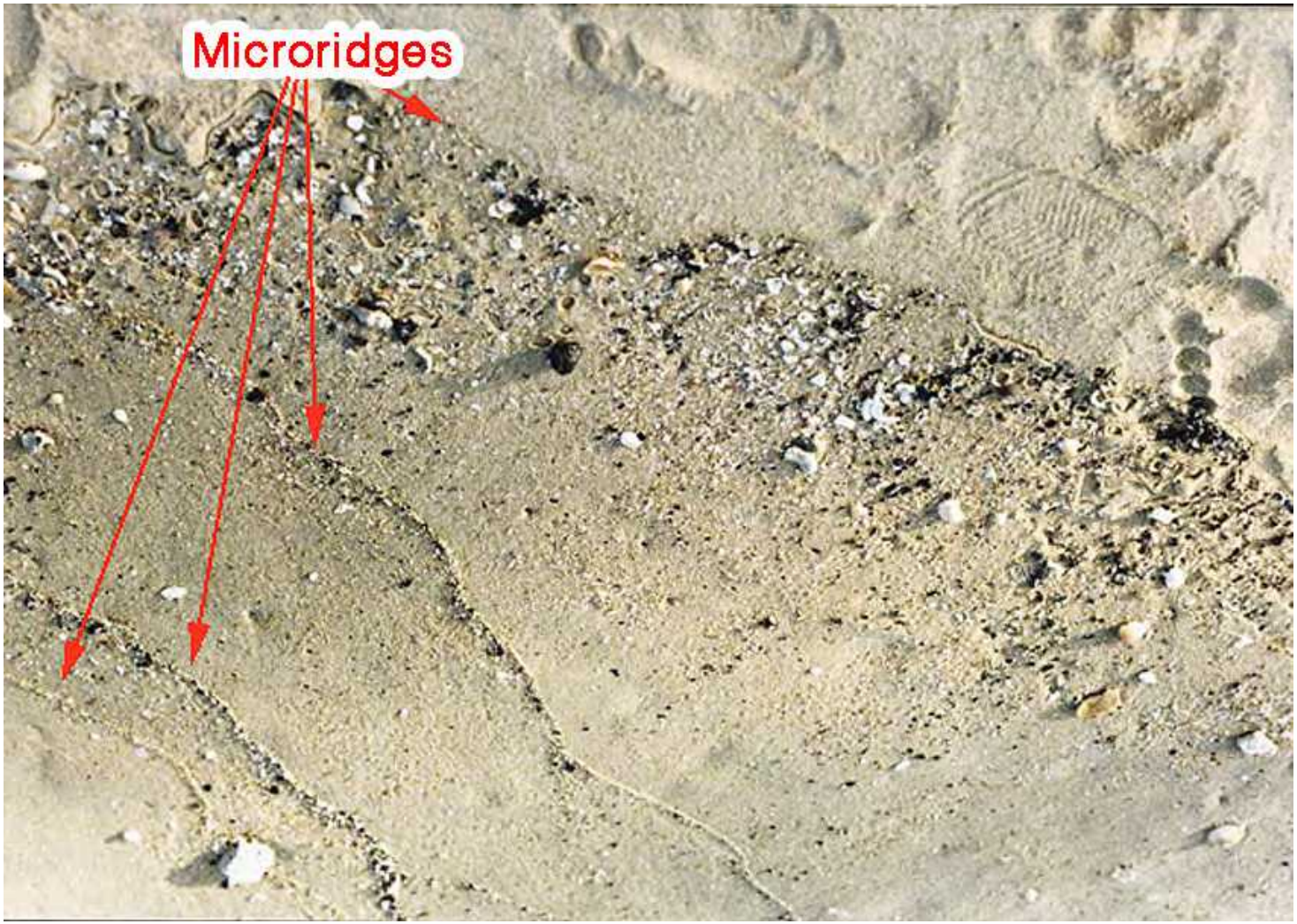
Bob Moffatt

A characteristic of the swash zone is the wave bore which carries this sand up the beach and when it stops forms a microridge.



Bob Moffatt

These are found all over the world



Bob Moffatt

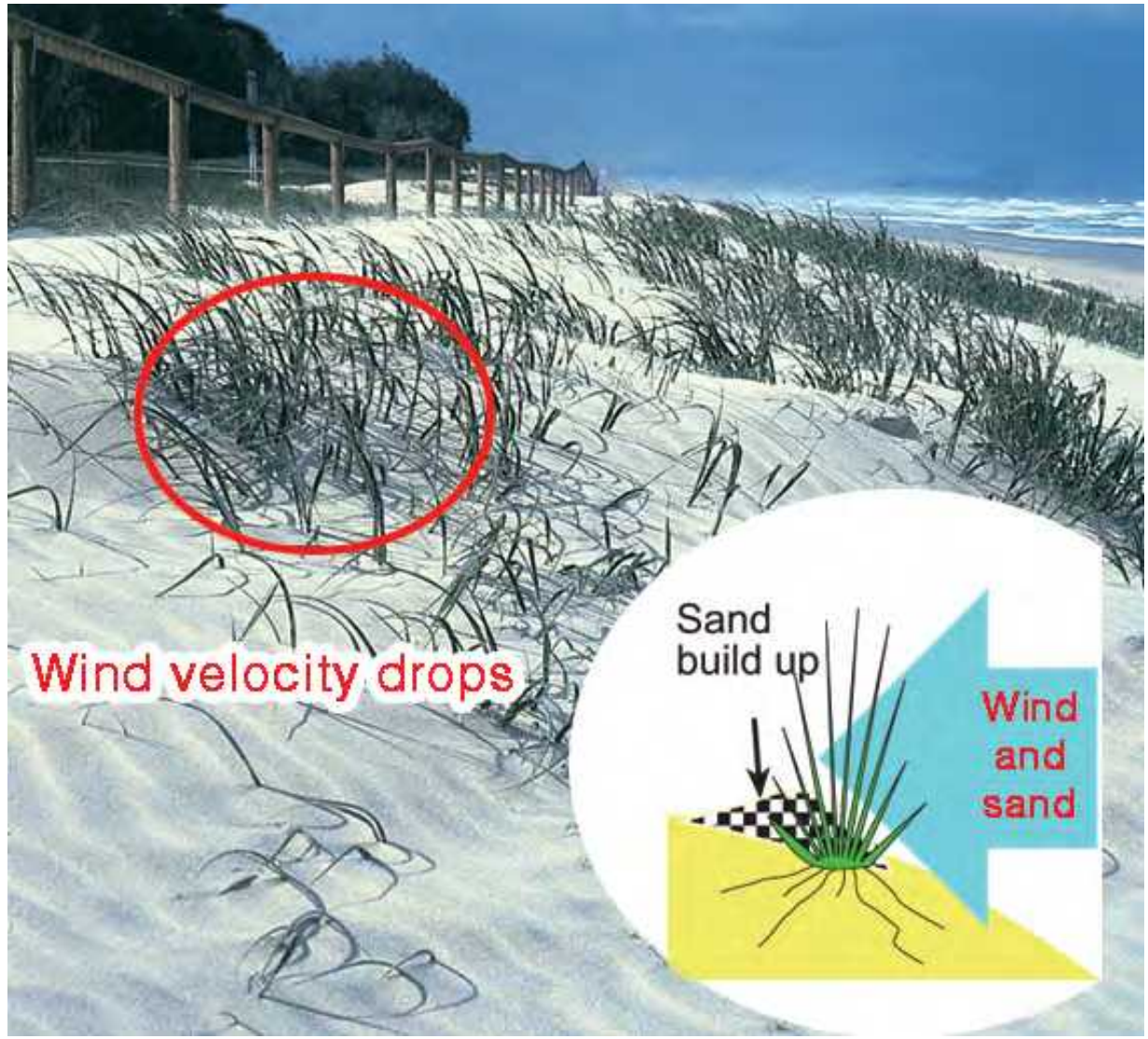
Now on hot days, this sand dries and if onshore winds occur, this sand is blown into dunes. These dunes act like a sand reservoir that can become available to the coastal system during periods of storm.

Bob Moffatt

Wind blowing sand along along the beach

Bob Moffatt

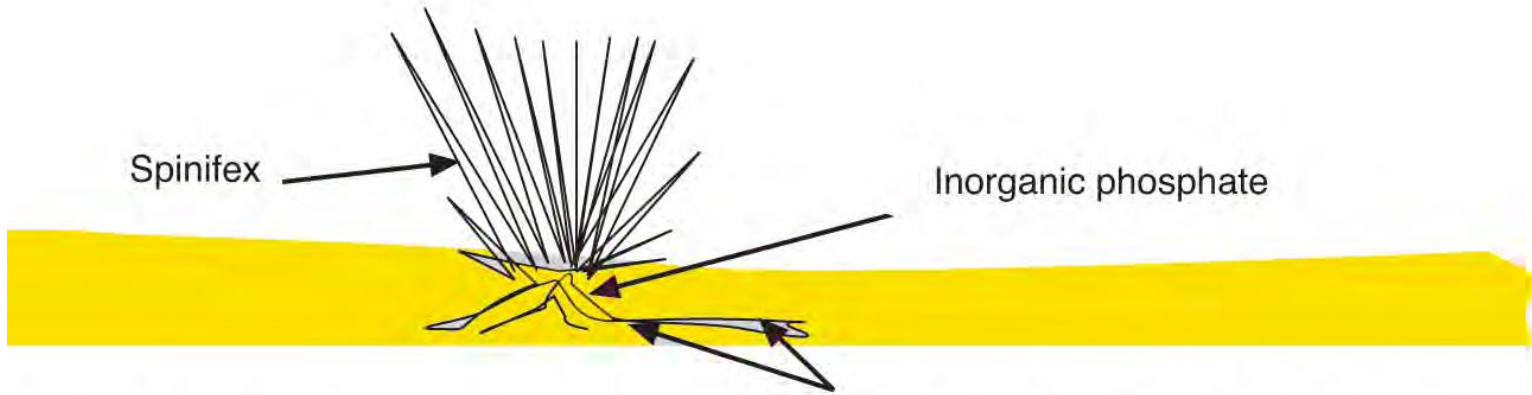
The shape of primary dune plants reduces the wind velocity causing sand to accumulates at the base of these plants.



Bob Moffatt

Nutrients in sand also accumulate in primary dune plants.

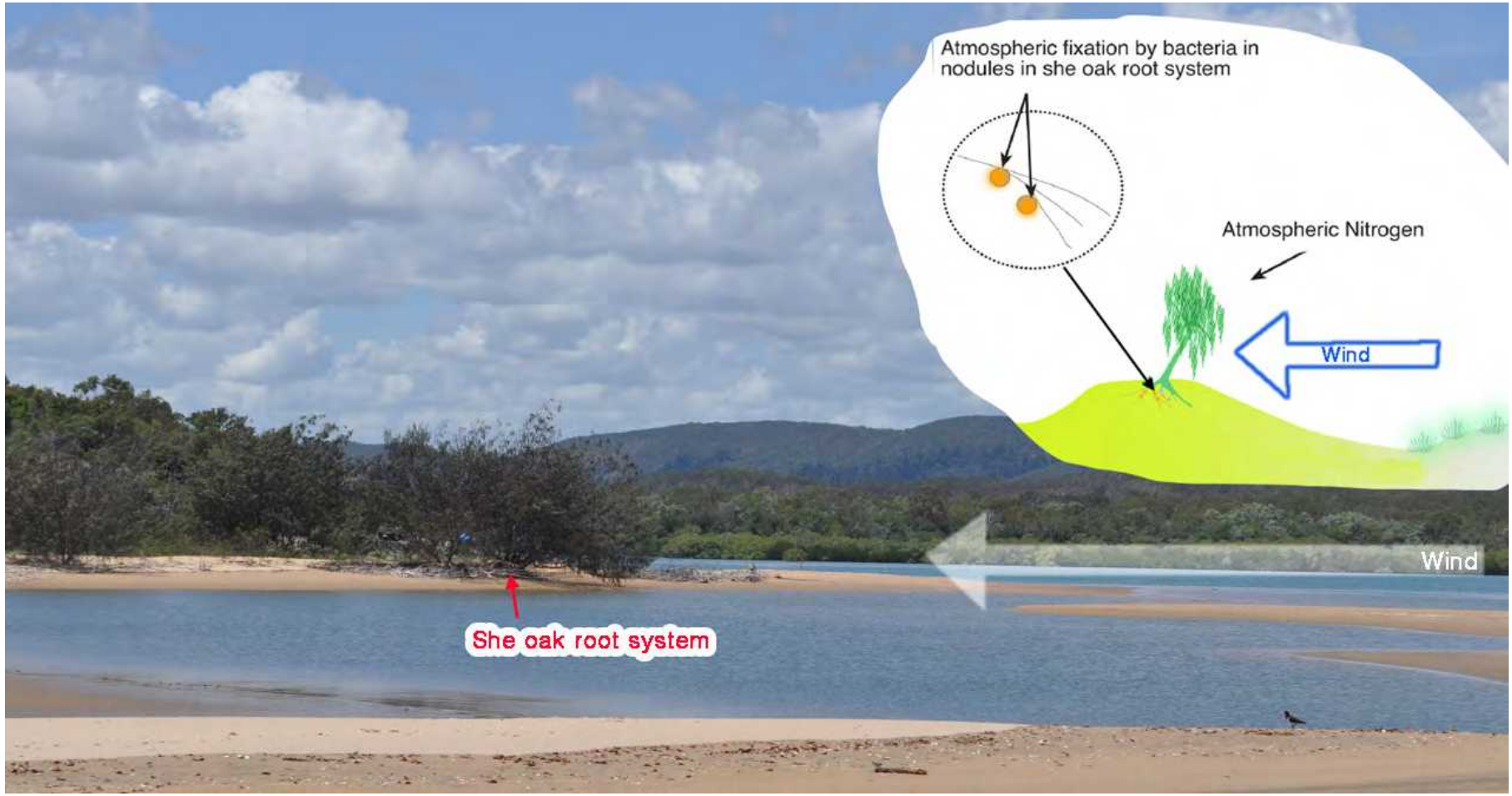
For example phosphorus is extracted by coastal spinifex.



Roots of the plant actually seek out the phosphorus on sand grains which have been carried down the rivers and washed onto the beach by wave action.

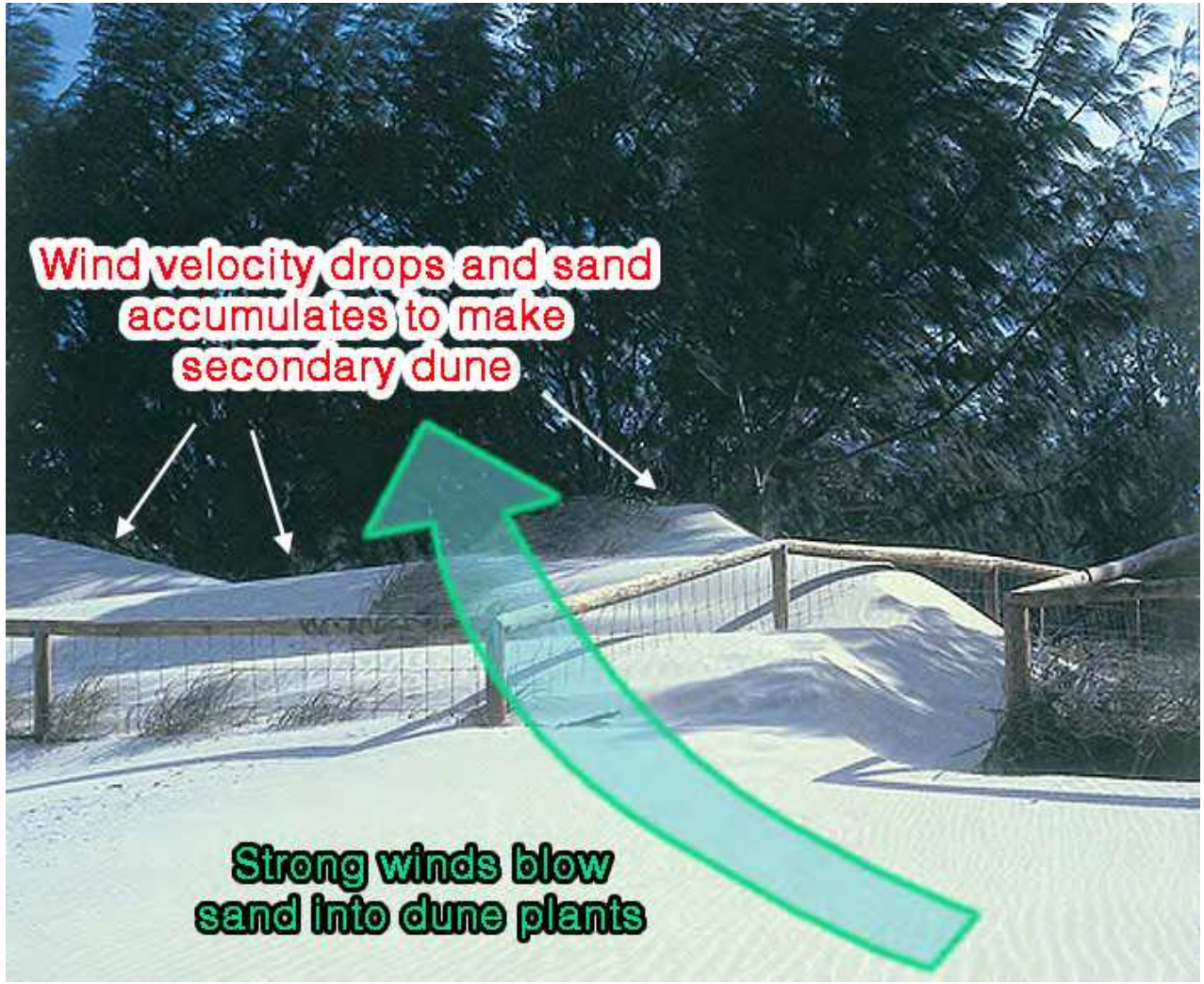
Bob Moffatt

Nitrogen is also extracted by Casuarina root nodules.



Bob Moffatt

If onshore winds are strong enough, sand blows into secondary dune plant branches and leaves which reduce the velocity and falls to the bottom of the dune.



Bob Moffatt

Large dune system can form in this way.

Bob Moffatt

Waves and Pollution

Waves can break up ships in storms.

For example oil tanker pollution.

Waves break up ship.
Photo: AMSA

Longshore drift and pollution

Longshore drift can carry pollutants for many hundreds of kilometres.

Marine debris on the Hawaiian coast By NOAA – http://marinedebris.noaa.gov/marinedebris101/photos_ecosys.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3834865

Wind and pollution

Plastic bag blows into sea.

Photo: Bob Moffatt

Copy this table into your notebook and indicate which features relate to your local coastline.

Factor	Management of water movement	Management of nutrient movement	Management of sand movement	Management of sediment movement	Management of pollution movement
Wave action	Waves can move water up and down the beach in the swash zone, into rock pools, into a lagoon, into an estuary or along the coastline or in rip currents	Waves break over rocks bringing plankton for filter feeding barnacles	Waves move sand onto the beach	Waves move sediment in wave bores into microridges	Waves break up containers, ships grounded
Longshore drift	Longshore drift moves water along the coastline	Longshore drift moves planktonic larvae from one ecosystem to another	Longshore drift moves sand into spits and into estuaries	Longshore move sediment along the coastline	Longshore drift moves debris along the coast and into river entrances
Wind	Wind over tide backs up water, creates on and offshore surf.	Wind blows plant seeds from place to place	Wind blows sand into sand dunes	Wind dries sand on beach in microridges	Wind blows plastic bags into the sea
Tides	Move water in and out of estuaries	Deposit nutrients at high tide	Exposed sand from spring tides with strong winds creates dunes	High tidal range causes greater movement	Tides into and out of a river can slow pollution dispersal

T016E Sand grain experiment

With data test

Syllabus statement

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

Conduct a beach profile/dune transect and use sand seives to decide on sphericity of sand grains

Conduct

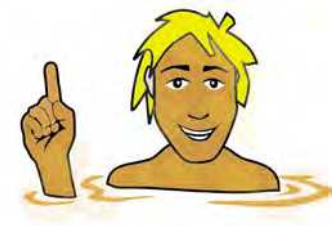
- direct in action or course;
- manage;
- organise;
- carry out.

Question

Are sand grain sizes different on a beach?

Experiment

Test the hypothesis that the sand grain size at the bottom of a beach is significantly different than on the top of the beach.



Null hypothesis

There is no significant difference between sand grain sizes at the top and bottom of a beach.

Research hypothesis

There is a significant difference between sand grain sizes when comparing samples from the top and bottom of a beach.

Study site

Bob Moffatt

Sample sites

Bob Moffatt

Risk analysis

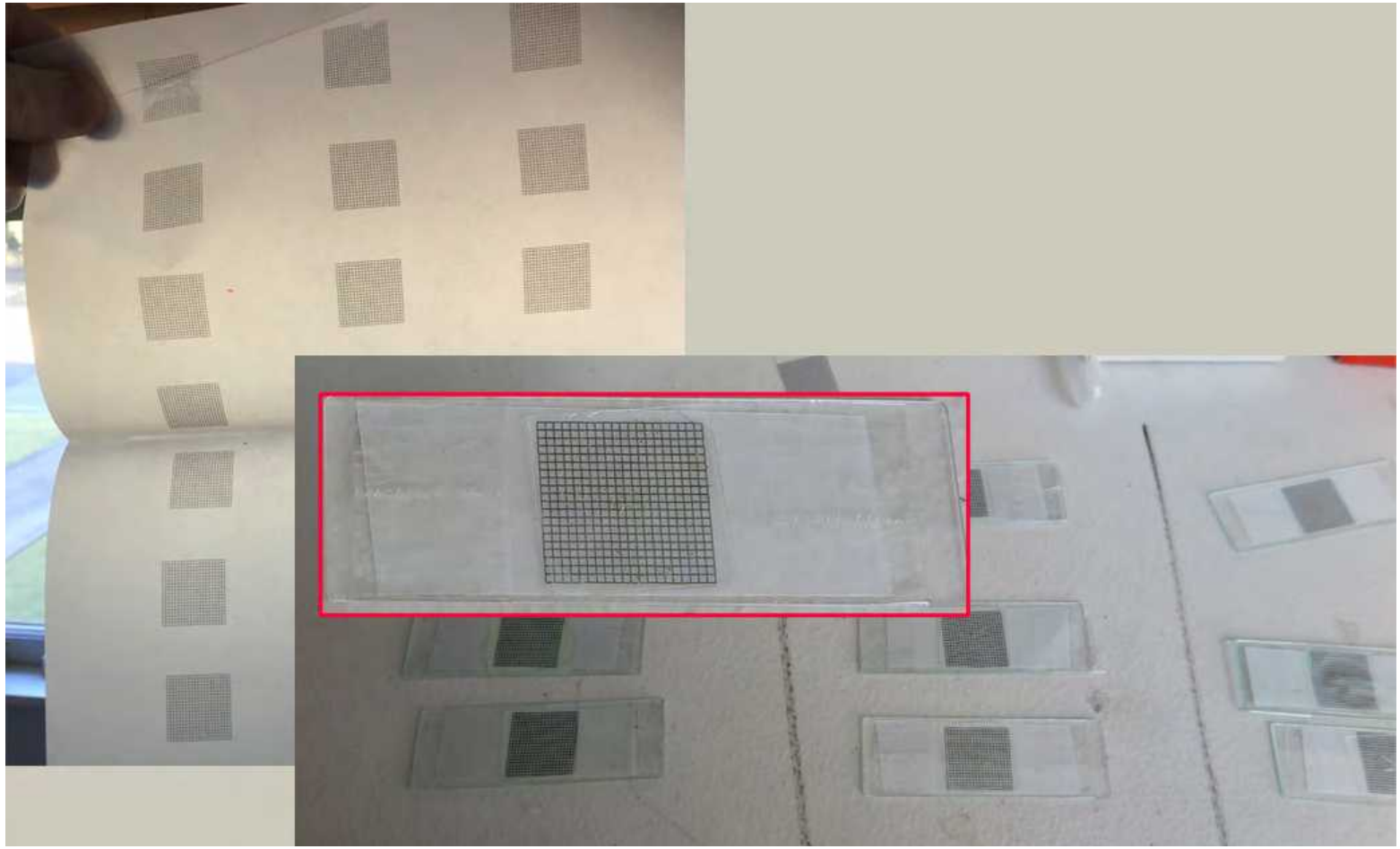
Consult school WPH&S for school excursions to a beach.

Follow control measures for local beach conditions.

Sun dried samples

Bob Moffatt

Equipment – home made slides from Danny Stevens
(PBC) office works wedding invitation paper



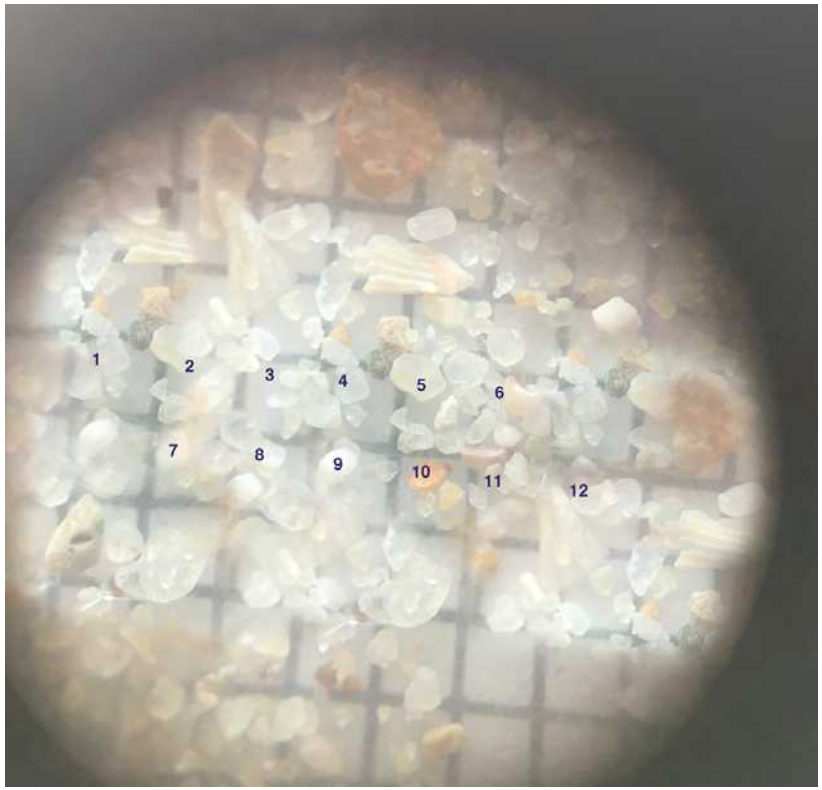
Bob Moffatt

Method Stereo mic – shake the sand until it is evenly distributed over the slide or paper

Bob Moffatt

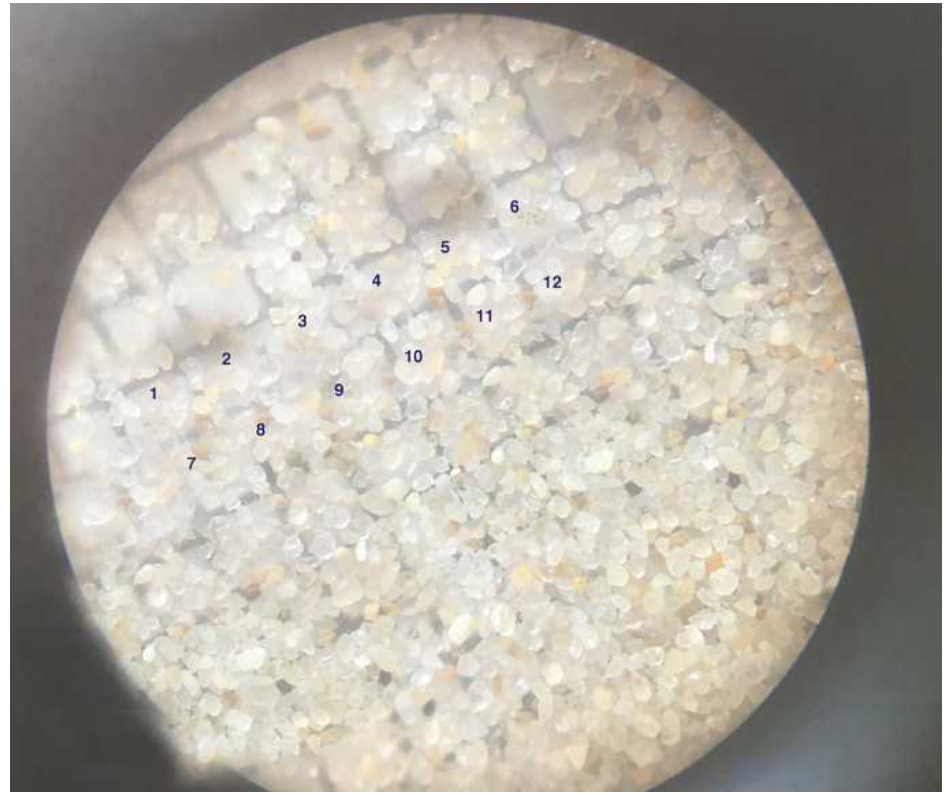
Count the numbers of sand grains in the squares (if a sand grain was partly in a square it was counted).

Bottom



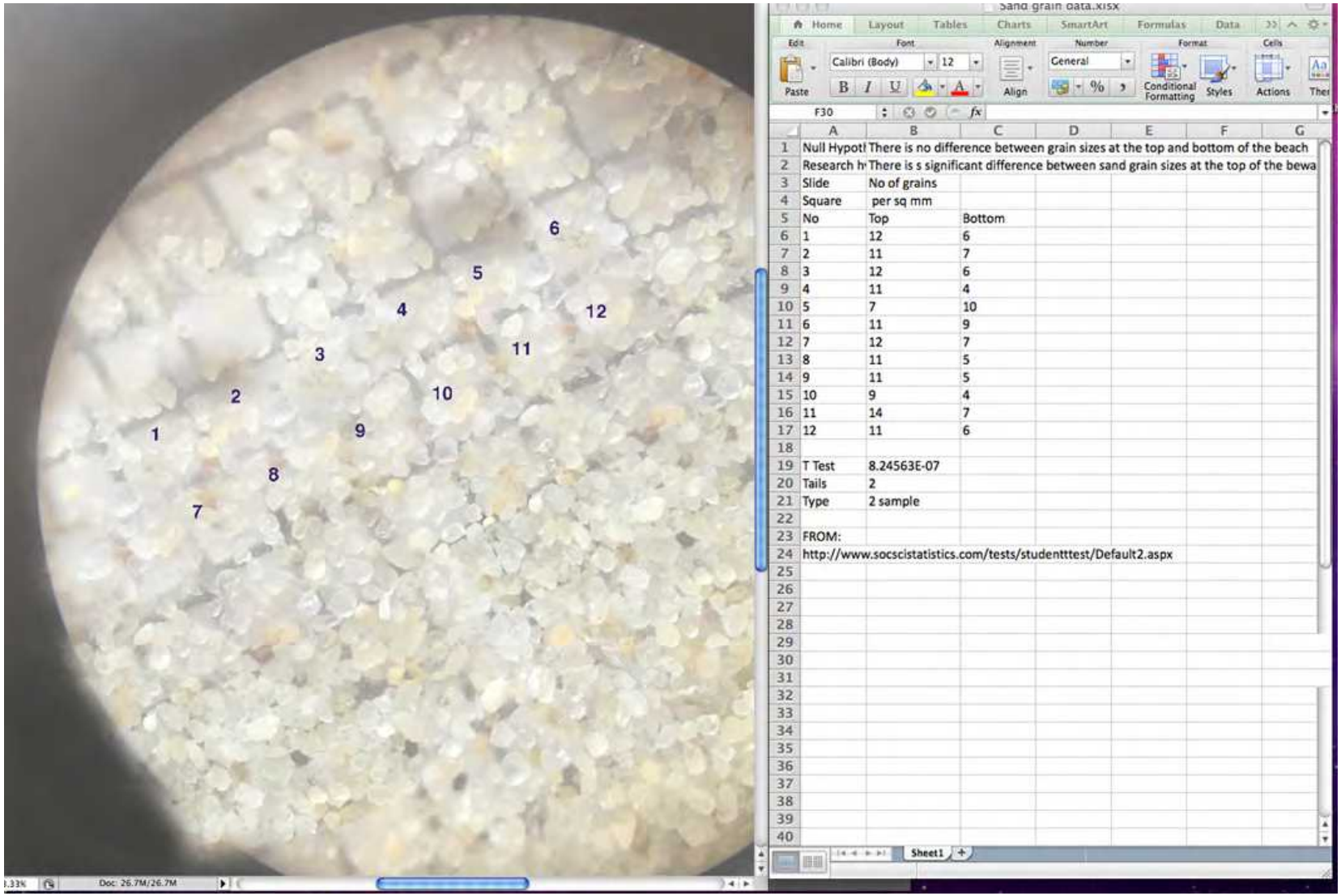
Bob Moffatt

Top



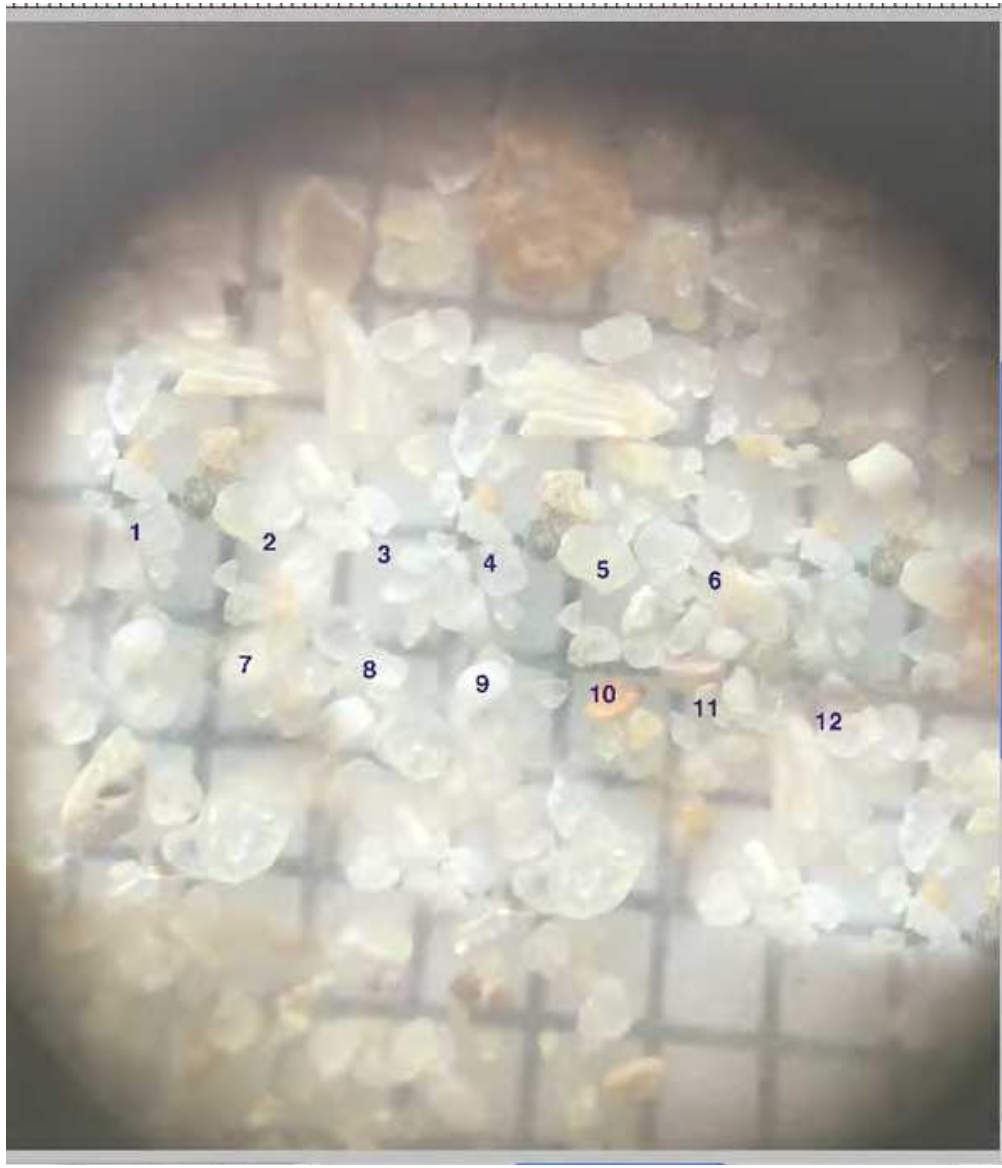
Bob Moffatt

Top results



Bob Moffatt

Bottom results

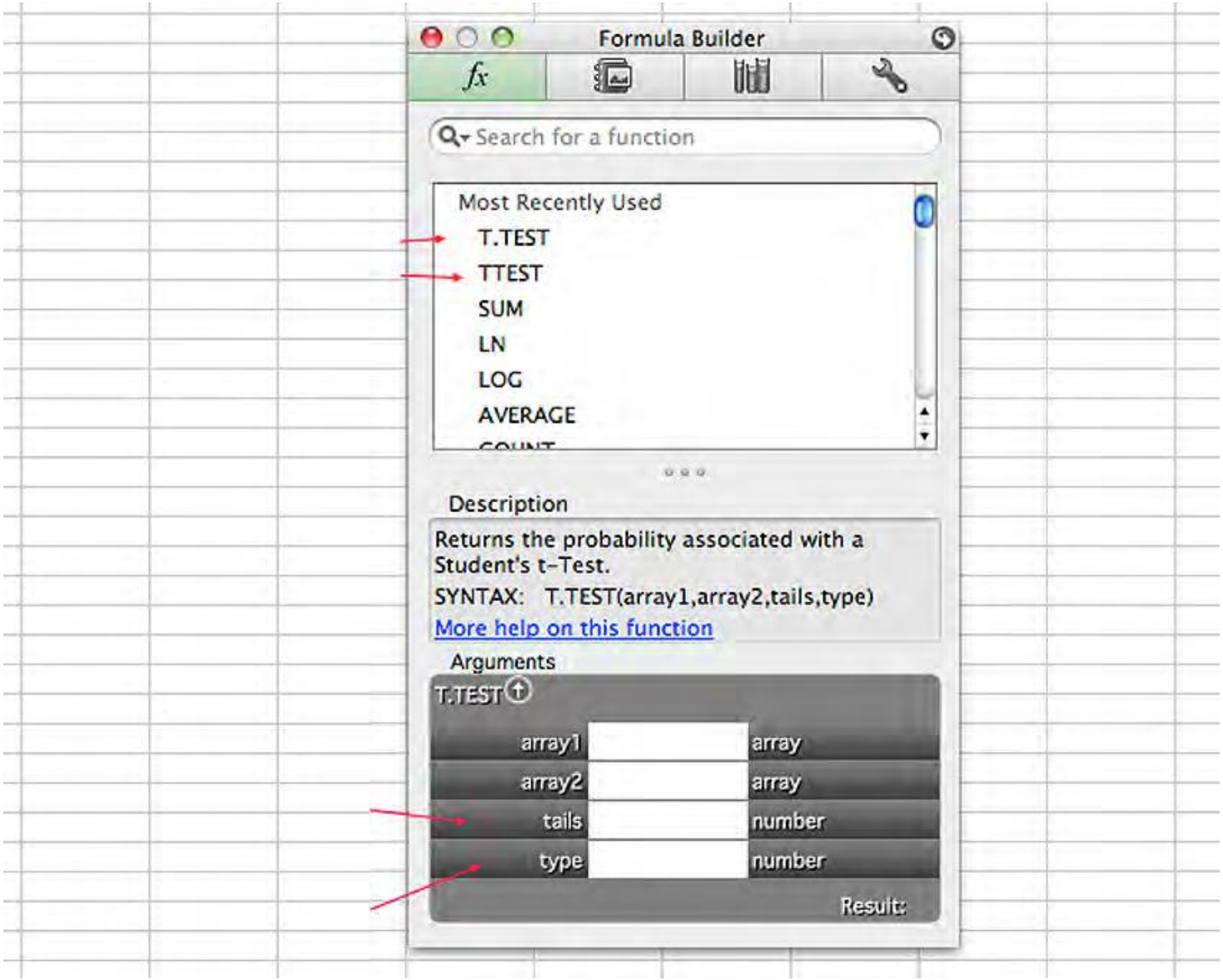


Sand grain data.xlsx

	A	B	C
1	Null Hypot	There is no difference between grain sizes at the top and bottom of the beach	
2	Research h	There is s significant difference between sand grain sizes at the top of the bewa	
3	Slide	No of grains	
4	Square	per sq mm	
5	No	Top	Bottom
6	1	12	6
7	2	11	7
8	3	12	6
9	4	11	4
10	5	7	10
11	6	11	9
12	7	12	7
13	8	11	5
14	9	11	5
15	10	9	4
16	11	14	7
17	12	11	6
18			
19	T Test	8.24563E-07	
20	Tails	2	
21	Type	2 sample	
22			
23	FROM:		
24	http://www.socscistatistics.com/tests/studentttest/Default2.aspx		

Bob Moffatt

Calculations – use excel formula builder to perform T test.



Ask your teacher how to do this.

Exercise 4.2 Sand per cent composition

Based on an original exercise by Bob Moffatt

In this experiment you are going to work out where the big sand grains are on the beach that you collected in Exercise 4.1

Materials and equipment (per group)

- Sieves — Note:

  For beaches with fine sand grains

  - sieves of sizes, 300 μ metres, 250 μ metres, 200μ metres (See Figure 100.1A)

  For beaches with larger grain sizes

  - sieves of sizes, 600 μ metres, 400 μ metres, 200μ metres
  - or larger sieves as shown in Figure 100.1B
- aluminium pie dishes labelled as follows:

  - subsample, >300 μm, 250 μm, 200 μm, < 200 μm
- 2 ice cream containers
- completely dry sand samples from top, middle and bottom of beach in plastic zip top bags
- lab balance
- 4 aluminium pie dishes or plastic jars as shown in Figure 100.2.

A. For beaches with fine sand grains

B. For beaches with larger grain sizes

Figure 100.1 Materials necessary to make sieves
(Photos Bob Moffatt - A, Geoff Jensen B)

FIELD WORK HINTS

1. Often it is impractical to take a balance into the field.

   In this case the use of small plastic containers as shown in Figure 100.2A may be of assistance.

2. You will need a labelled container for each sieve as shown and use a rough estimation as shown in Figure 100.2B to work out the percent.

3. Use zip-top plastic bags to collect other sand samples that can be taken back to the lab and analysed if time permits.

TO MAKE SIEVES

1. Mesh of very fine mesh sizes is available from Swiss Screens, Randall St, Slacks Creek, Q'ld, 4127. Plastic sieves as shown are available from Hardie Iplex, in a trades pack of 10, and are called a weathering apron, 50mm, product code is VO 7450. The silk comes in widths ranging from 900 - 1200mm and a 125mm long strip will make 9 sieves of the sizes mentioned above. If you use the 50mm weathering apron, then cut the 125mm strip into nine equal squares.

2. Use a rubber band to hold down the mesh and then add bonderete glue around the rubber band. Take the all weathering tape and bind the mesh to the sieve. Pull down the tape as you bind to make a strong seal. Allow to dry for 24 hours. Make sure you mark the sieve with the correct size.

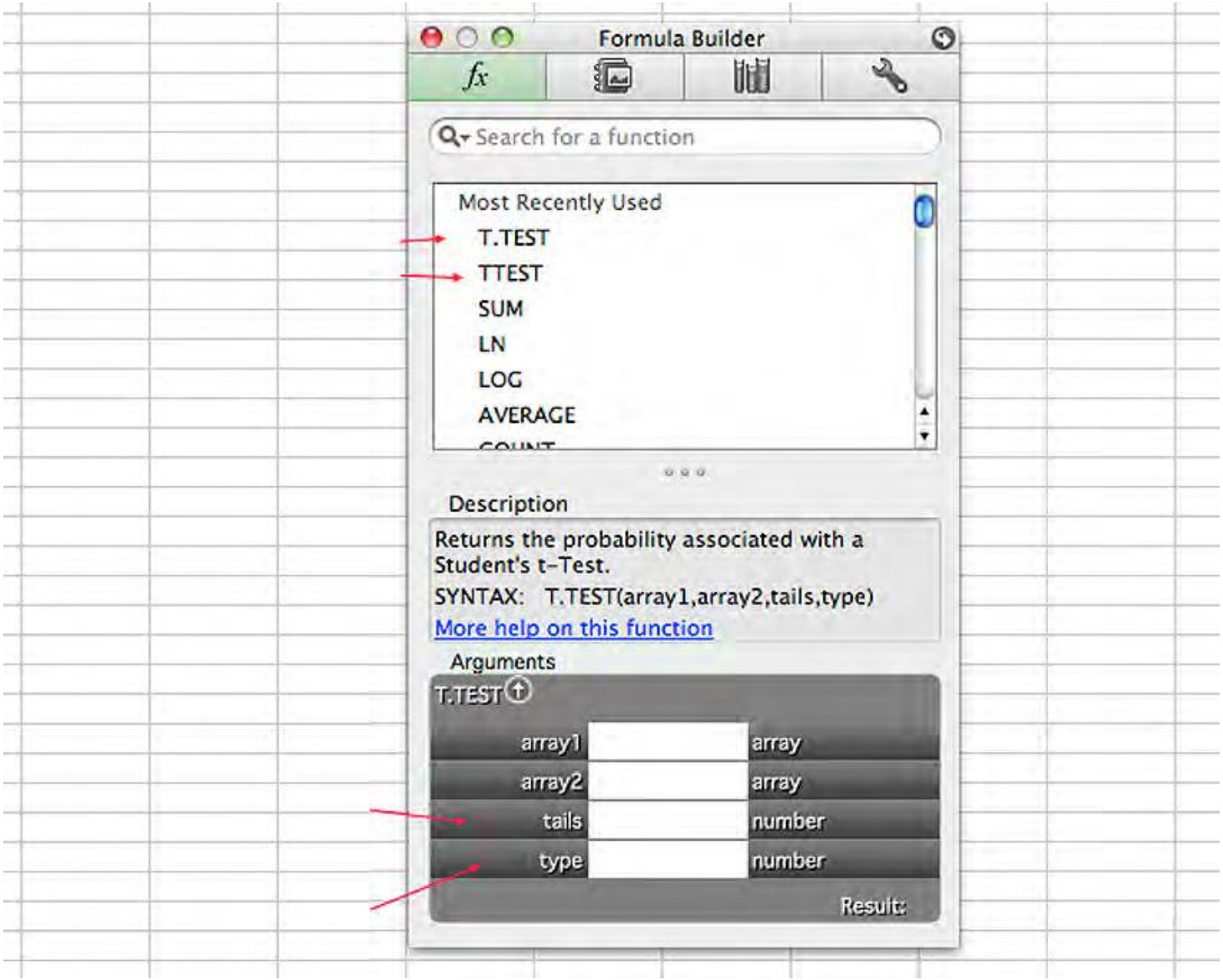
Figure 100.2 Field analysis
(Photos Bob Moffatt)

You could also compare the % sand grain size from a series of seives.

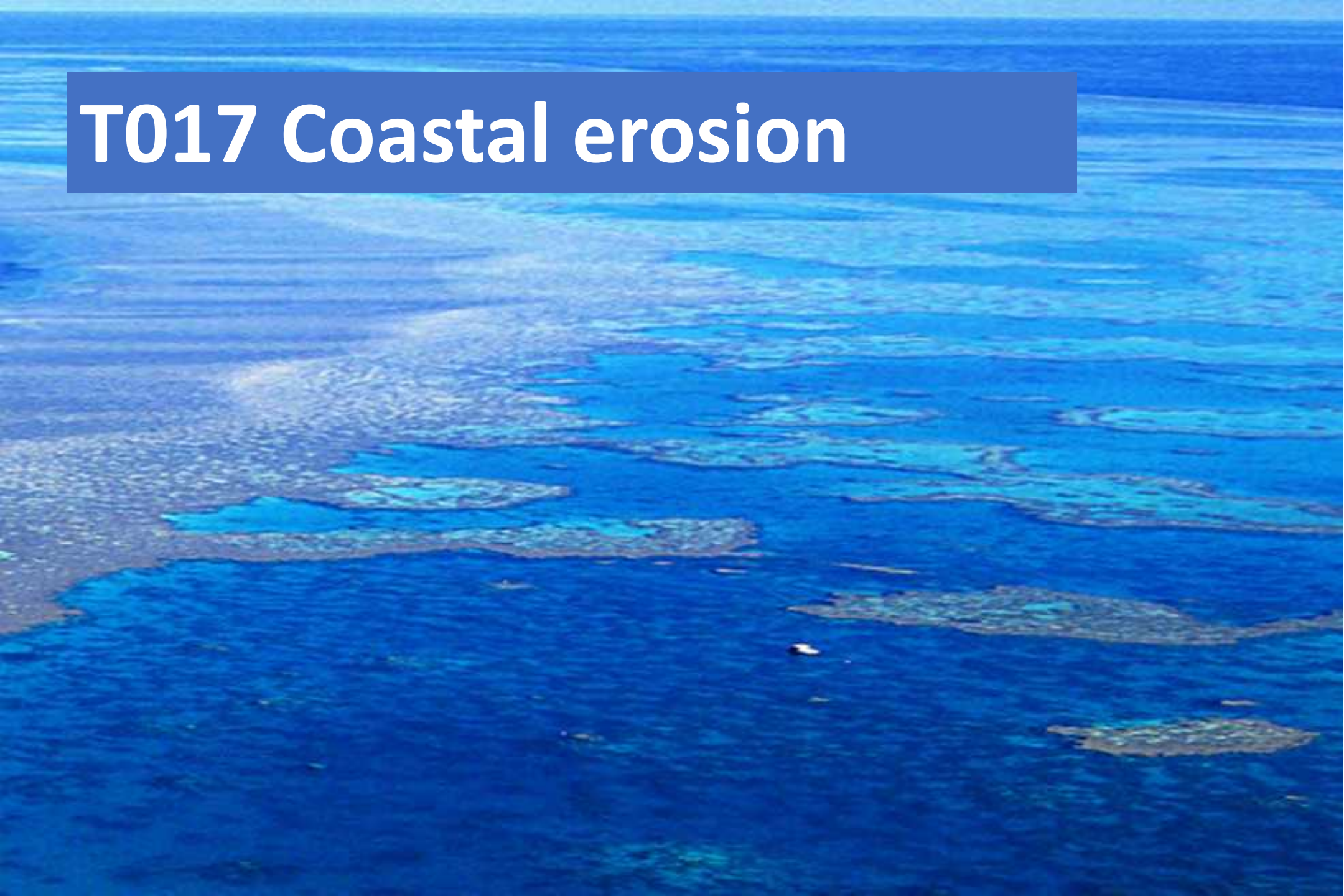
Hypothesis – the percentage of large sand grain sizes at the bottom of the beach is significantly different than those at the top.

Use a students t test to confirm this and how many degrees of confidence do you have?

Calculations – use excel formula builder to perform T test.



Ask your teacher how to do this.


T017 Coastal erosion

Syllabus statement

At the end of this topic you should be able to … **Describe** the processes of coastal erosion (in terms of accretion and erosion)

Describe

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

Question

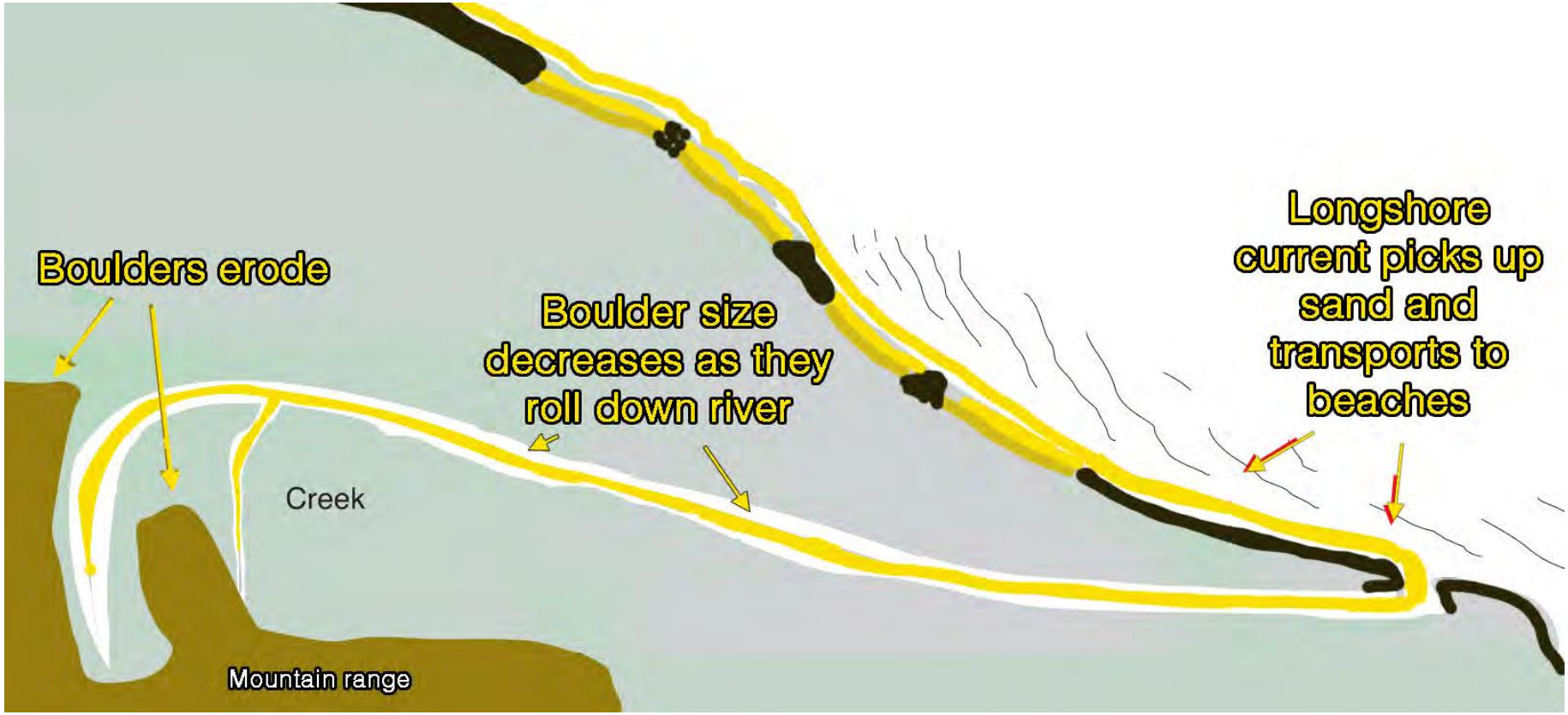
Describe changes in coastal dune and beach systems using the following terms and giving examples

A. Accretion in sand dunes

B. Beach erosion

Accretion in sand dunes

Beaches are made of sand originating from the erosion of rocks and have been washed down to the sea over many years.



Sand enters sand system

Illustration Bob Moffatt

Sand moves in a sand system which is governed by the shape of the coastline, prevailing winds, tides and currents.

Sand in the longshore drift

Photo View finder

Sand is added to the system at one end, creeps along the coastline, is deposited in sand dunes and finally is lost at the other. It can take thousands of years for sand to move along a coastline.

Shape of a coastline and drift

https://www.tweedsandbypass.nsw.gov.au/

Sand can also come from corals or shellfish.

Sand movement reef coral cay

Photo Bob Moffat

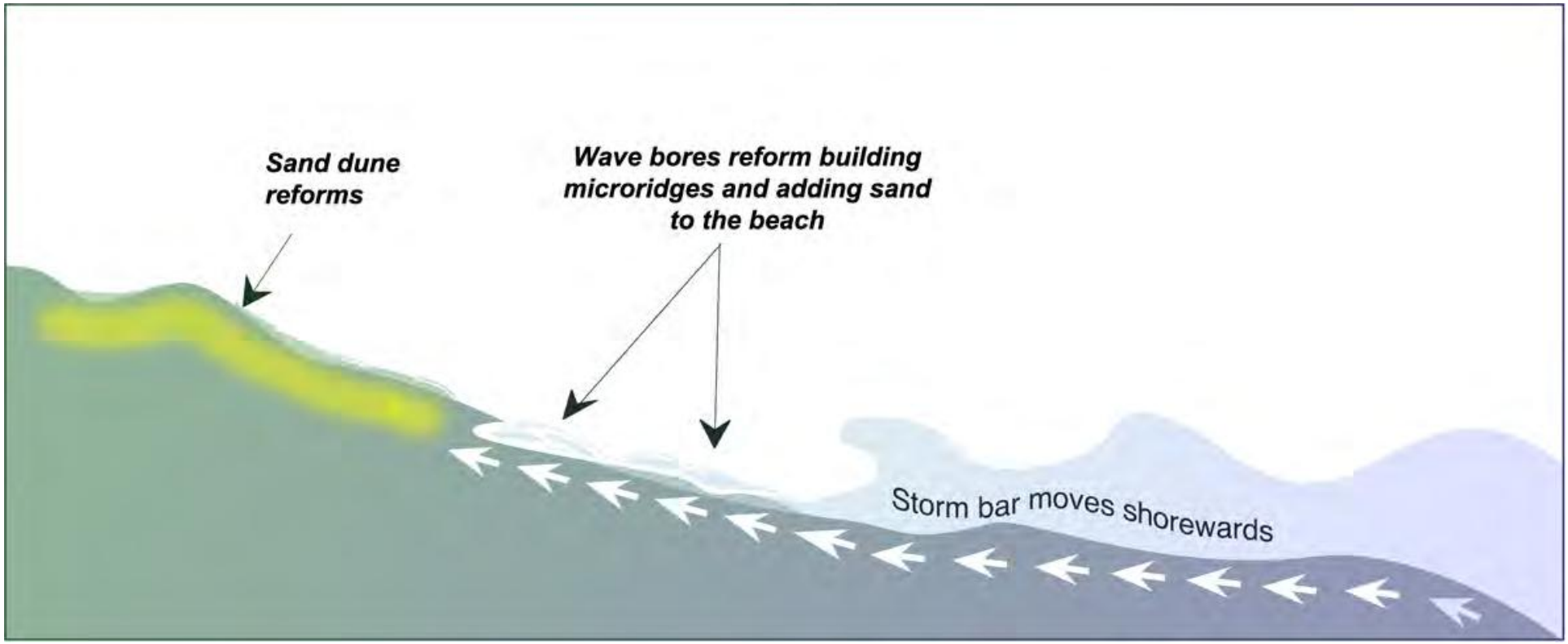
Accretion is the deposition of sediment, usually sand, which is evident by the seaward advance of a shoreline indicator, such as the high water line, berm crest, or vegetation line.

a. Accretion causes the beach to become wider.

b. It is the opposite of Erosion.

Accreting beach
Photo Bob Moffatt

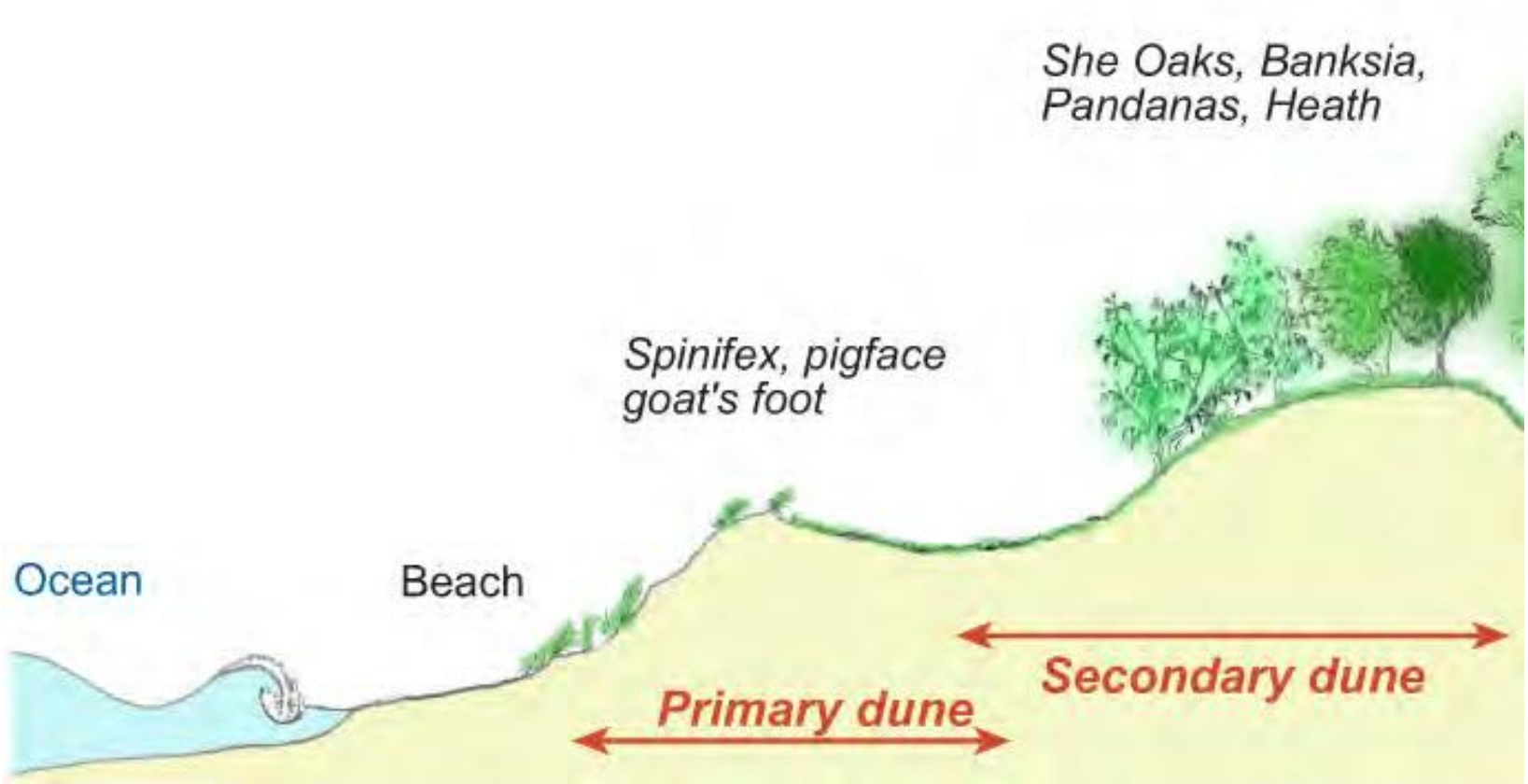
Accretion begins with sand deposition on shore, from the movement of the waves, tides and longshore current. Some sand is then dried out by the wind and sunlight, allowing it to be blown to other areas of the beach by the prevailing winds.



Beach accreting

Illustration Bob Moffatt

This process forms primary and secondary dune systems



Primary and secondary dune

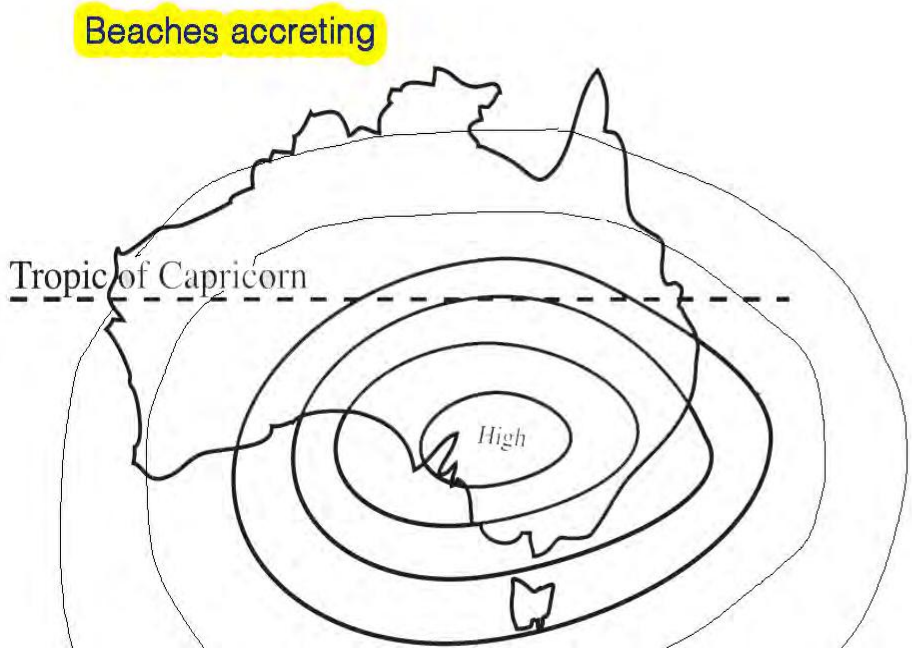
Illustration Bob Moffatt

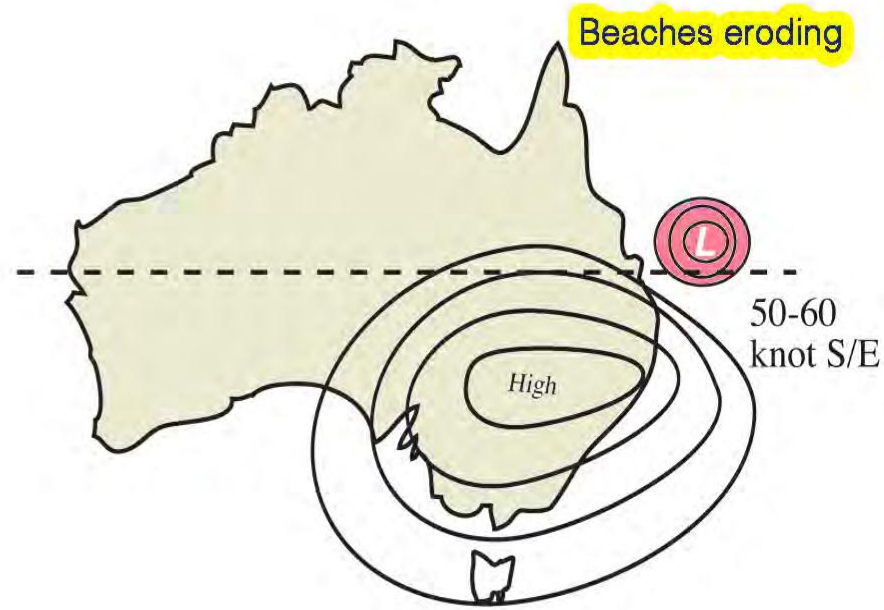
During more unsettled conditions, such as storms and periods of large waves, removal of material is much higher.

Erosion - accretion comparison

Photo Bob Moffatt

These conditions are usually associated with cyclones





Cyclone map for beaches

Illustration Bob Moffatt

Beach erosion

Larger waves formed during storms break down the beach. Initially they erode the beach face dragging sand out to sea.

Storm surf and erosion

Photo Angus Jackson

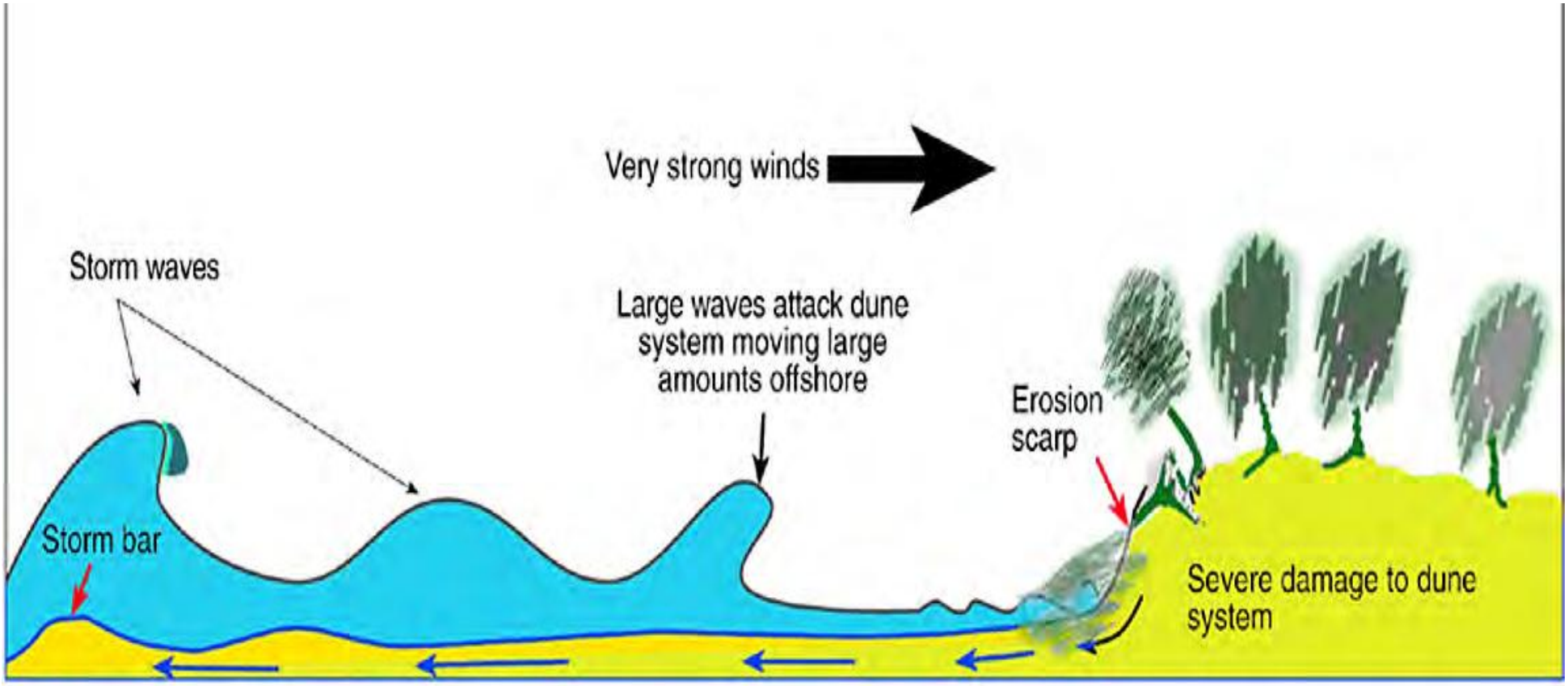
Wave bores are very long and drag the sand offshore to a storm bar.
The sand runs back forming runnels.
There are not enough wave bores to keep the sand there.

Beach eroding
Illustration Bob Moffatt

Runnels on a beach

Photo Bob Moffatt

The beach keeps eroding till the forces of the storm waves can be absorbed on the storm bar. Large erosion scarps and fretting can be seen and the beach angle changes dramatically..

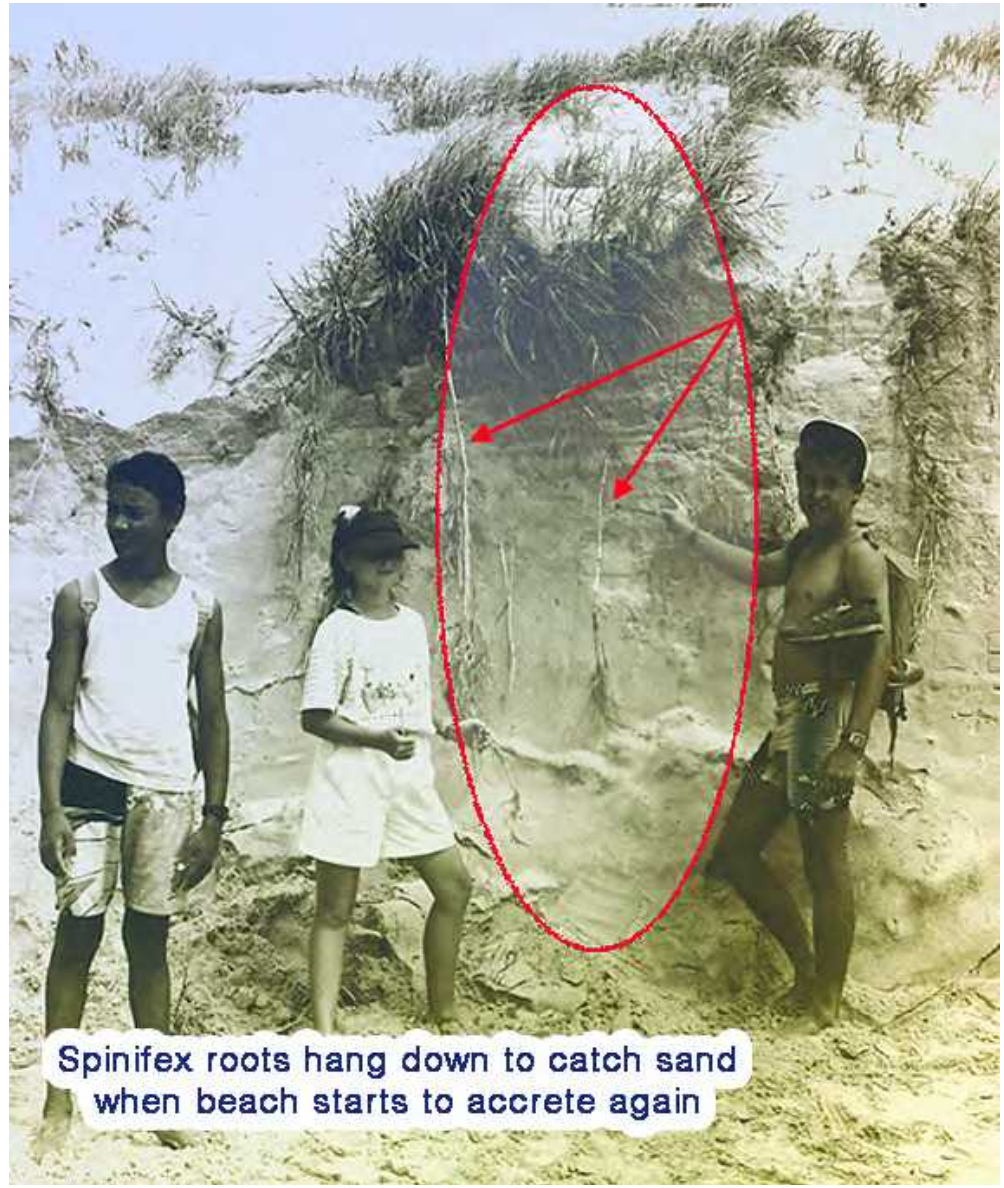


Sand to storm bar

Illustration Bob Moffatt

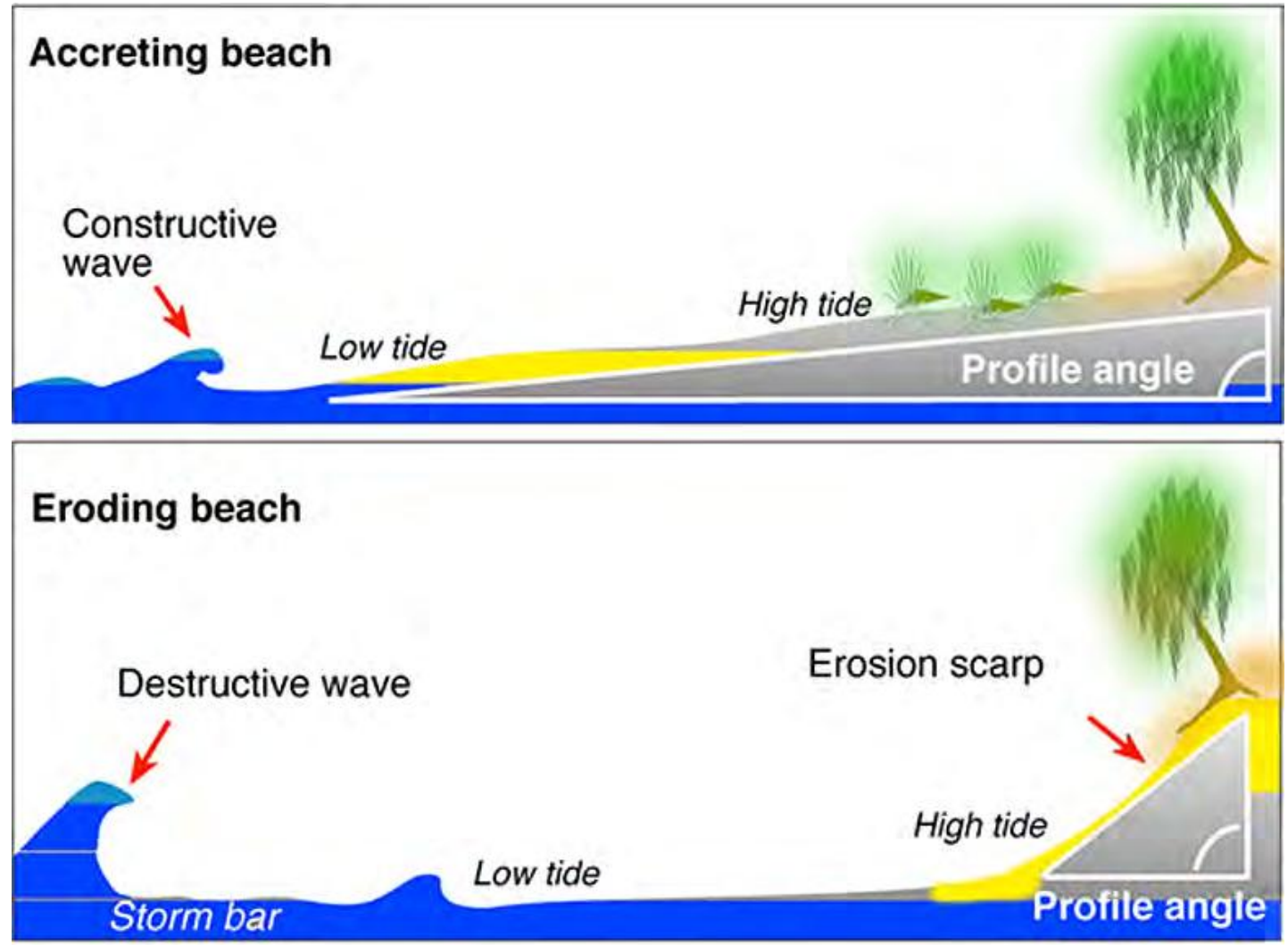
Spinifex roots hang down these erosion scarps waiting to catch new sand when beach accreting begins again.

This is called beach fretting.



Erosion scarp with fretting
Photo Bob Moffatt

The angle of beach profiles is very different in these two situations



Comparison accreting and erode beach profiles

Illustration Bob Moffatt

Question

Draw diagrams to show the difference between beach erosion and beach accretion. If you stood on a beach, how could you tell if it was eroding.

T018 Weather patterns

Syllabus statement

At the end of this topic you should be able to … **identify** the factors between the atmosphere and the oceans that drive weather patterns and climate (e.g. temperature, wind speed and direction, rainfall, breezes, barometric pressure)

Identify

- Locate, recognise and name;

- establish or indicate who or what someone or something is;

- provide an answer from a number of possibilities;

- recognise and state a distinguishing factor or feature

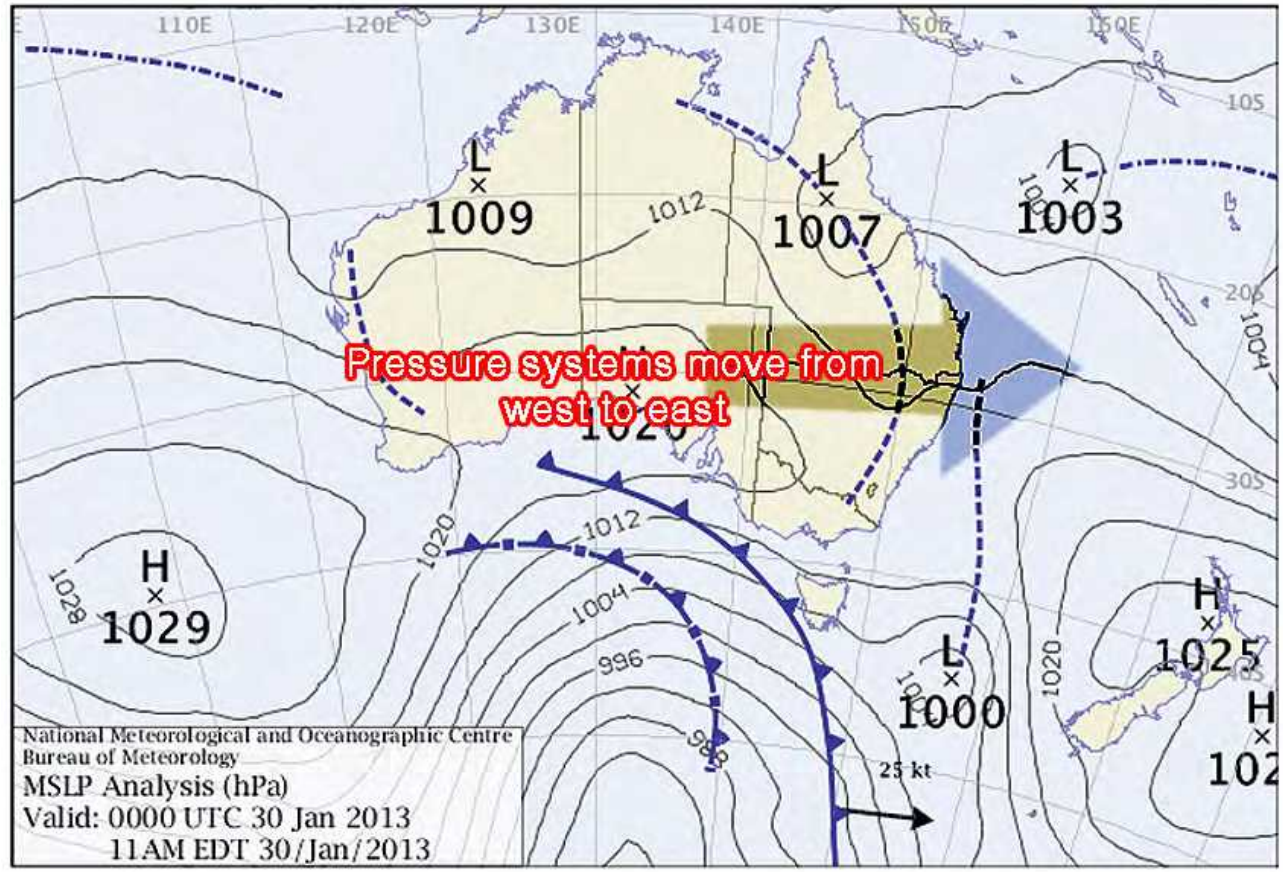
Question

Indicate how each of the following drives ocean and nearshore weather patterns

A. Barometric pressure
B. Temperature and breezes
C. Wind speed
D. Rainfall

Barometric pressure

Weather maps show areas of high and low pressure moving from west to east across Australia.



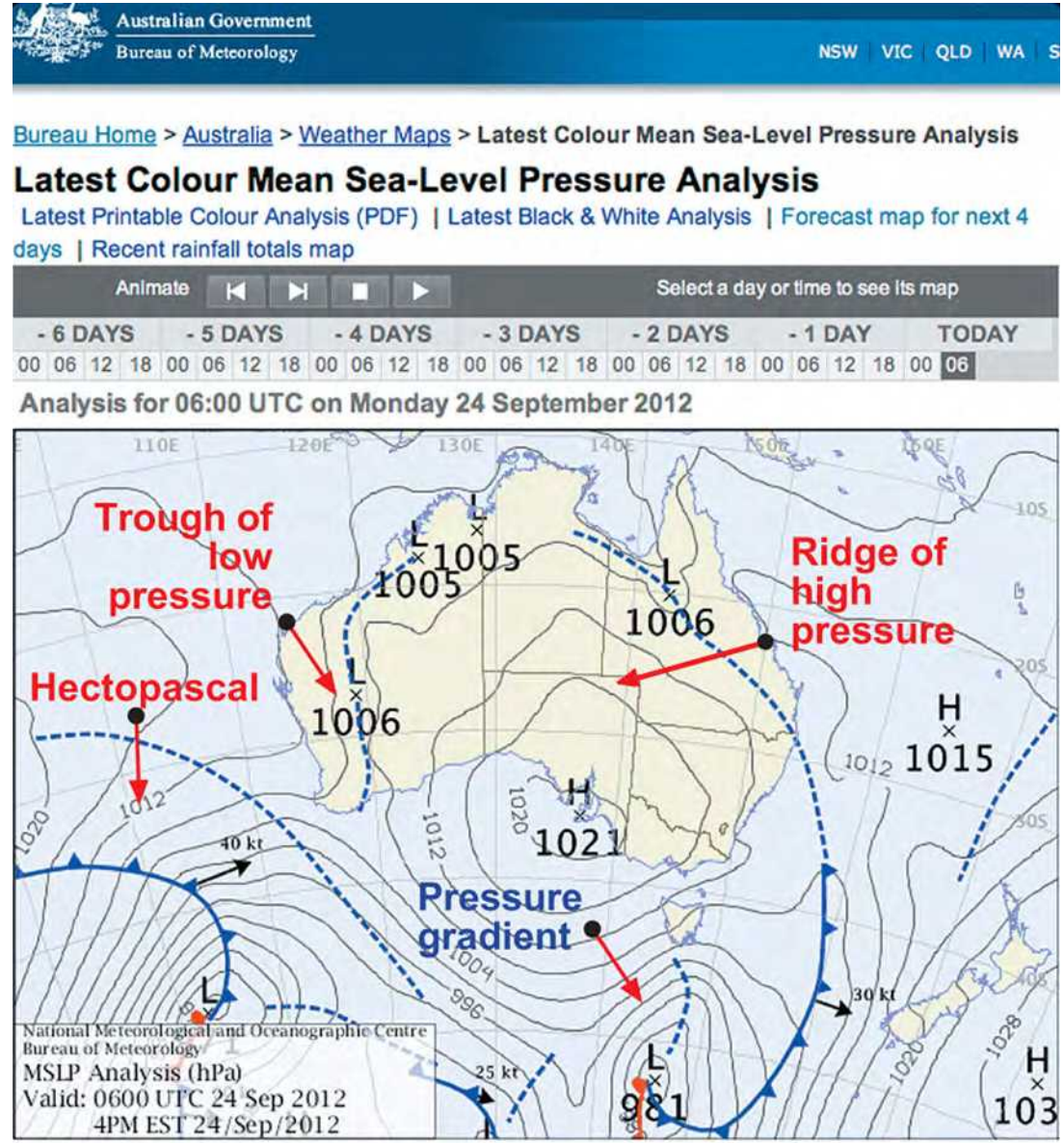
Weather map showing pressure systems movement

Illustration Australian Government Bureau of Meteorology

These high and low pressure systems are associated with storms, cyclones, fronts and ridges.

A ridge is an elongated area of high pressure extending out from a high.

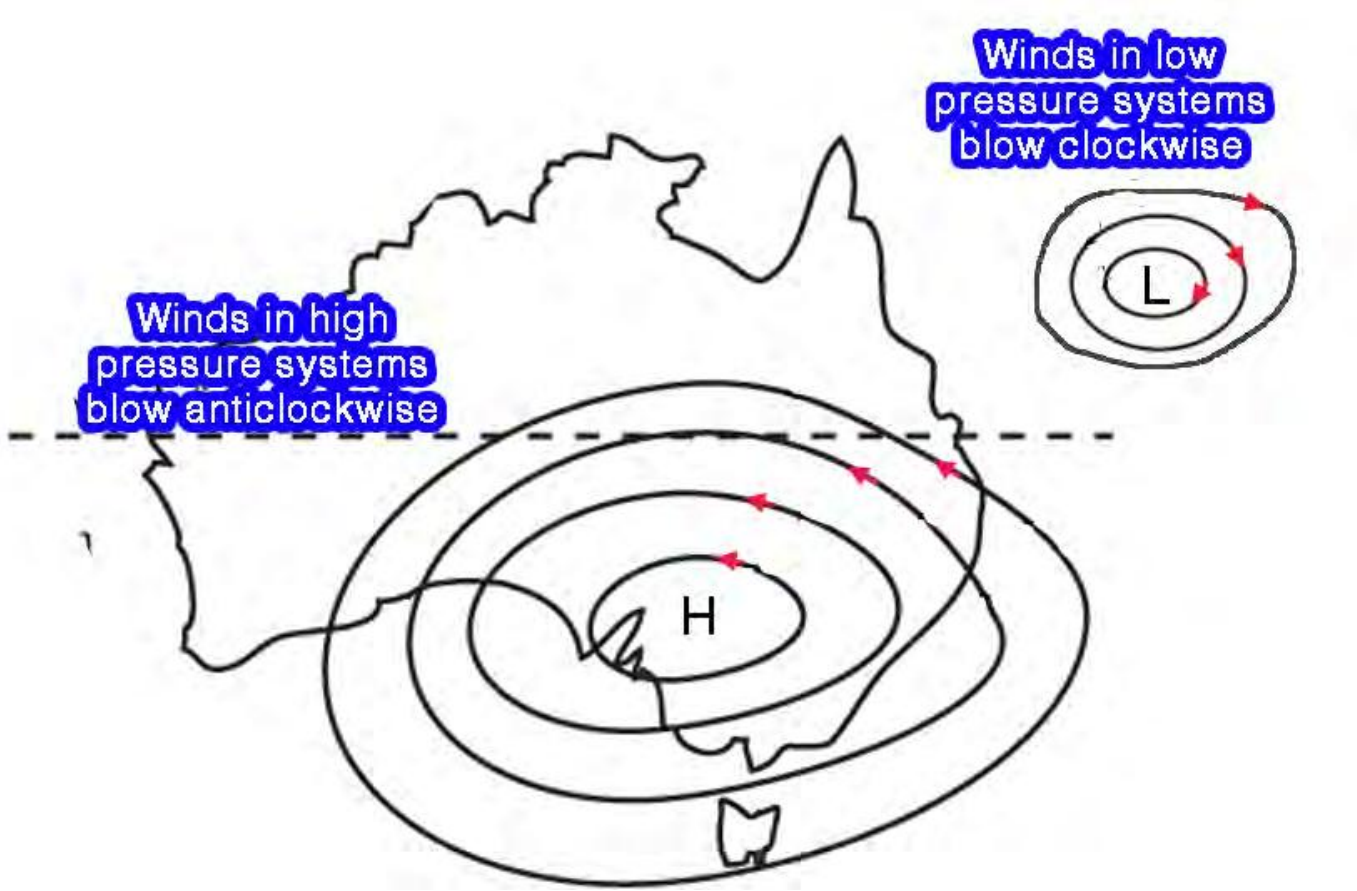
A trough is a elongated area of low pressure, extending south from a low, also shown on the map to the right.



Weather map with ID

Illustration Bob Moffatt using Australian Government Bureau of Meteorology weather map

Winds in high pressure systems blow anticlockwise, and lows clockwise.



High and low pressure wind direction

Illustration Bob Moffatt

Winds that tend to blow out of a high pressure system, are cool, rotate anticlockwise (anti-cyclone) and tend to produce fine stable conditions.

Surf with high pressure system with isobars far apart (no pressure gradient)

Photo Bob Moffatt

Low pressure systems contain warm, moist air and bring heavy rain for long periods of time.

Low pressure rain depression

Australian Government Bureau of Meteorology weather map

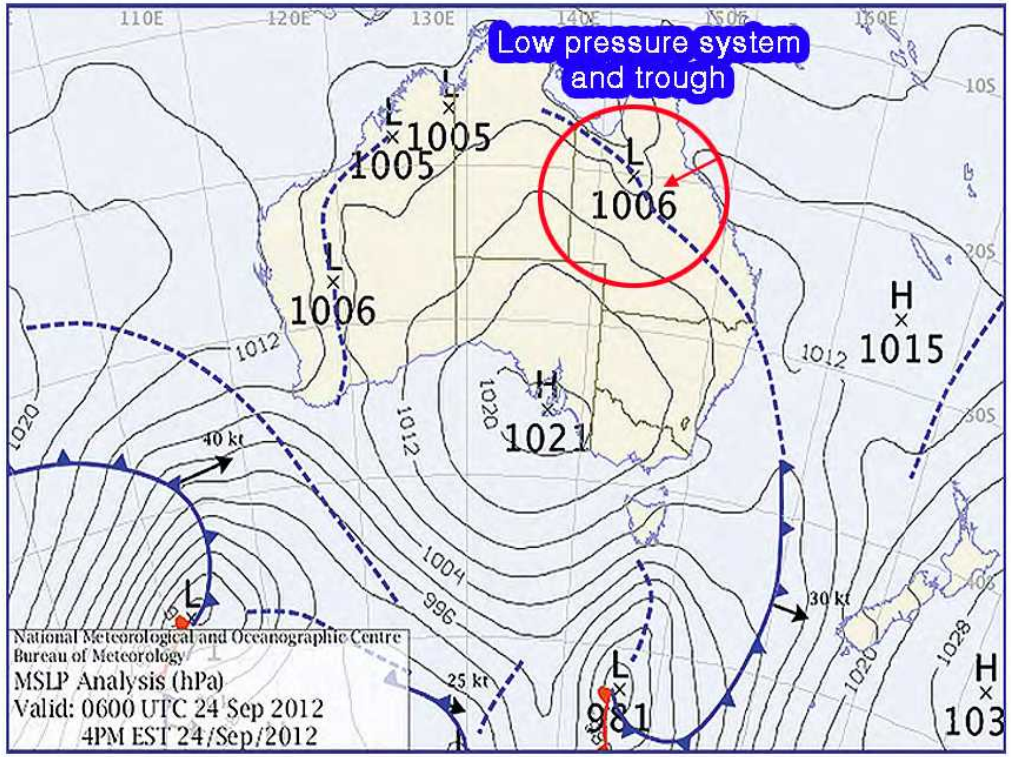
High pressure systems bring the south east trade winds which create dominant patterns of longshore drift on the east coast.

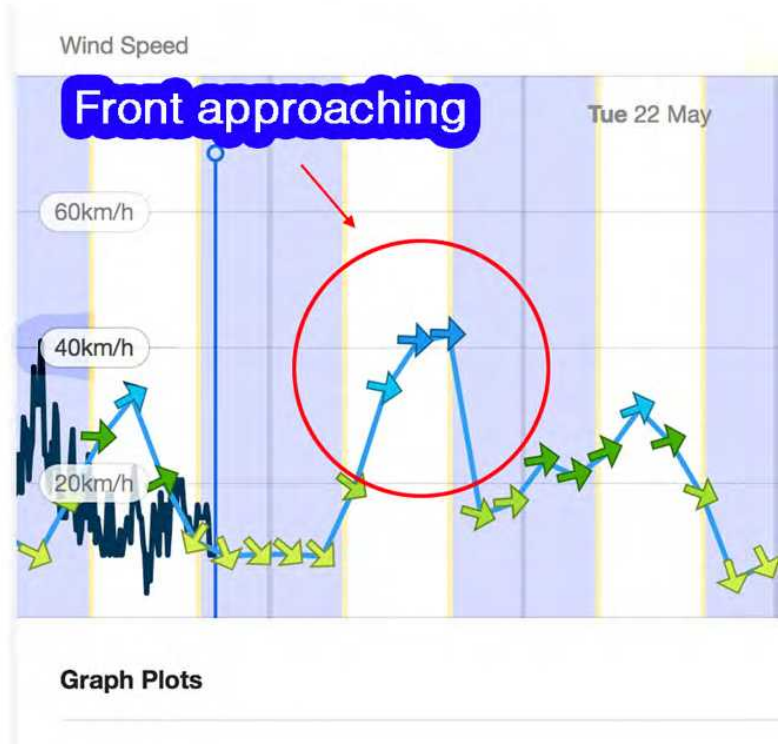
Trade wind effects on Qld coast islands

Photo Viewfinder

Fronts

A front is formed when a body of air of one temperature meets a body of air of another temperature. Wind speeds increase as a front passes the coastline.





Weather map with front and wind speed

Illustration Bob Moffatt using Australian Government Bureau of Meteorology weather map

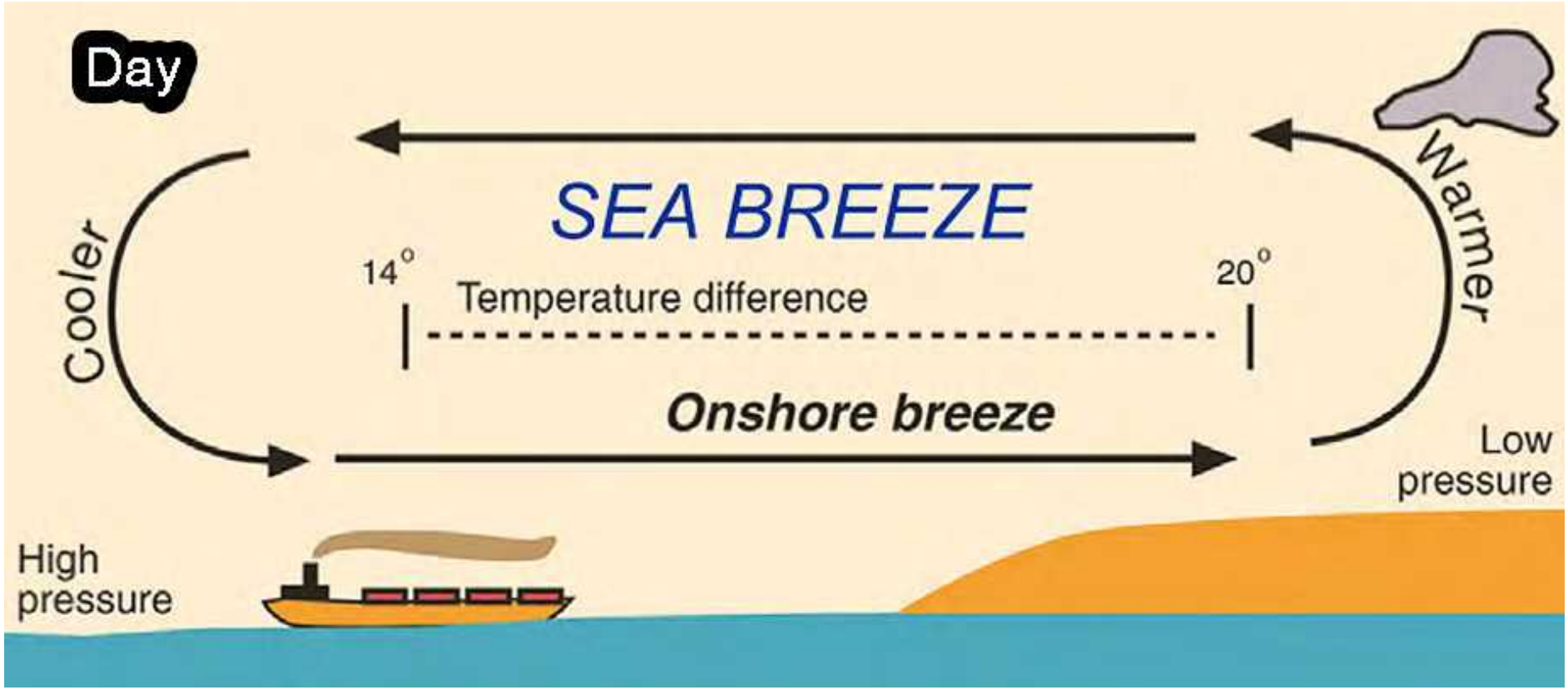
Temperature and breezes

During the cool of the night, air above the sea, being warmer than that above the land, begins to rise. Cooler air moves seaward to replace the warm sea air creating a land breeze.

Night breeze

Illustration Bob Moffatt

During the heat of the day, air above the land warms, and becomes less dense, causing it to rise. The air above the sea, being cooler and more dense replaces the air on the land creating a sea breeze.

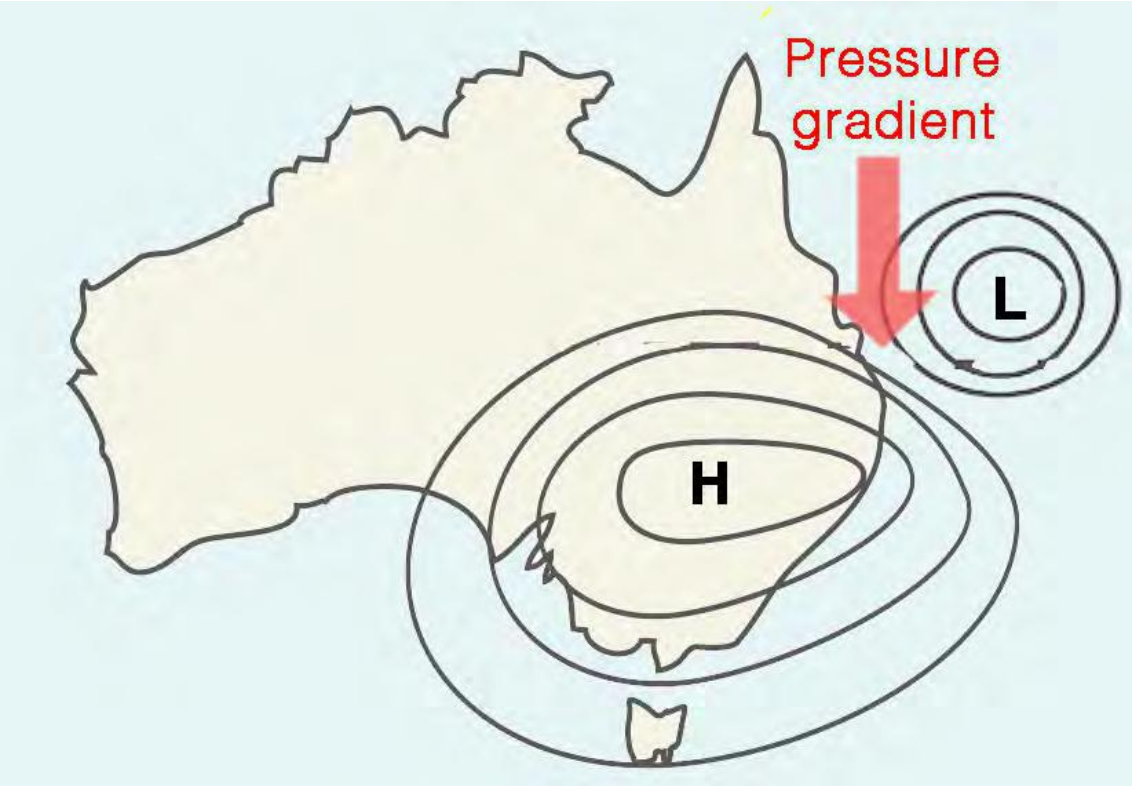


Daytime breeze

Illustration Bob Moffatt

Wind speed

Isobars indicate wind speed and are lines that join places of the same atmospheric pressure. When high and low pressure systems squeeze together, a pressure gradient forms.



The closer the isobars, the steeper the gradient, the windier it is.

Illustration Bob Moffatt

Rainfall

Ridges bring fine weather. A high-pressure system generally brings good weather – clear skies, cool, dry air.

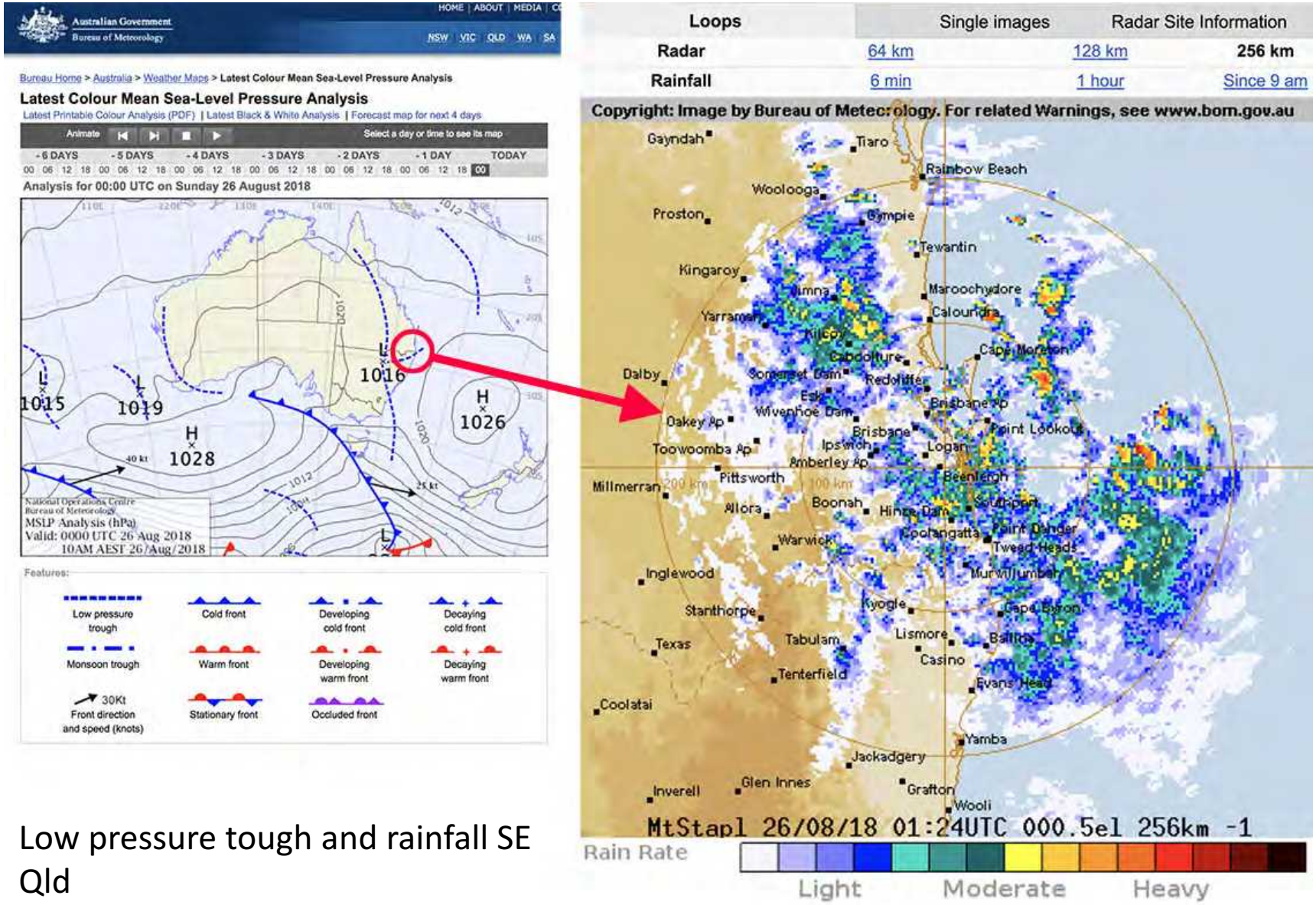
Ridges bring fine weather

Photo Bob Moffatt

Most troughs bring clouds, showers, and a wind shift, particularly following the passage of the trough.

Storm clouds and wind

Photo Bob Moffatt



Low pressure tough and rainfall SE Qld

Images Bureau of Meteorology (Copyright)

Cyclones are low pressure systems with very high winds and waves that alter the marine environment significantly. High rainfall causes large sediment runoff which can affect reefs. High rainfall pushes huge amounts of sediment onto our reefs.

A flood plume containing sediments, nutrients and pesticides flowing onto the Great Barrier Reef from Bundaberg. AAP Image/James Cook University

Flood plume Bundaberg 2015

Photo James Cook University

Question

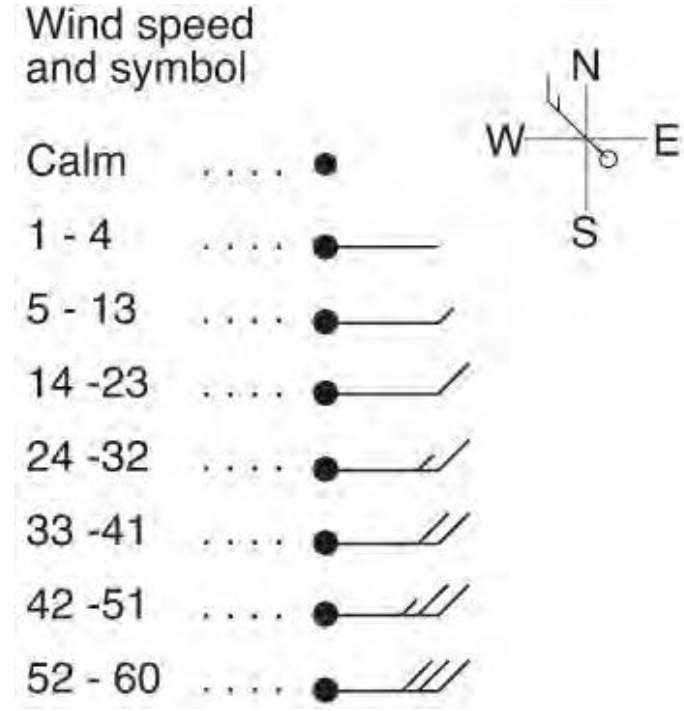
What is the difference between the following meteorological terms and what effects do they have on your local weather?

A. Barometric pressure

B. Temperature and breezes

C. Wind speed and direction

D. Rainfall



T019 Wave formation

Syllabus statement

At the end of this topic you should be able to … **Recall** wave formation processes (e.g. fetch, relationship of wave height and type to water depth and wave celerity), barometric pressure)

Recall

- remember;

- present remembered ideas, facts or experiences;

- bring something back into thought, attention or into one’s mind.

Question

Use the following terms to recall common ocean wave characteristics.

A. Fetch, wave crest, trough, length, height, orbit field, lip, whitewater and face

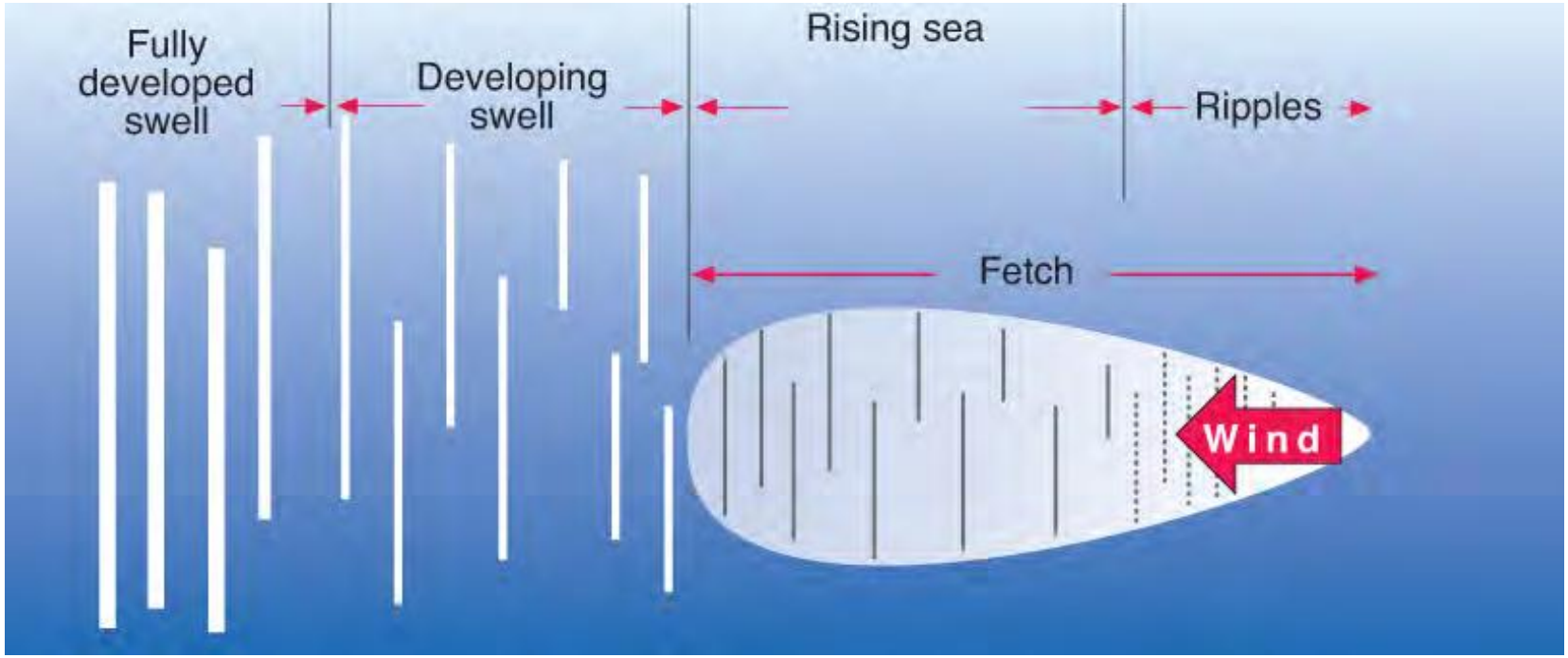
B. Wave height to water depth relationships

C. Wave speed, wave period

Fetch

Wave formation depends on wind speed, length of time the wind blows, the distance over which the wind travels, and the depth of the water.

A fetch is the distance over which the wind travels.



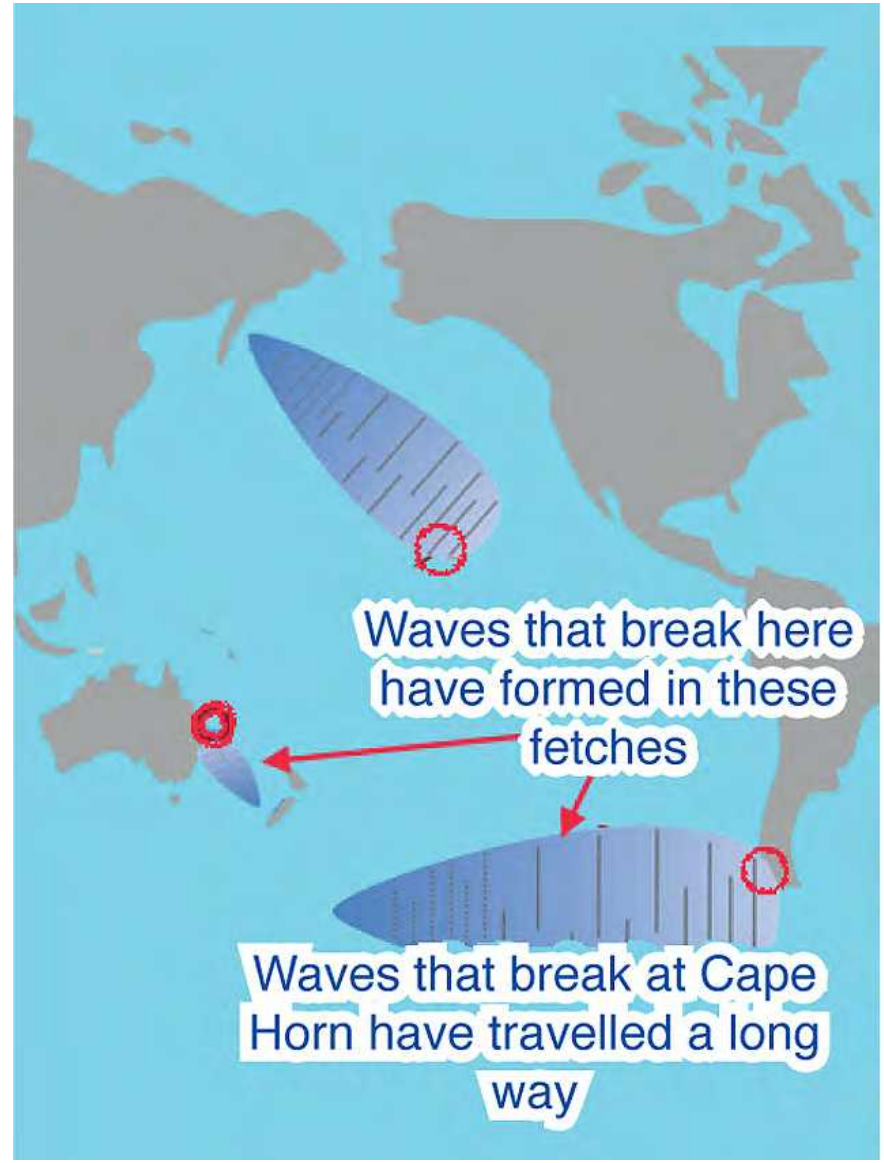
Fetch

Illustration Bob Moffatt

Winds initially produce small ripples.
As these ripples join together, they form waves in a rising sea.
Finally the waves move out of the fetch zone and become ocean swells.

Ocean swells
Photo Bob Moffatt

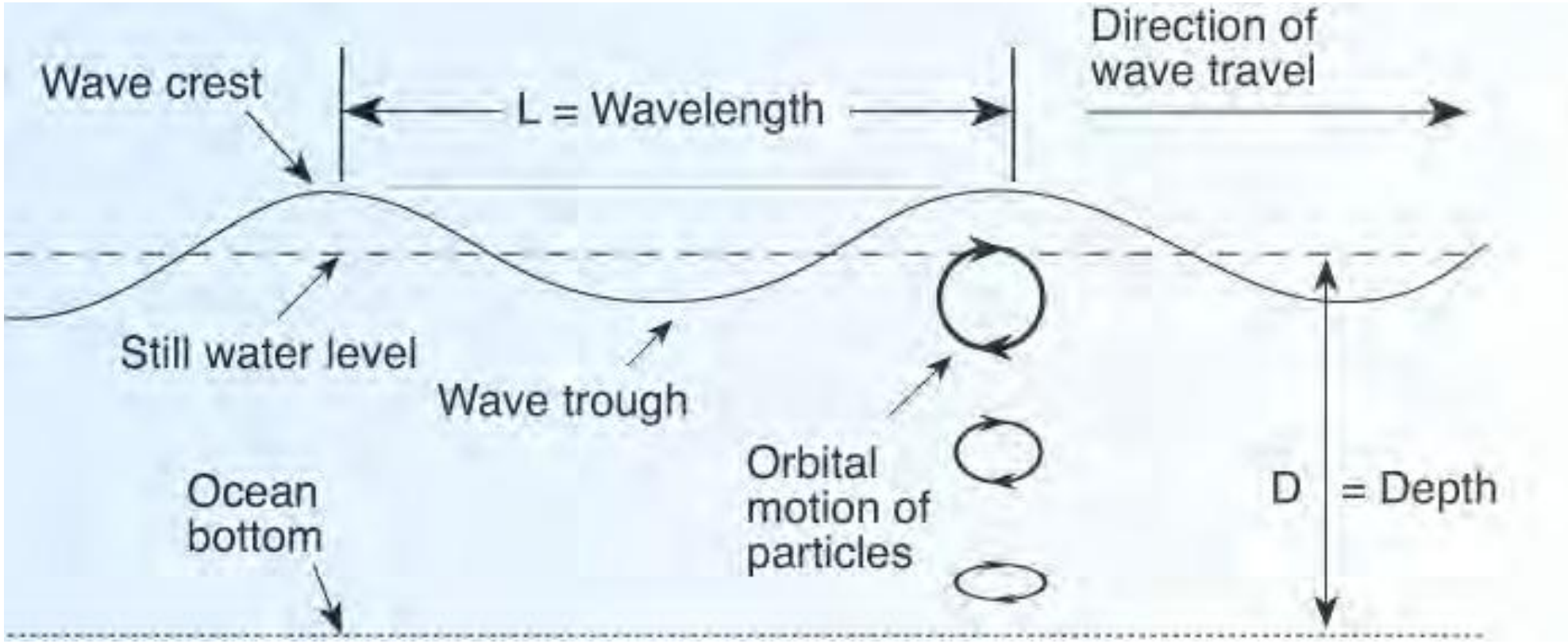
The length of the fetch zone determines shape of ocean waves.



Fetch sizes

Illustration Bob Moffatt

Waves have a length, height and length as show in the diagram below.



Wave characteristics

Illustration Bob Moffatt

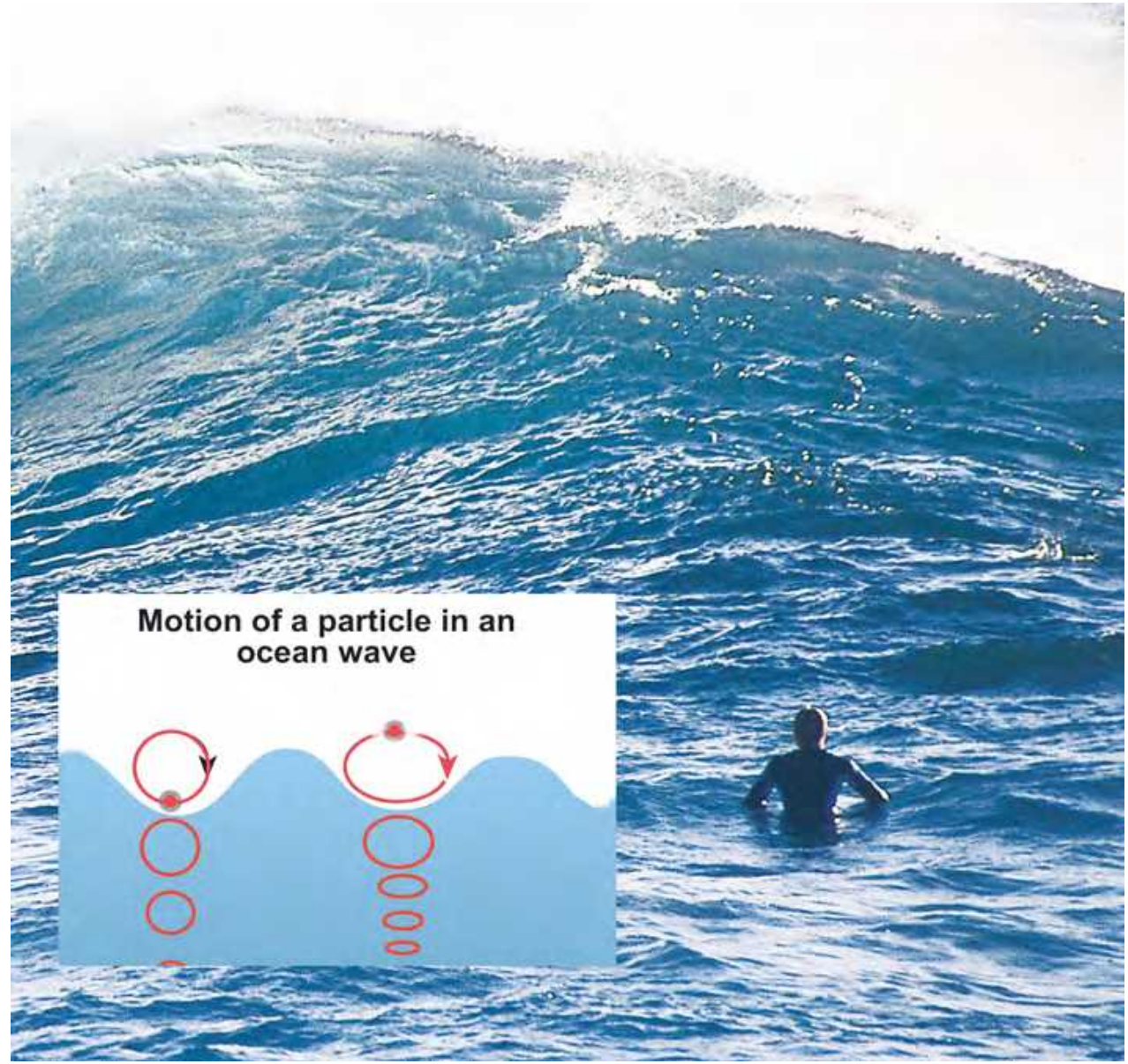
Oceans waves are simply energy moving through the water.

They do not take the water with them.

As the wave arrives it lifts water particles.

These travel forward and circle back in an orbital motion.

The surfer will just go up and down as the wave passes.



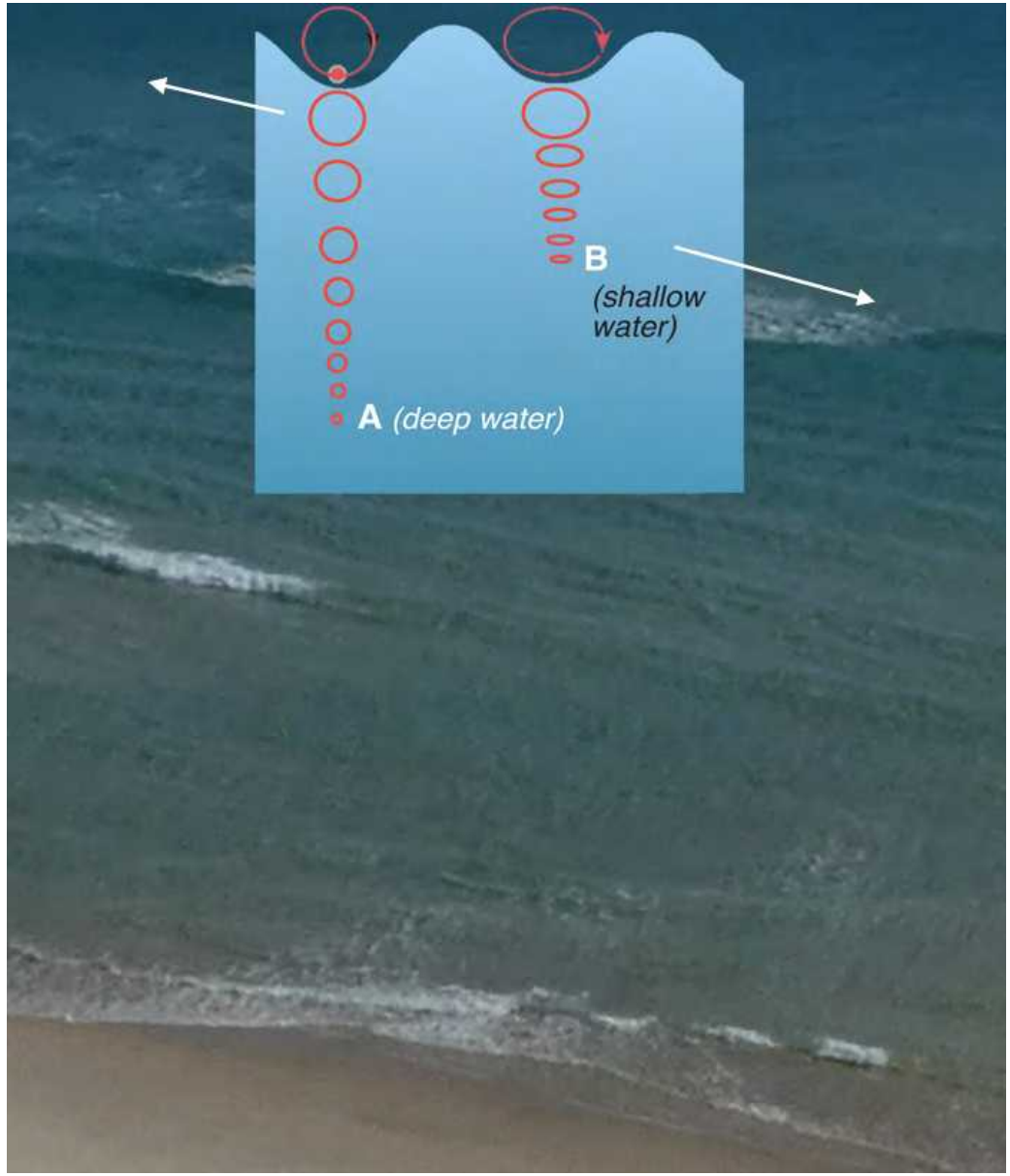
Surfer in orbit field

Photo Bob Moffatt

The circling water near the surface sets off smaller circling movements below them.

In deep water the orbital motion of fluid particles decreases rapidly with increasing depth below the surface.

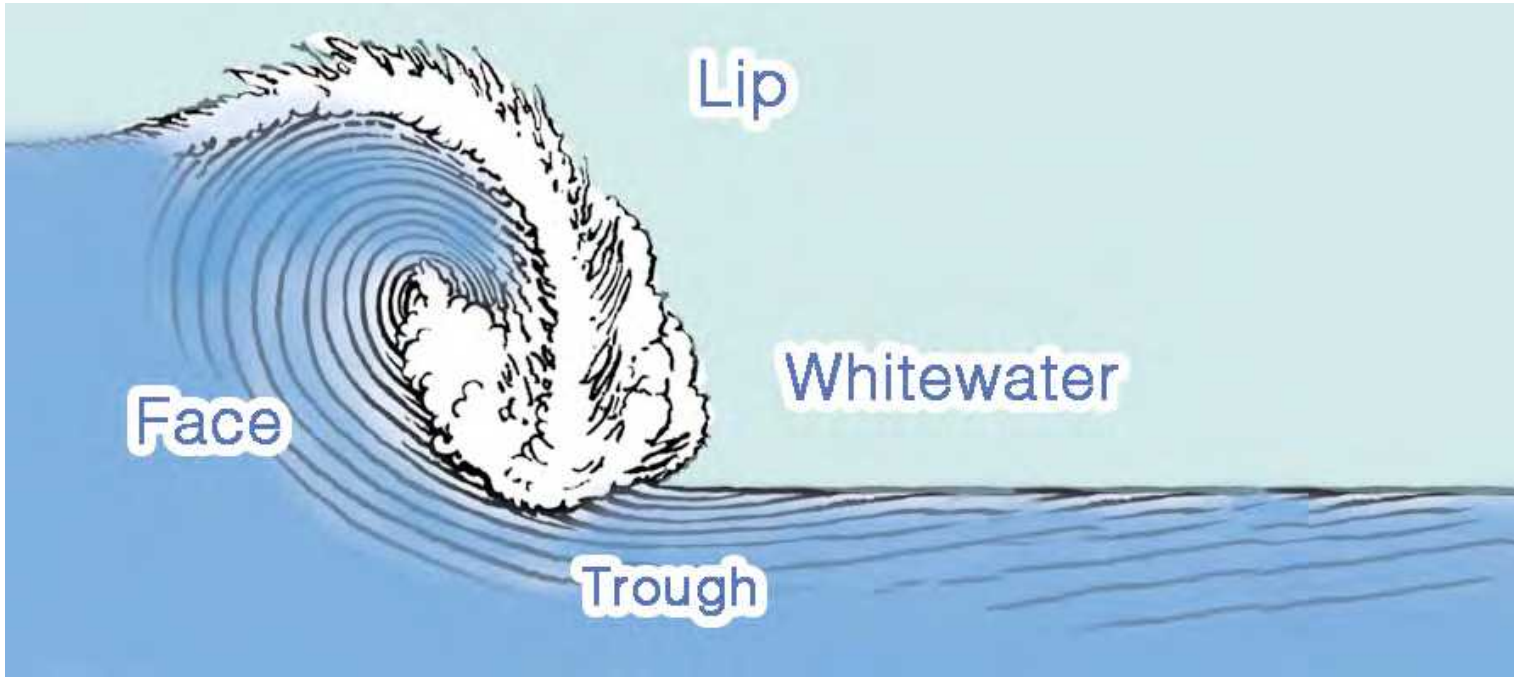
In shallow water, the elliptical movement of a fluid particle flattens with decreasing depth.



Orbit fields deep and shallow water

Photo and Illustration Bob Moffatt

A breaking wave is called a shoaling wave having the characteristics of a lip, face, whitewater and trough.



Parts of a shoaling wave

Illustration Bob Moffatt

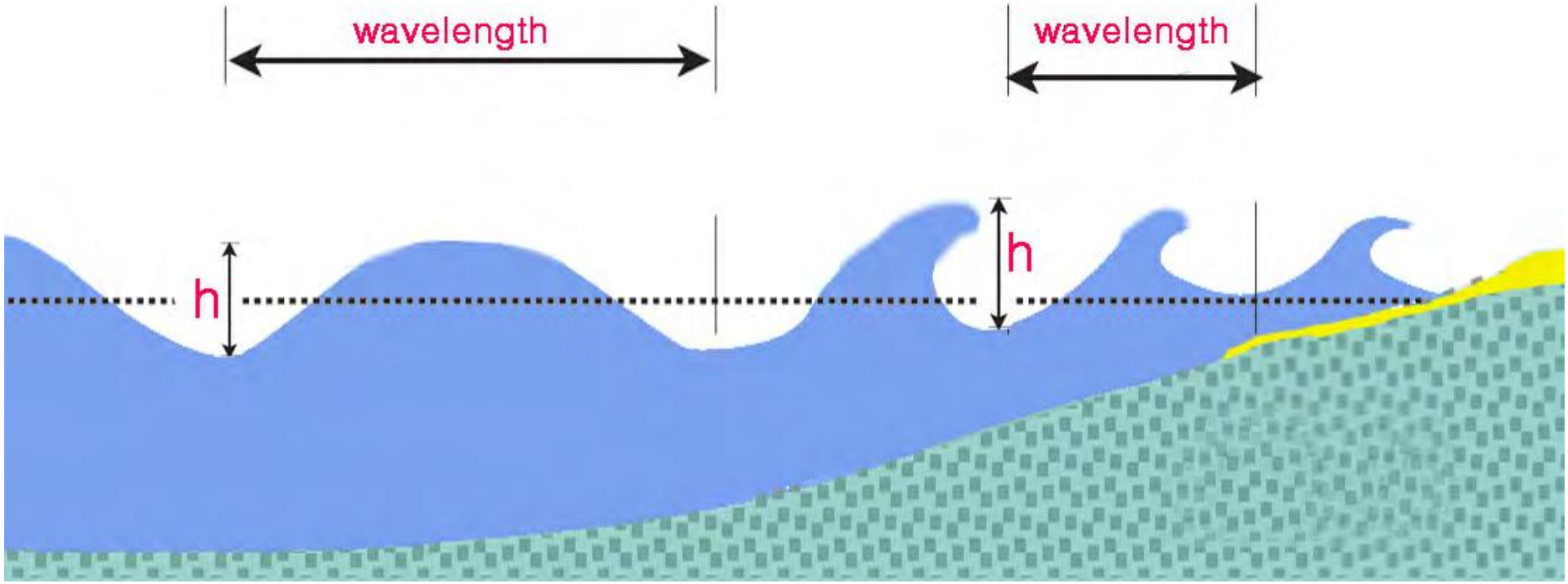
Wave height to water depth relationships

Waves approaching a shore are called shoaling waves.

Shoaling waves

Illustration Bob Moffatt

Shoaling waves become breaking waves and height increases and wavelength decreases because the orbit field interacts with the seafloor, hence the wave slows down.



Waves as they approach a shore

Illustration Bob Moffatt

Three types of wave can form depending on the bathymetry of the ocean floor.

Spilling waves are normally associated with gently sloping beaches where the top of the wave “spills” down the face of the wave.

Spilling wave
Photo Bob Moffatt

Plunging wave or “barrels” occur more commonly at low tide when the water is shallower.

Surfer in barrel

Photo View finder

These waves carry a great amount of energy and are dangerous for the inexperienced surfer (capable of spearing the surfer into the sand or reef below the shallow water).

Plunging wave

Photo Dick Hoole

Surging waves never break as they approach the shore, and are mostly associated with rocky headlands.

As surging waves carry enormous
power, rock fishermen need to take extreme care when fishing from rocky outcrop

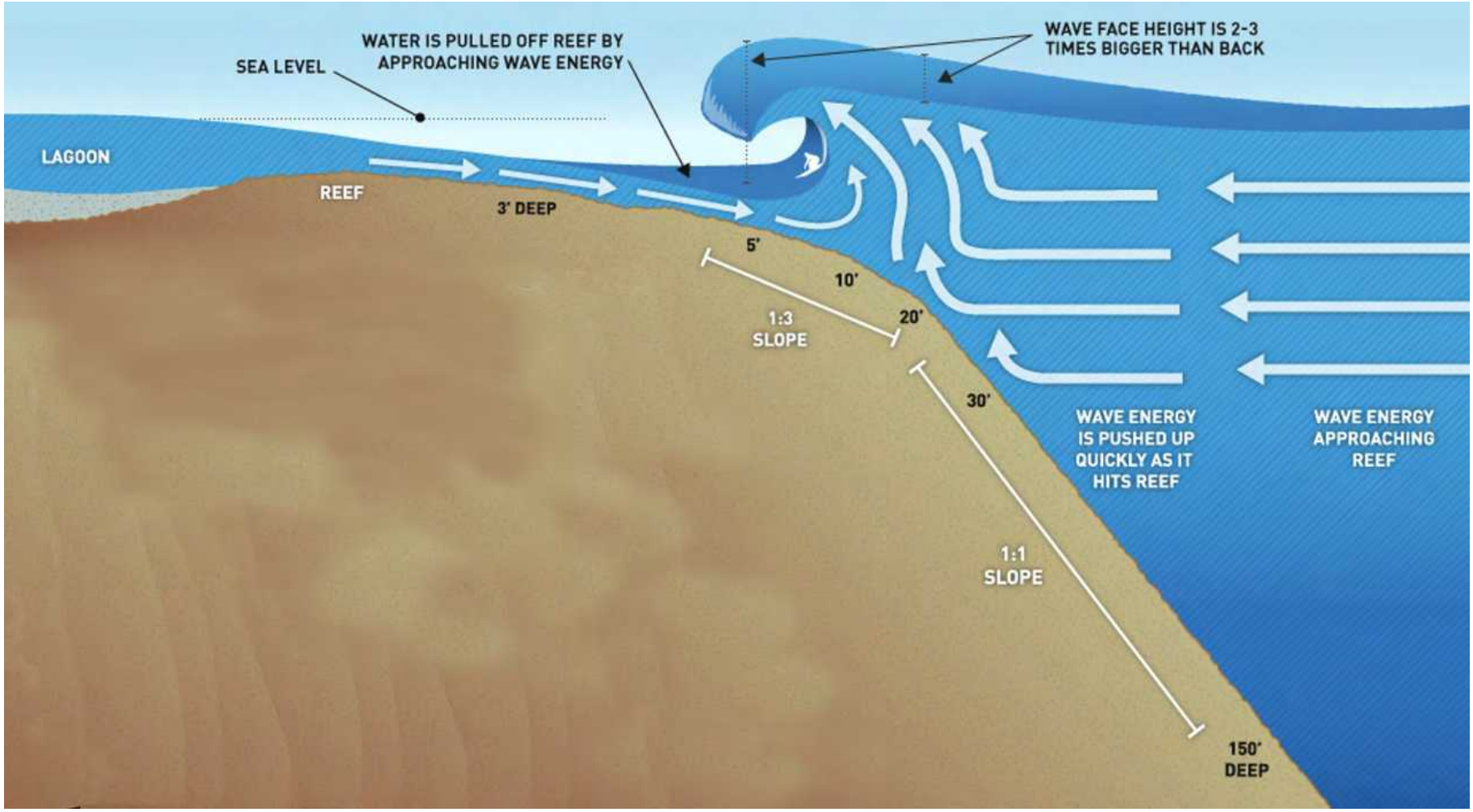
Surging wave
Photo Bob Moffatt

Wave height to water depth relationships can be useful in describing some famous surf breaks. For example Teahupo reef break in Tahiti.

“Choooww poo”

Kite surfing Teahupoo

Here the coral reef juts up from 45 metres changing rapidly from a 1:1 slope to a 1:3 slope



Teahupo wave mechanics

http://www.surfline.com/surf-news/teahupoo-surf-mechanics_58392/

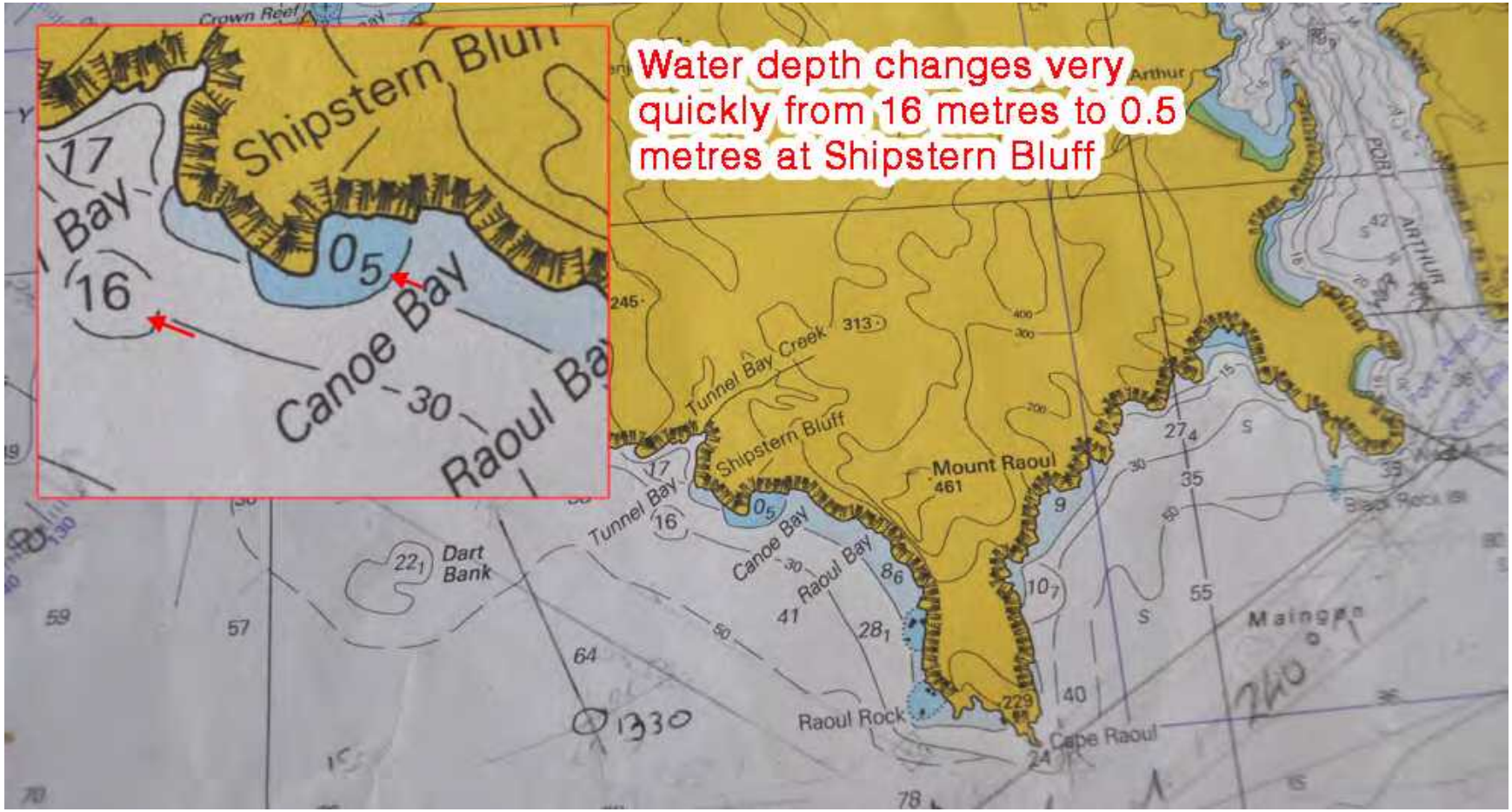
In Australia, a famous surf break at Shipstern Bluff in Tasmania.

Shipstern Bluff

Photo Jones

https://www.adventuresportsnetwork.com/sport/surf/top-ten-deadly-waves-of-the-world/

The seafloor at Shipstern is a slab of granite that takes the brunt of huge swells traveling from deep water and expounding all their force onto this ledge.



Shipstern Bluff water depth changes

Photo Bob Moffatt

Wave celerity, wave period and sets

The time taken for two successive crests (or troughs) to pass a fixed point is known as the wave period (T).

Time between two waves at a point

Photo Bob Moffatt

Wave period is also shown in weather apps

Swell height and period on an app

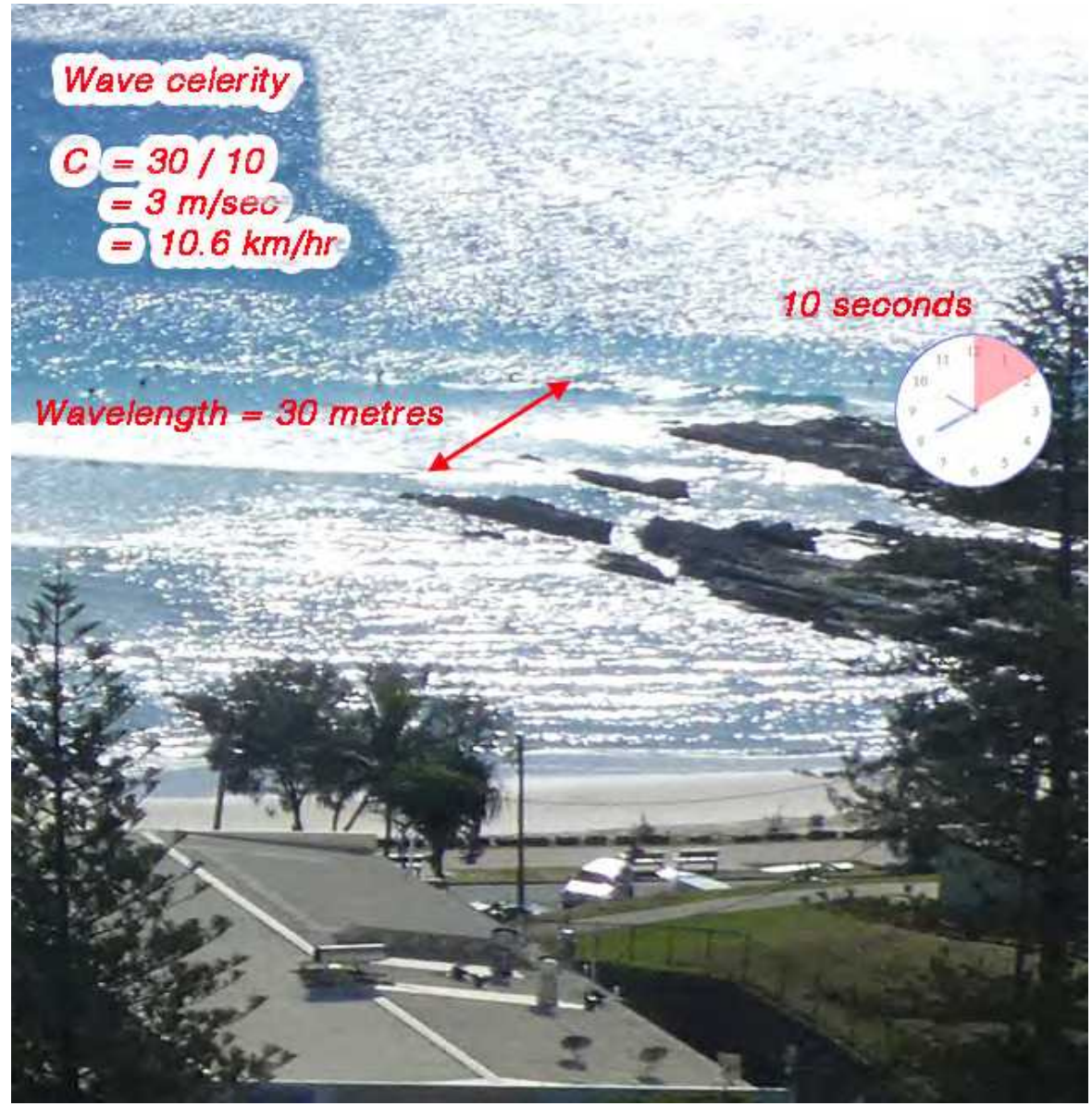
https://www.willyweather.com.au/

The wave celerity (C) or speed is calculated by dividing the wavelength by the wave period (C = L/T).

If the wave period at a point is 10 seconds and length estimated 30 metres, the speed of the wave is 3 m/sec

or

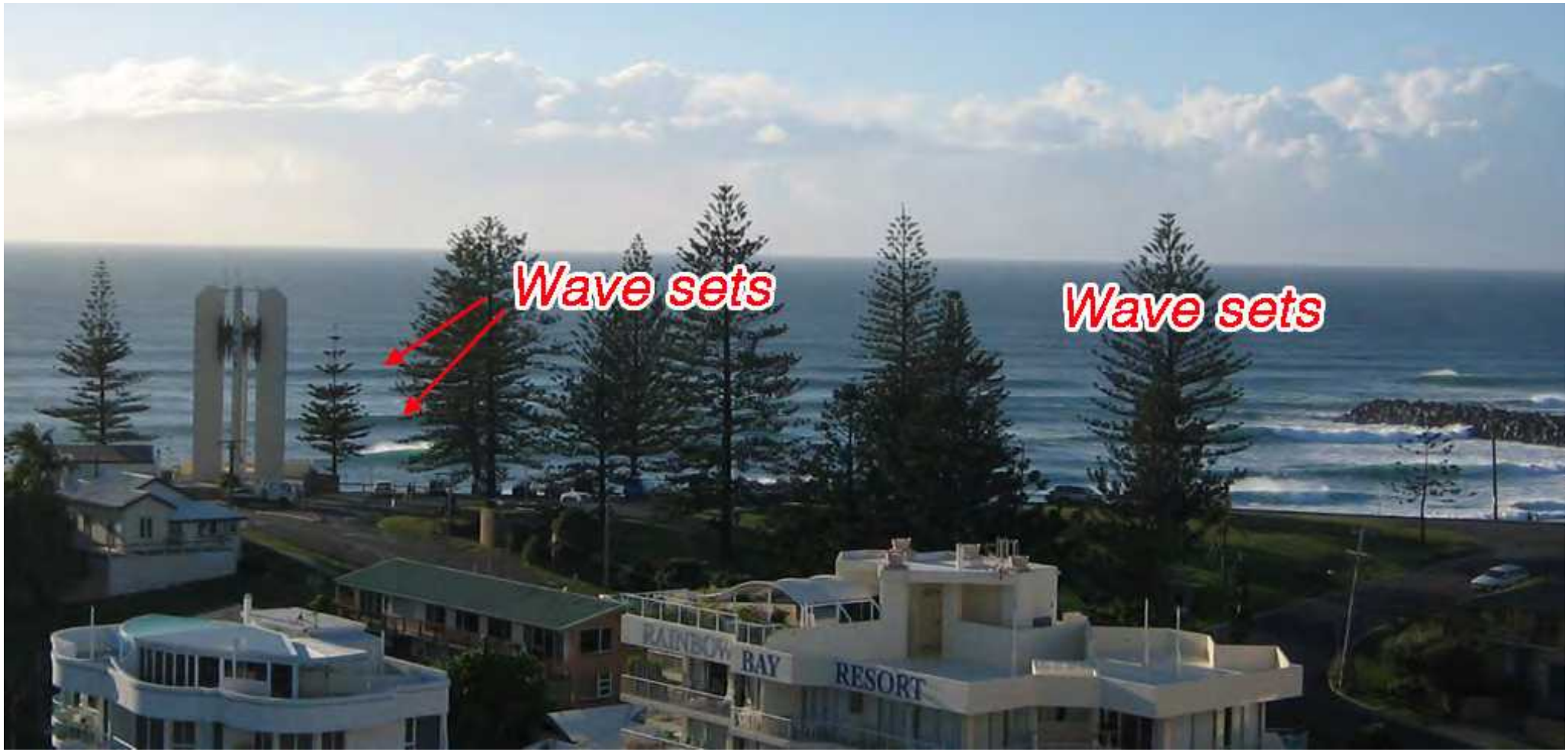
10.8 km/hr



Wave celerity at a point break

Photo Bob Moffatt

Wave sets are waves that come in groups.



Wave sets

Photo Bob Moffatt

Question

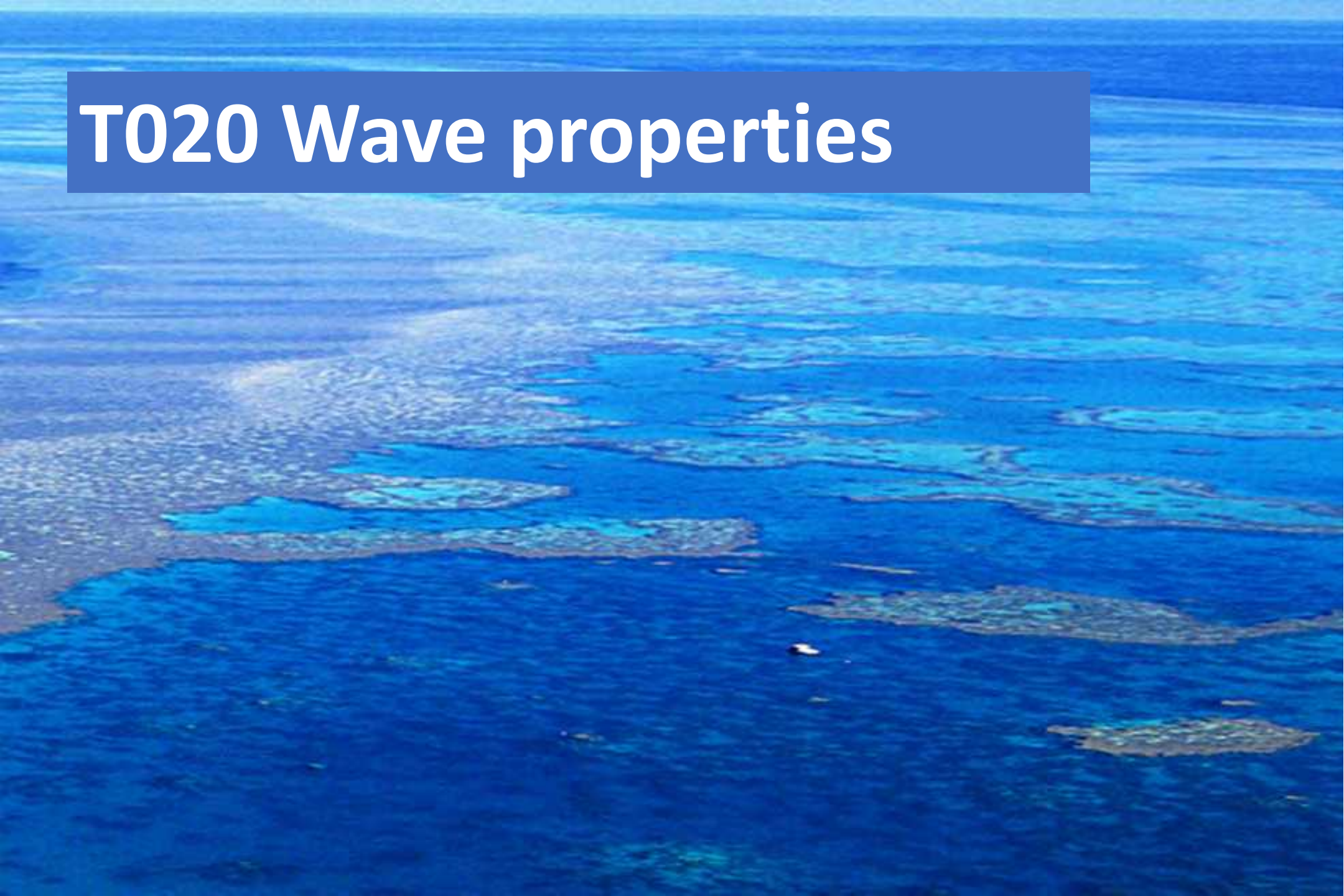
Write a sentence to show you know the meaning of the following wave terms. Draw diagrams to illustrate your answer from your local beach.

A. Fetch, wave crest, trough, length, height, orbit field, lip, whitewater and face

B. Wave height to water depth relationships

C. Wave speed, wave period

T020 Wave properties



Syllabus statement

At the end of this topic you should be able to … **explain** how the properties of waves are shaped by weather patterns, natural formations and artificial structures (e.g. interference patterns, fetch, wave sets).

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

Question

Explain how wave shapes are affected by each the following

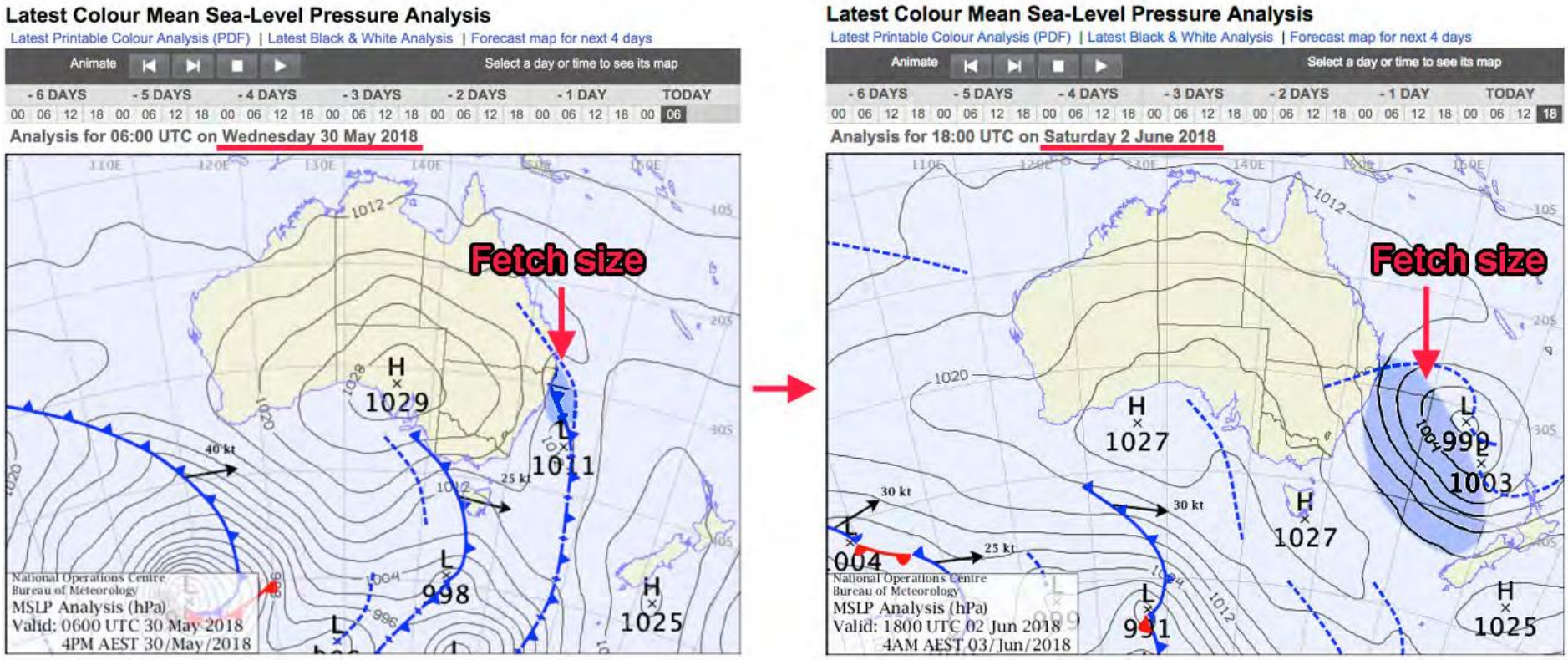
A. Weather patterns

B. Natural formations

C. Artificial structures

Weather patterns

As a low pressure moves adjacent to the East Australian coast, the fetch size increases.



Fetch changes SE Aus

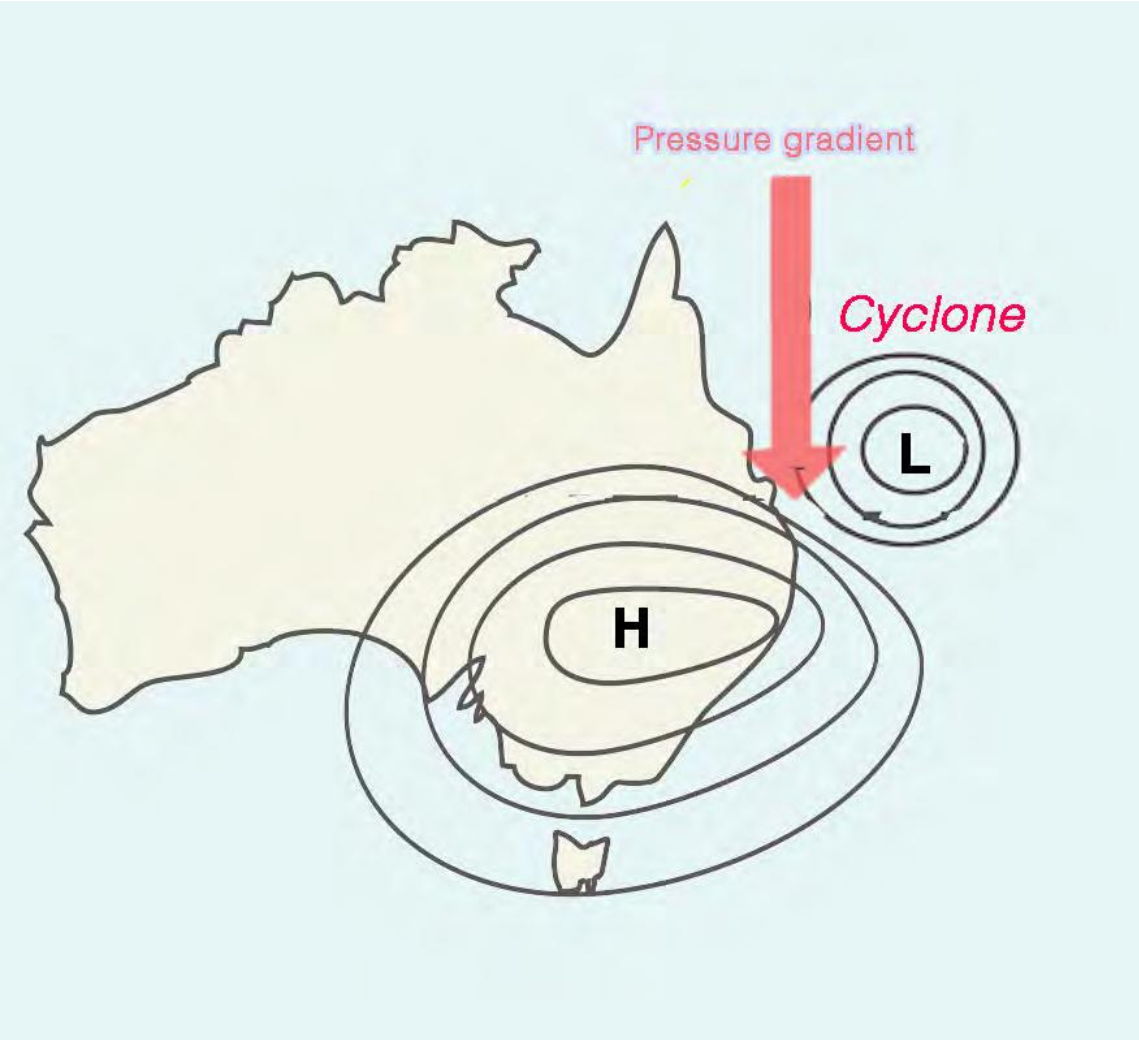
Illustration Bob Moffatt

These high and low pressure systems interact to produce different wave periods and celerities (wave speed).

Wave period short vs long

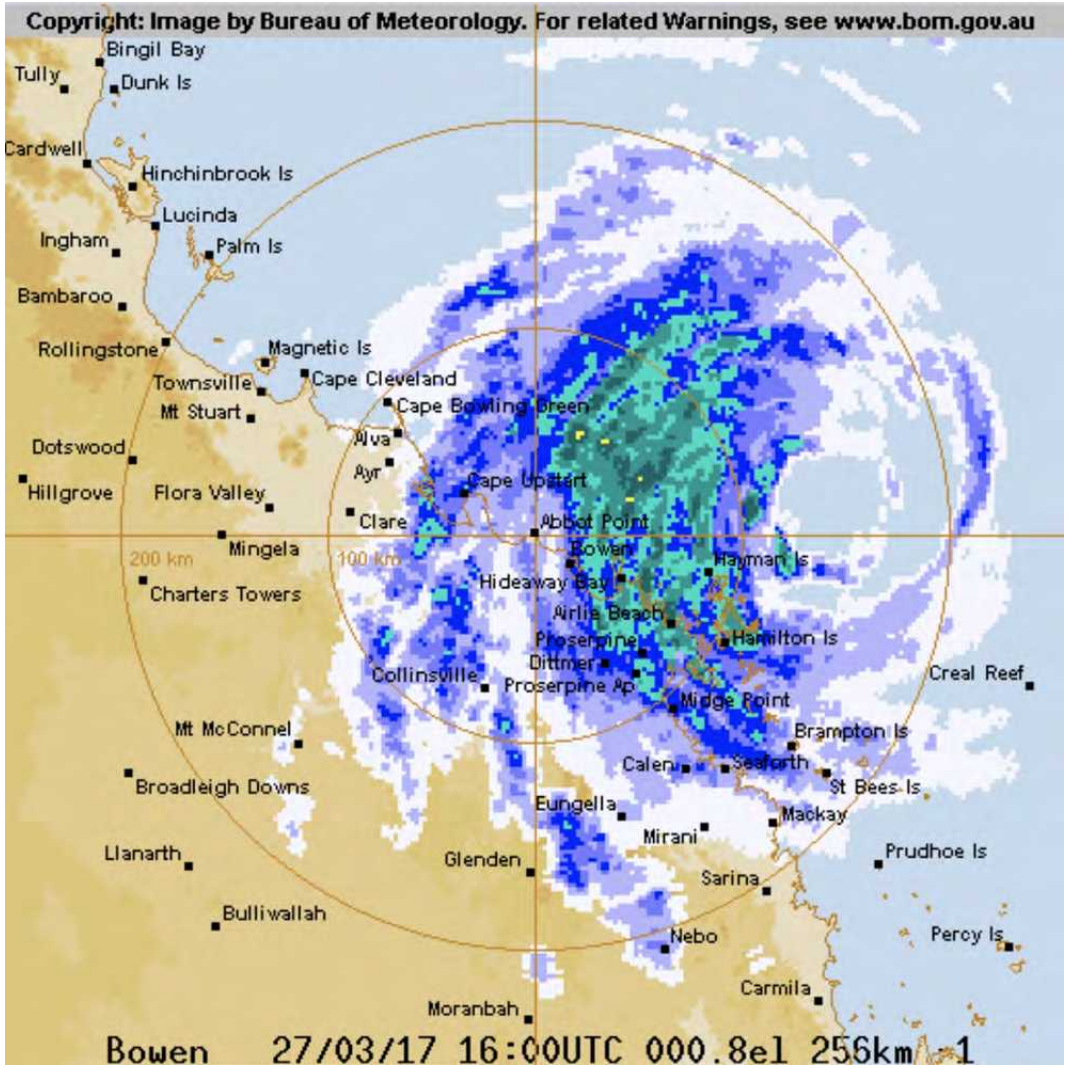
Photo Bob Moffatt

Cyclones also have the same effect creating very high pressure gradients.



Pressure gradient and cyclone

Illustration Bob Moffatt



Cyclone Debbie

Illustration Australian Government Bureau of Meteorology

These pressure system interactions create storm waves.

Storm surf created by east coast low

Photo Bob Moffatt

Winds also affect wave shape.

Waves become lumpy when winds blow onto the shore and smooth out when they change to off shore.

Onshore - offshore surf days

Photo Bob Moffatt

Natural formations

Point break:

A point break refers to the place where waves hit a point of land or rocks jutting out from the coastline.

The seafloor can be made of rocks, sand, or coral.

Point break

Photo Geoff Jensen

Beach break:

A beach break takes place where waves break on a usually sandy seabed.

Beach break Triggs WA

Photo Bob Moffatt

Reef break:

A reef break happens when a wave breaks over a coral reef or a rocky seabed.

Cloudbreak in Fiji.

Shore break:

A shore break is a wave that breaks directly on, or very close to the shore.

This happens when the beach is very steep at the shoreline.

These waves are really just a form of beach or reef break, but breaking very close to the shore.

Shore break
Photo Bob Moffatt

River mouth break:

A river mouth break breaks at or near the entrance to a river or creek.

It can break as either a left-breaking or right-breaking wave, or a peak which breaks both ways.

The bottom is usually sand, but can be pebbles, rocks, or even coral reef.

Surf rivermouth
Photo Bob Moffatt

Tidal bore breaks:

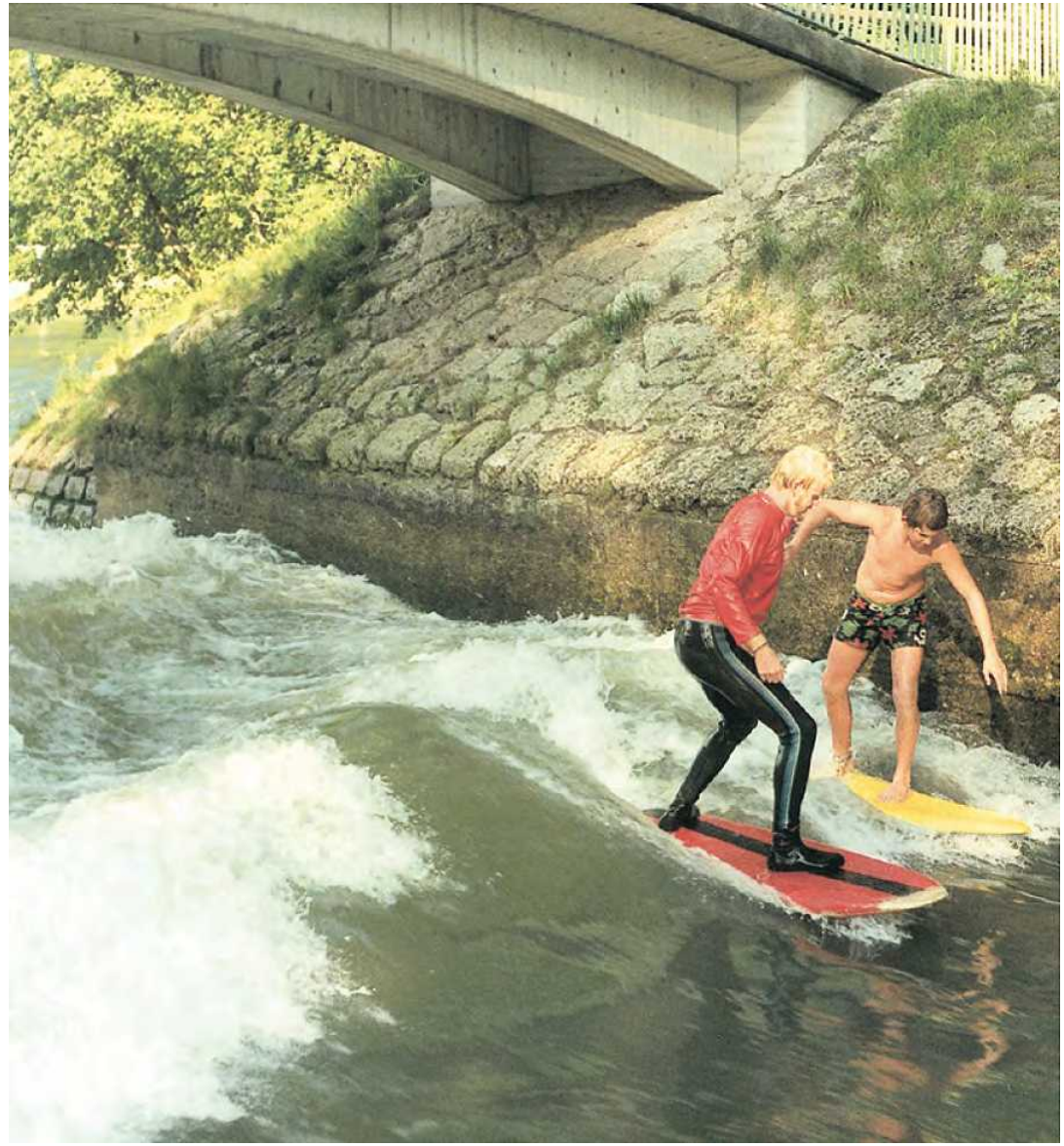
They are formed where stronger and larger tides enter a river or deltaic system, allowing the tide to forcefully push and extend up the river, sometimes forming rideable waves.

The waves can be singular or multiple crested.

Tidal bore seven river

Standing river breaks:

These are waves which are created in some fast flowing rivers or creeks, allowing a surfer to ride a wave for several minutes or more whilst standing or lying more or less stationary within the river.



Standing wave in River near Munich, Germany

Photo Bob Moffatt

Ocean canyon breaks:

Very high breaking waves in Portugal form due to the presence of an underwater Canyon.

Nazaré Canyon in Portugal coast.

By NASA (Blue Marble Next Generation) [Public domain], via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Canh%C3%A3o_da_Nazar%C3%A9.jpg

Can you see the surfer?

Biggest surf break in the world

You can read more at

https://www.surfertoday.com/surfing/8247-the-mechanics-of-the-nazare-canyon-wave

Artificial structures

Artificial reef break:

These are made by placing geotextile bags filled with sand on the seafloor close to the coastline. Waves are created as water approaches the underwater obstacles (artificial reef).

Artificial reef break

Photo Bob Moffatt

Artificial reef from geotextile bags

Photo Bob Moffatt

Geotextile bag

Photo Bob Moffatt

Groyne break:

These waves break along or near a groyne or training walls.

Photo Bob Moffatt

Artificial wave pool breaks:

These are waves generated in an artificially created pool with a powerful wave-generating device, to form waves which can be surfed without any need for an existing, natural water environment, such as an ocean or shoreline.

Wavepool - Snowdonia Wales

By DeFacto [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], from Wikimedia Commons
https://upload.wikimedia.org/wikipedia/commons/9/9a/Surf_Snowdonia_overview_from_the_west.jpg

Question

Explain how wave shapes are affected by each the following

A. Weather patterns

B. Natural formations

C. Artificial structures

Ch 5 Coastal impacts

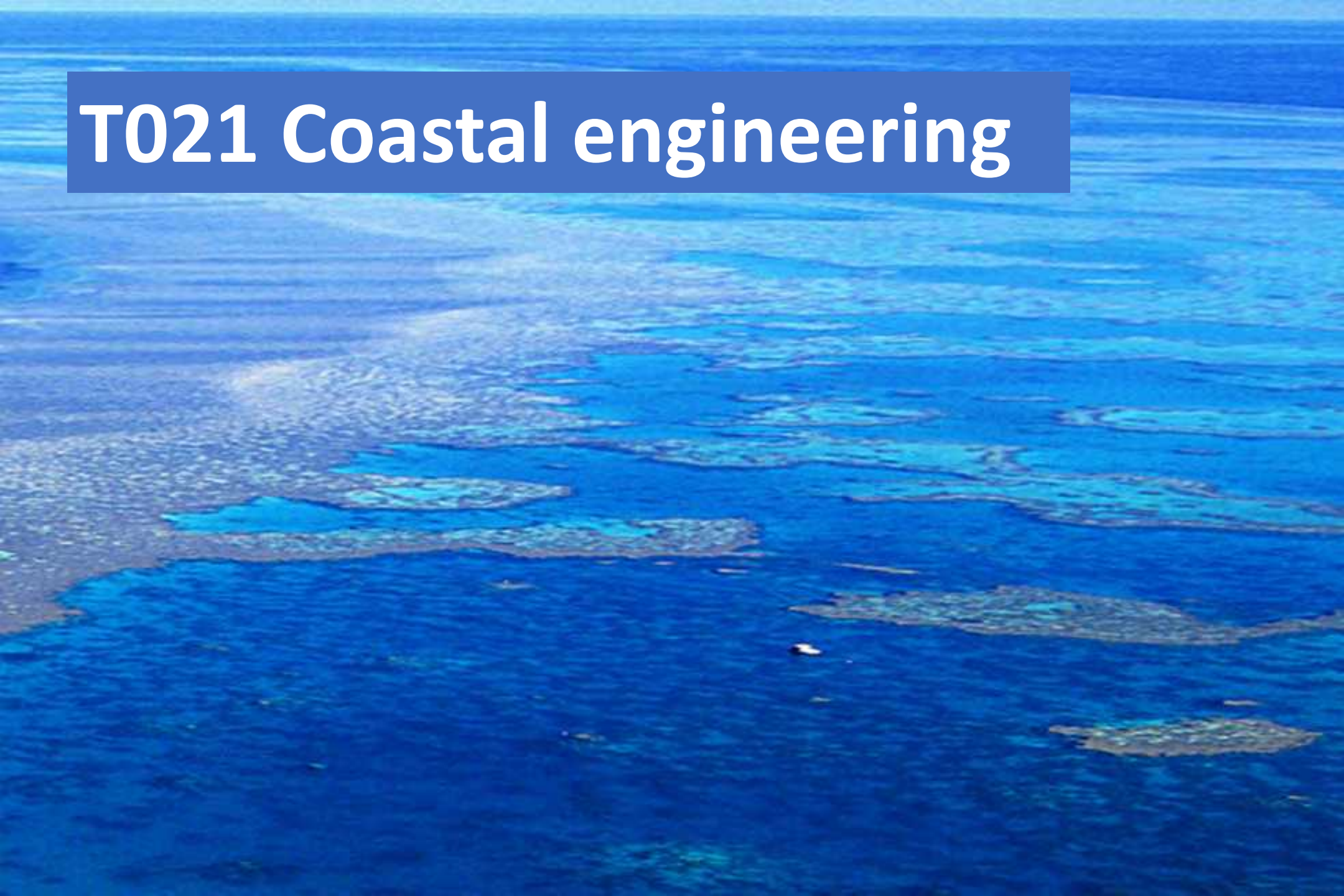
Coastal engineering

Longitudinal studies

How organisms populate areas

Population density data

Types of pollution


T021 Coastal engineering

Syllabus statement

At the end of this topic you should be able to … **explain** how coastal engineering regulates water or sediment flow, affects currents and impacts the coastline, including marine ecosystems

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.

Question

Explain how the following coastal engineering works regulate water, sediment flow, longshore current and impact on a coastal ecosystem.

A. Groynes and training walls

B. Sand pumping jetties

C. Marinas and canal estates

Groynes and training walls

A groyne is a rigid structure built from an ocean shore or from a bank (in rivers) that interrupts water flow and limits the movement of sediment.

Photo Bob Moffatt

Photo Bob Moffatt

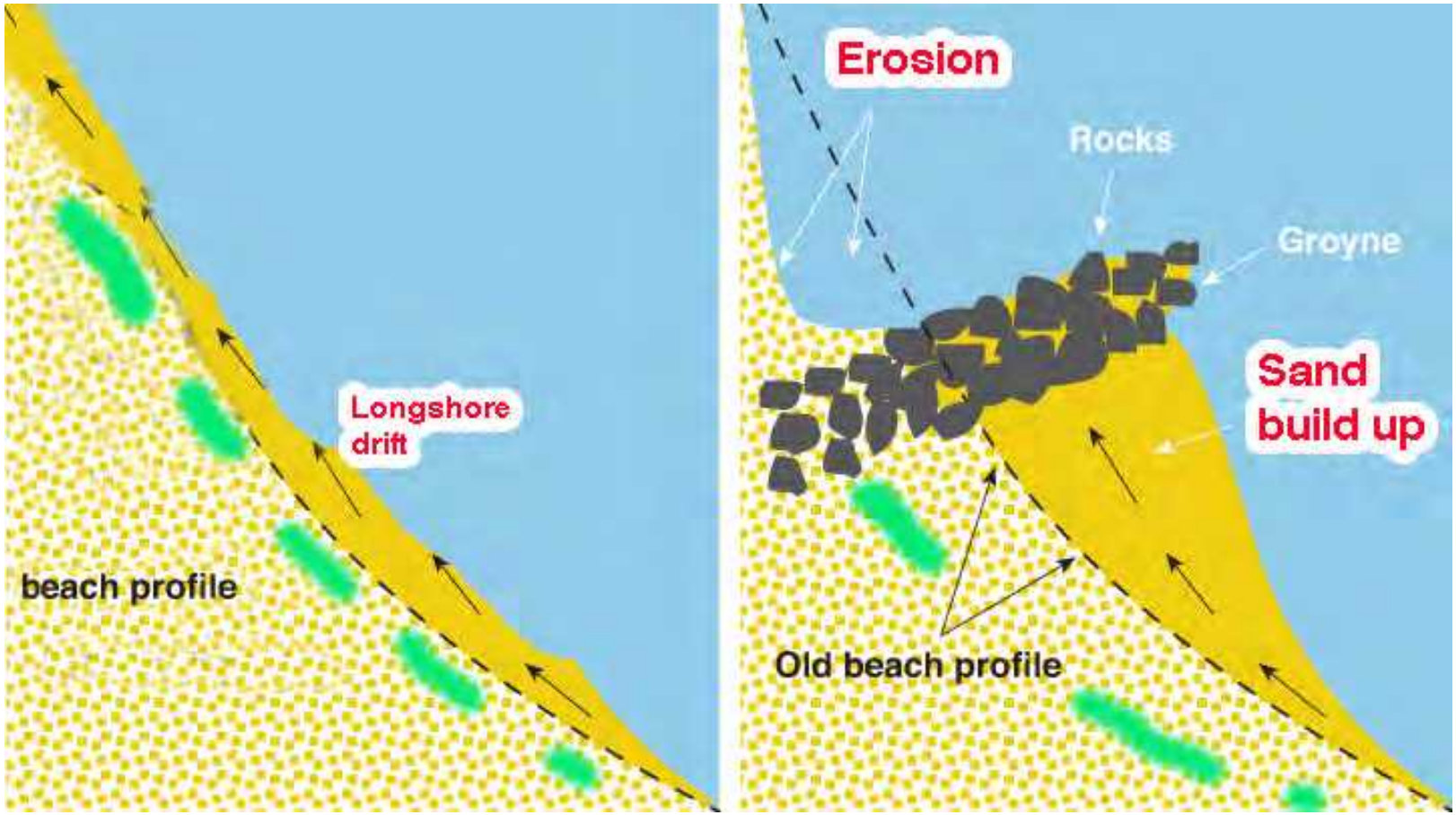
A training wall is two groynes at the mouth of a river to ensure safe navigation through a passage.

Training wall

Photo Bob Moffatt

The effect of groynes is that longshore flow of sediments is significantly reduced.

Sand builds up on one side and erodes on the other due to refraction.



Effect of a groin

Photo Bob Moffatt

Effect of a groyne.

Photo Bob Moffatt

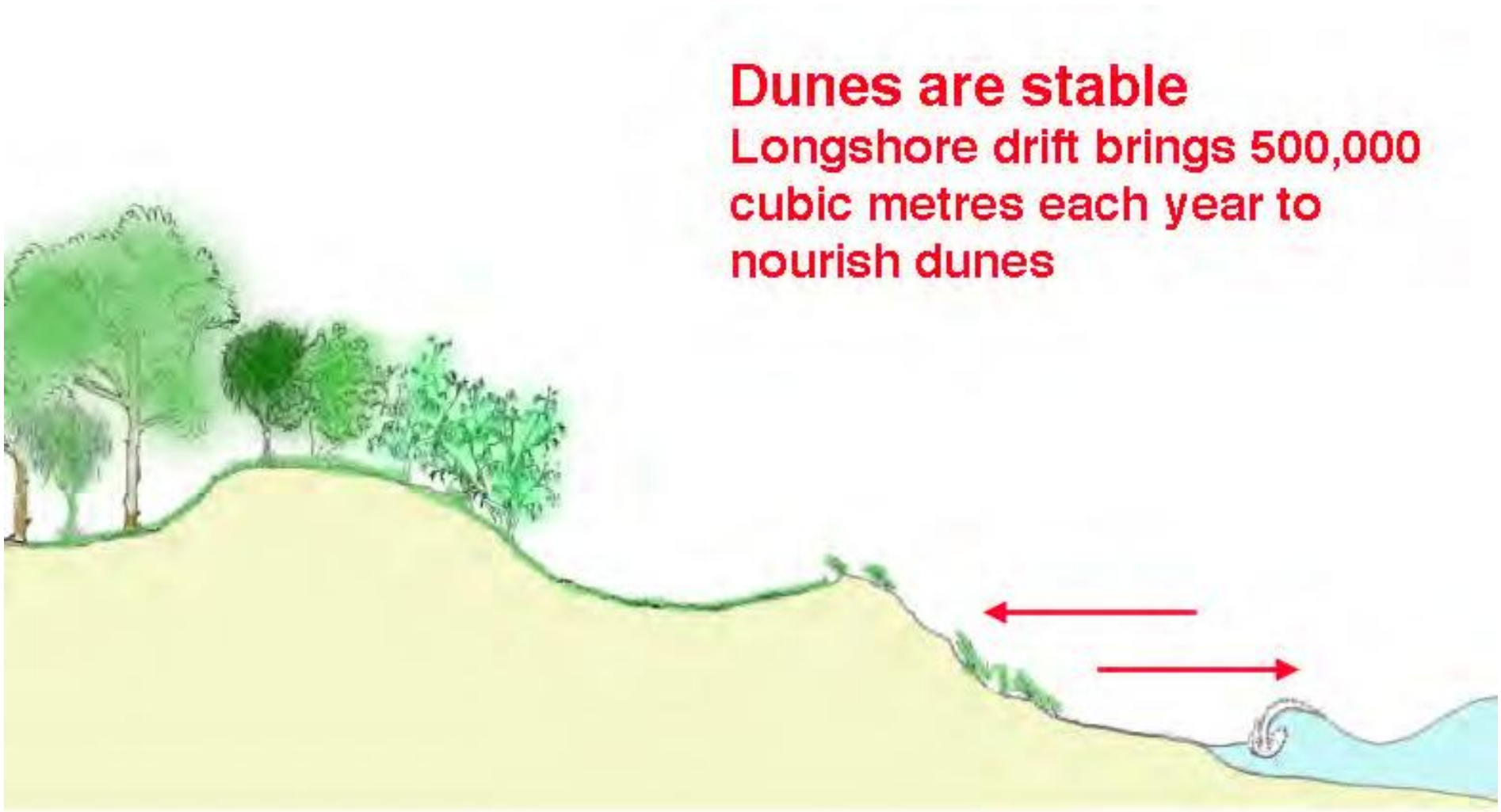
Training walls can severely disrupt the flow of longshore drift by trapping sand and altering the flow direction. This keeps the passage deep for navigation.

Training walls distrupt sand movement volumes

Photo Geoscience Australia

Dune systems rely on a constant flow of sand to function correctly.

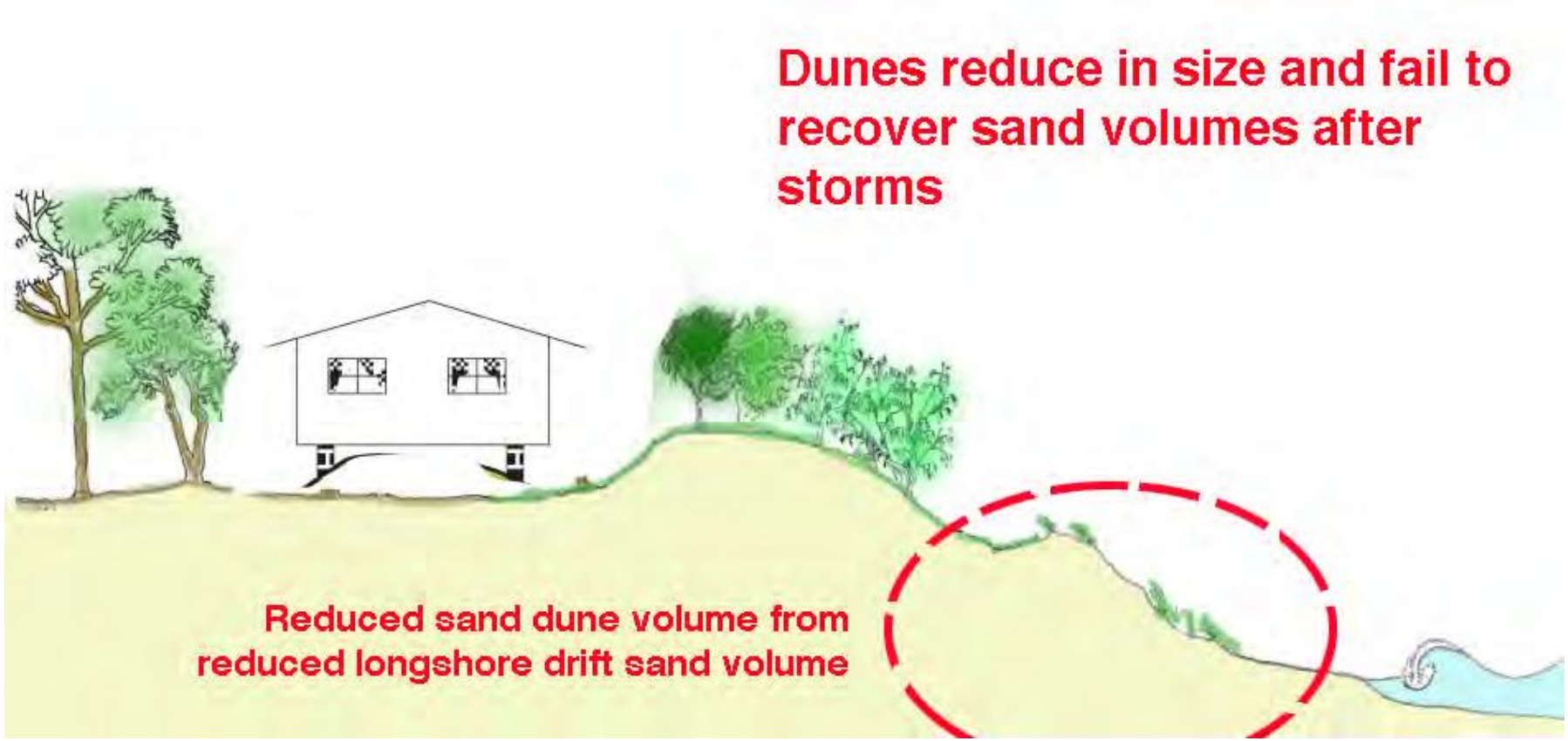
Photo Bob Moffatt



Dunes stable

Illustration Bob Moffatt

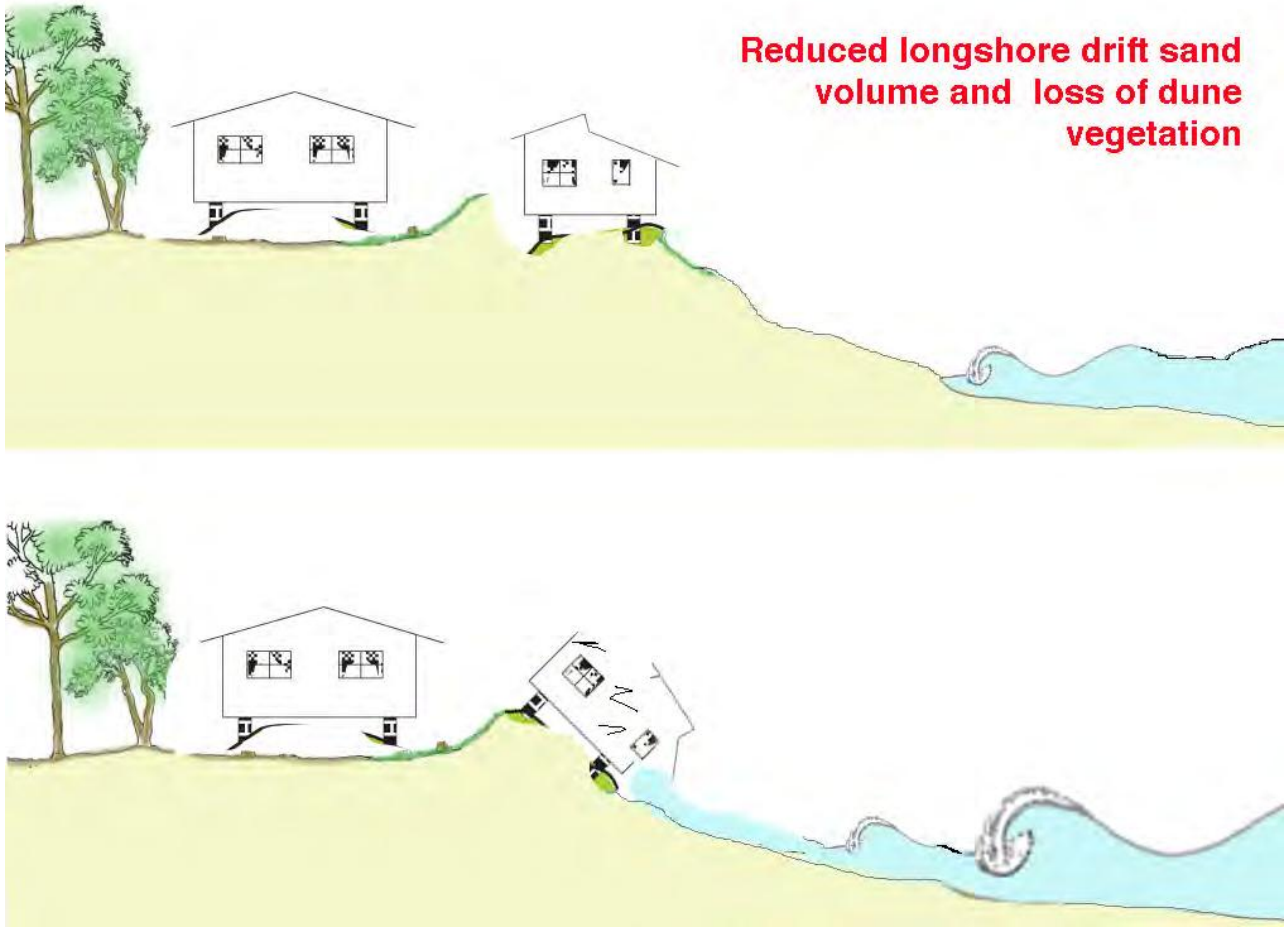
If houses are built on secondary dunes and the volume of sand is reduced by engineering such as training walls or groynes, dune nourishment is reduced.



Reduced sand volume from longshore drift

Illustration Bob Moffatt

This reduced sand flow from a training wall built many kilometres down the beach can have dramatic effects on beaches and development over time.



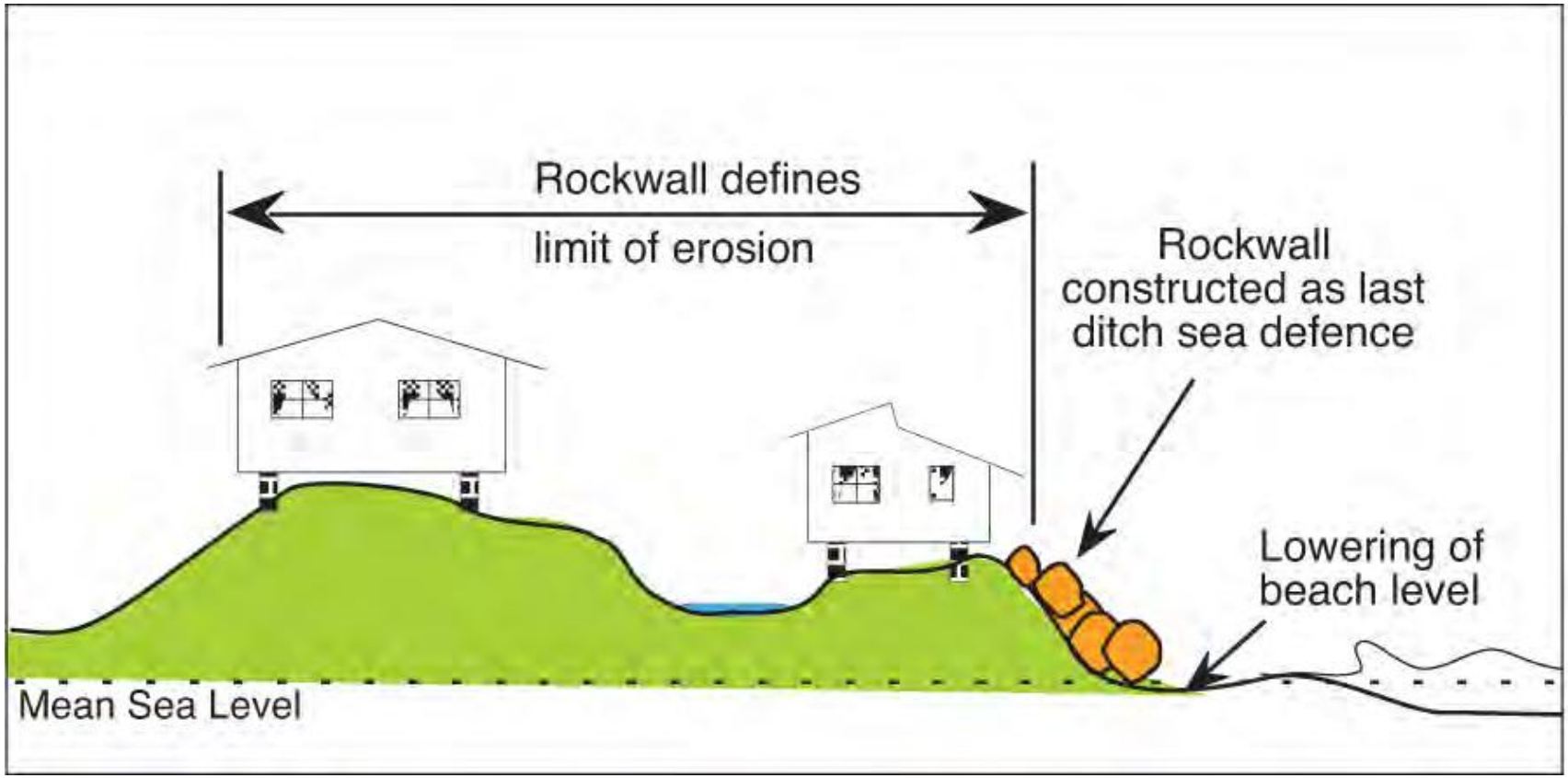
Houses fall into sea illustration

Illustration Bob Moffatt

Houses fall into sea

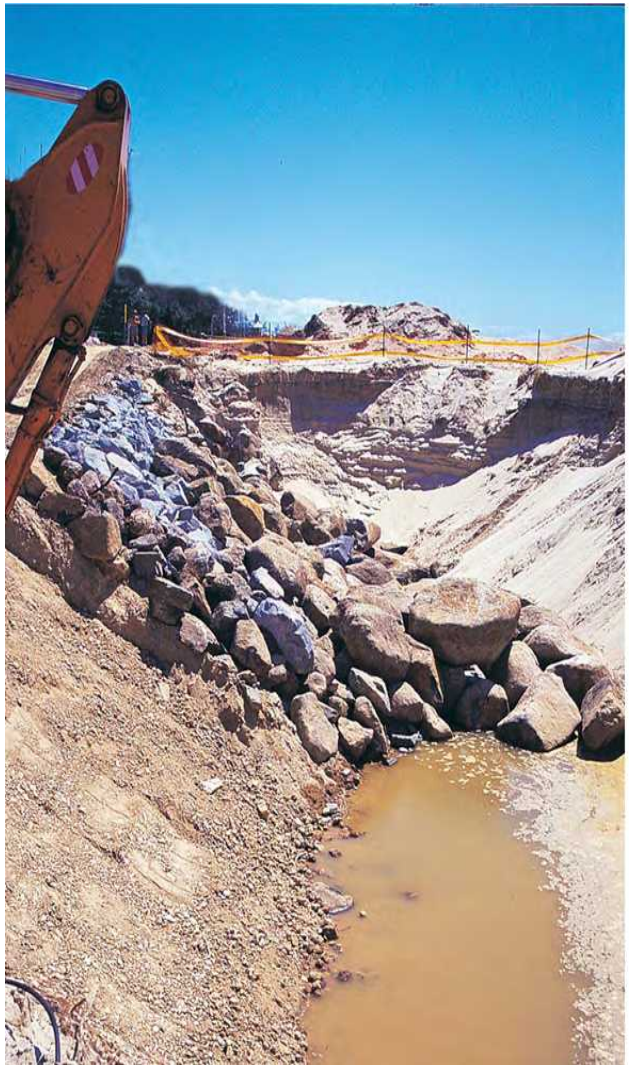
Credit: Australian Women's Weekly

Boulder walls are then built to protect houses at great expense to property owners.



Houses with boulder wall

Illustration Bob Moffatt



Boulder wall construction and effect

Photo Bob Moffatt

Sand pumping jetties

In Queensland, sand pumping jetties, associated with training walls, have been built in an effort to keep a steady supply of sand flowing in the longshore current and to maintain the passage depth.

Sand pumping jetty

Photo Bob Moffatt

The principle is to pump the exact volume of sand necessary onto the other side of the passage, therefore bypassing the passage ensuring its depth is maintained.

Sand pumping jetty principal

Photo Bob Moffatt

Pumping regimes have been the subject of huge debates amongst stakeholders, especially when contractors are paid by the volumes of sand they are paid to pump.

Protest rallys often bring pressures on Governments to change pumping regimes to increase amenity for beach goers.

Protest rally
Photo Bob Moffatt

Marinas and canal estates

Marinas in Queensland are similar to training walls, but usually have a less dramatic effect because they are built in wave reduced areas.

Marina

Viewfinder

One effect is the loss of amenity as dredging occurs.

Dredge in marina

Photo Bob Moffatt

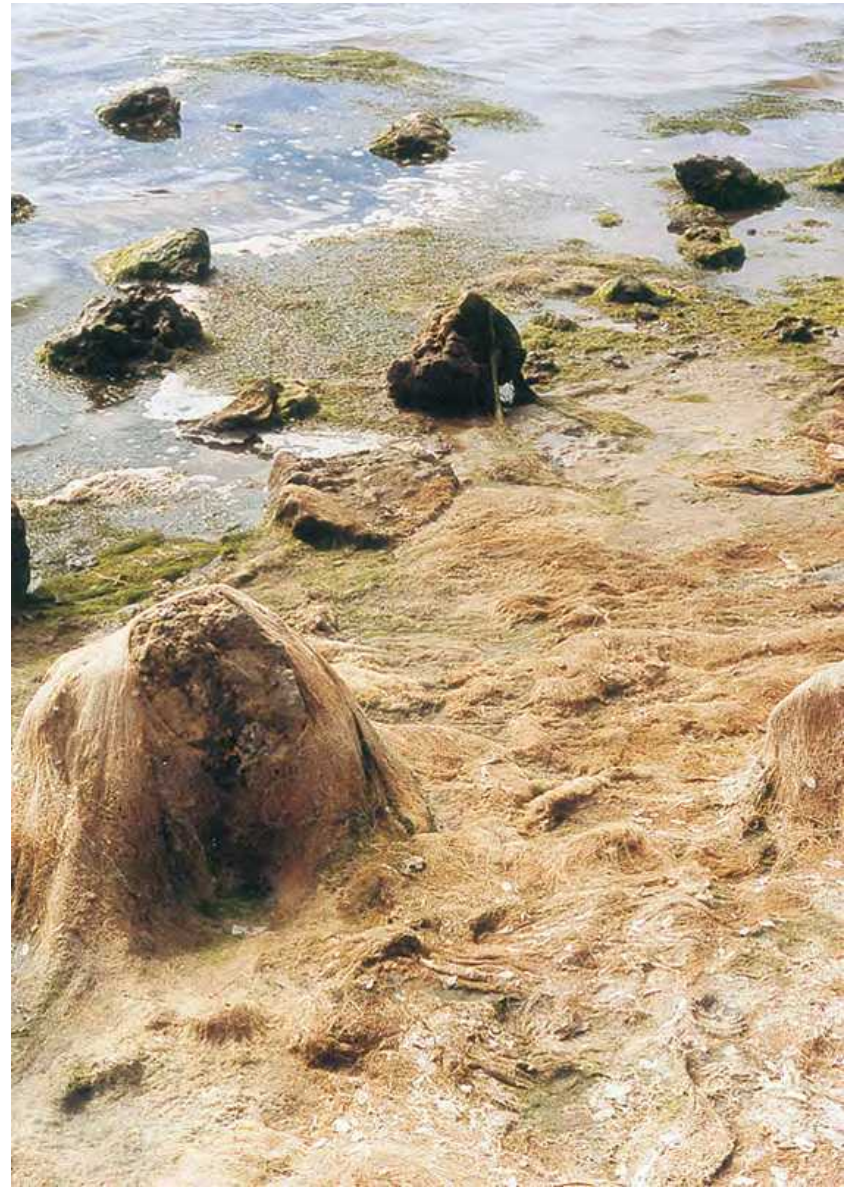
Canal estates disrupt the natural flow of rivers to the sea

Canal estate

Photo Murray Waite

Increased use of fertilisers so that people can have green lawns results in algal blooms from canals that don't flush properly to the sea.

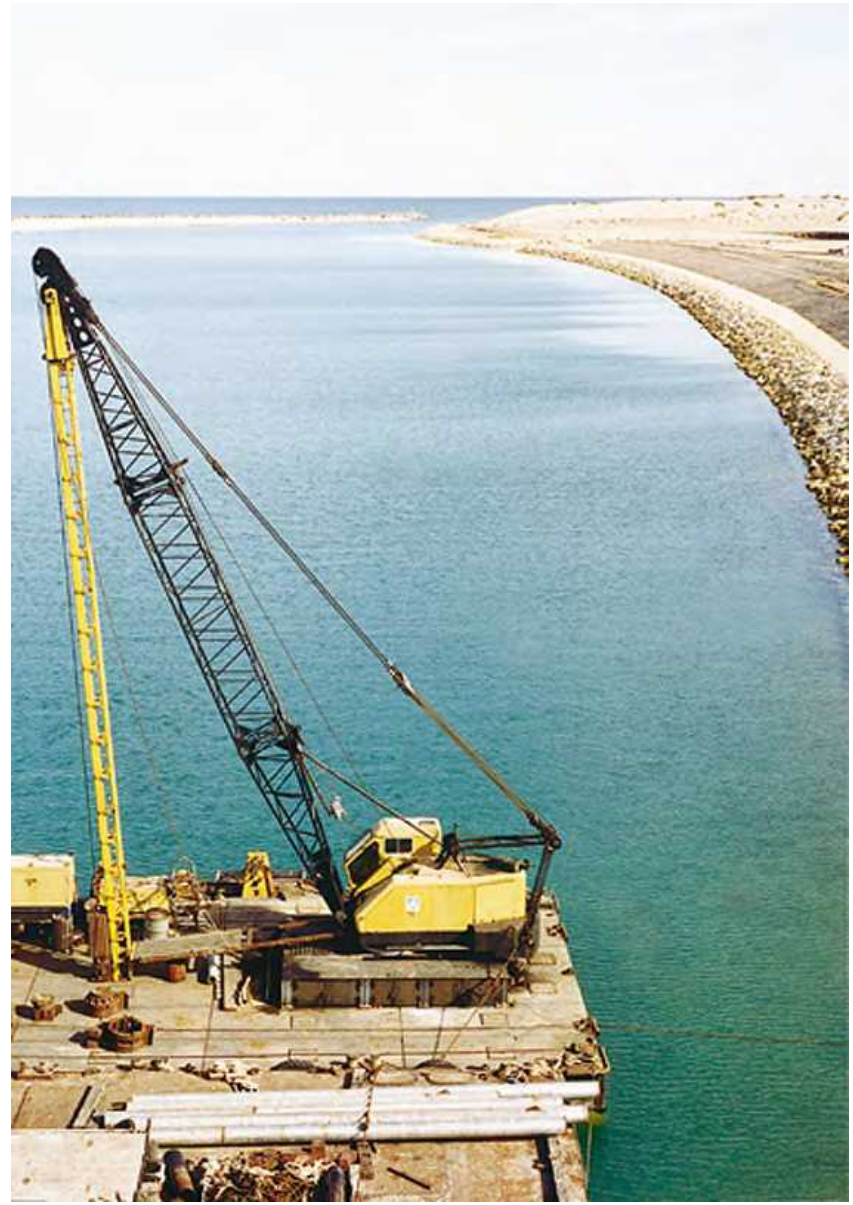
At low tide algae coats rocks decreasing the original amenity of the canal and reducing oxygen needed for marine life to survive.



Algae on rocks in canal

Photo Bob Moffatt

To solve this problem, engineering works have to be undertaken to dredge new river entrances that prevent algal pollution and allow the river to flush.



Dredging new entrance to the sea
Photo Bob Moffatt

Beach nourishment

Pumping sand into the offshore bar is another method of beach engineering.

Photo Bob Moffatt

Question

Explain how the following coastal engineering works regulate water, sediment flow, longshore current and impact on a coastal ecosystem.

A. Groynes and training walls

B. Sand pumping jetties

C. Marinas and canal estates

T022 Longitudinal studies

Syllabus statement

At the end of this topic you should be able to … **Recognise** that longitudinal studies allow scientists to observe changes occurring in marine environments (e.g. satellite imagery, aerial photography, field research)

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.

Question

Recall how each of the following have enabled coastal engineers to observe changes occurring in marine environments caused by groynes, training walls and sand pumping jetties:

A. Satellite imagery

B. Aerial photography

C. Field research

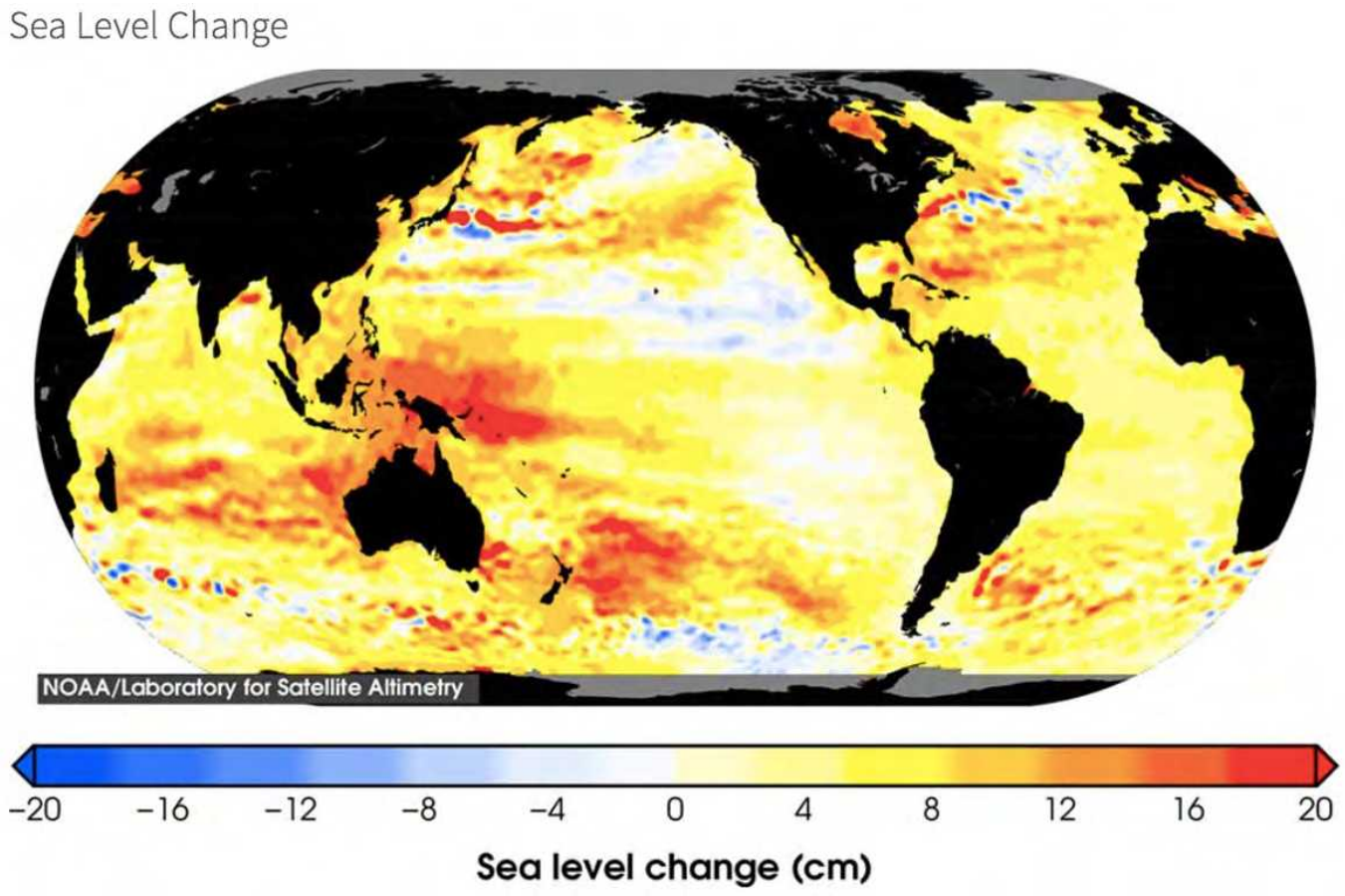
Satellite imagery

Satellites are used to create images of Earth in a multitude of ways.

GOES R Spacecraft

By NASA/NOAA - http://www.goes-r.gov/spacesegment/spacecraft.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=58302419

Information gathered by satellites over long periods of time can tell us how sea levels change.



Sea level rise from satellite data

https://en.wikipedia.org/wiki/Sea_level_rise

A common satellite tool is Google Earth, a computer program that renders a 3D representation of Earth based features on satellite imagery.

Google Earth Australia 3d screenshot

The program maps the Earth by superimposing satellite images, aerial photography, and GIS (Geographic Information System) data onto a 3D globe, allowing users to see cities and landscapes from various angles.

Google satellite image part of Queensland coastline

See separate statement at end of this powerpoint
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For example, in our discussion on sand budget systems, the Clarence and Richmond Rivers that supply the sand that enters the Southern Gold Coast System and finishes in Moreton Bay, can be seen entering the sea in the google image at Yamba and Ballina.

Google Earth Sand system SE Qld

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Mackay Harbour and reef are other images from google and its satellite partners.

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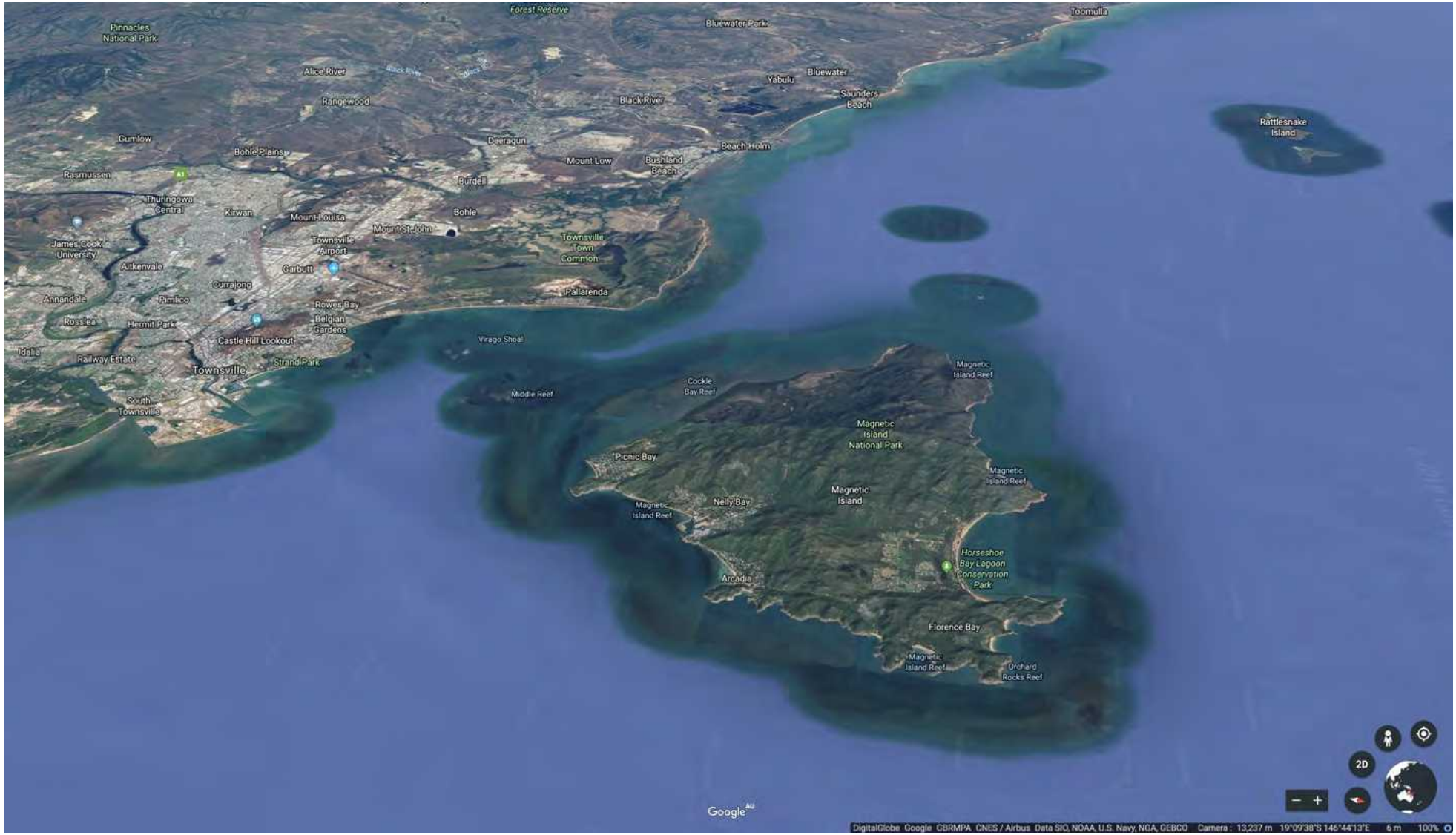

Townsville.

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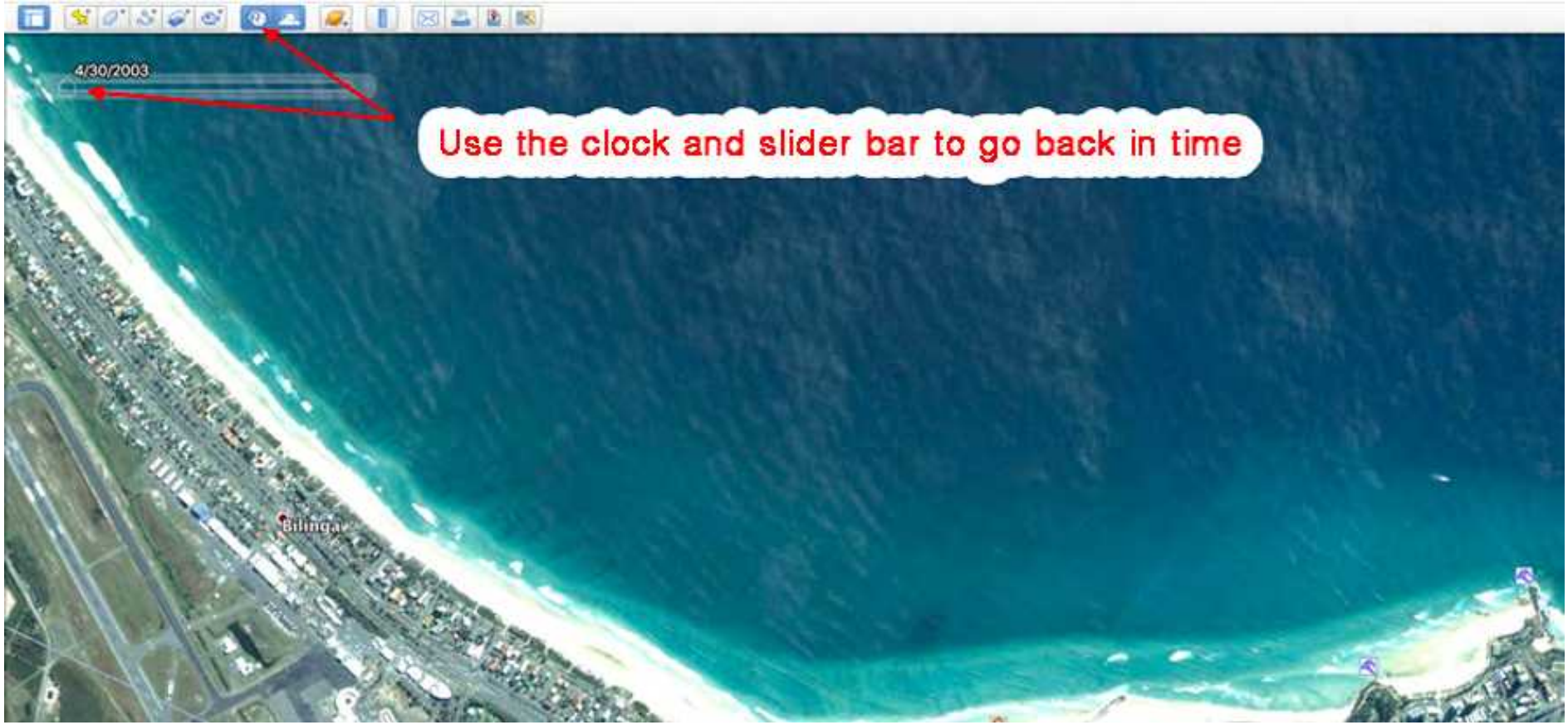
Torres Strait.

See separate statement at end of this powerpoint
https://www.google.com/intl/en/permissions/trademark/rules.html

Google Earth can also show you images from previous years allowing a long term record of your local study areas to be shown.

Download Google Earth to your hard drive and use the clock tool in the top of the menu bar.



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This allows you to study data from previous years allowing a long term record of your local study.

Comparison Kirra 2013 and 2017

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Aerial photography

Aerial photography can be oblique and overhead with photographs taken from various height in planes, helicopters or drones.

Camera drone

Aerial photographers use special cameras to take photos from a light aircraft.

Aerial photographer

Aerial photographs are useful as they can show degrees of refraction by waves on an engineered beach system.

Wave refraction from aerial photograph

Photo Murray Waite and viewfinder

Aerial photos can also show changes over time where housing development occurs on beaches.

Tweed aerial 1963

Photo Geoscience Australia

Aerials can show sand placements for epic surf conditions

Kirra epic surf bank and aerial

Photo GCCC and Surfing Australia

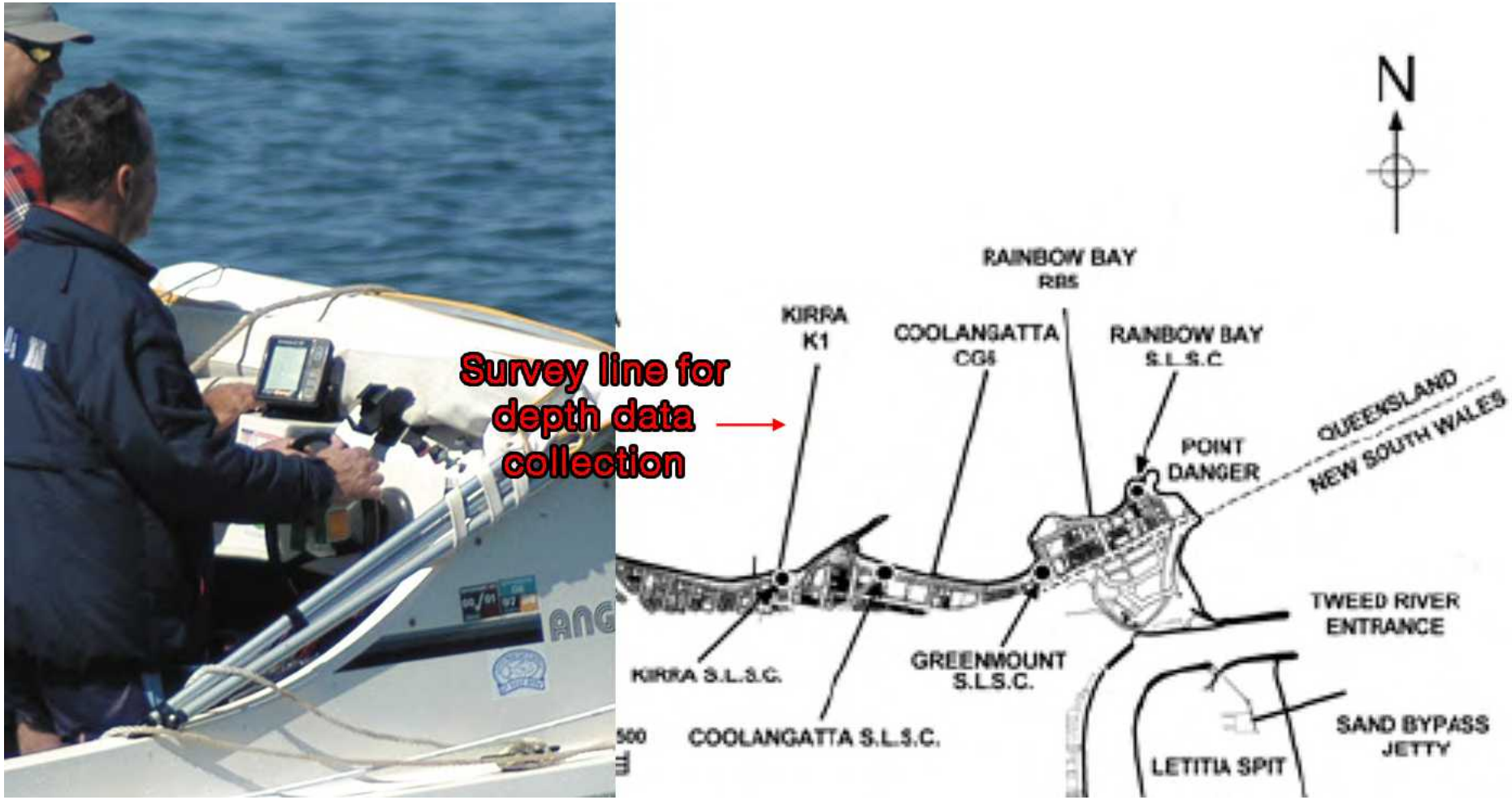
Field research

All aerial photography has to undergo a process called "ground truthing" where surveyors collect data on beach profiles.

Survey lines Bilinga beach

Photo GCCC

Boats are also used to plot water depths using depth sounders on fixed survey lines.



Fixed survey lines used to collect depth data

Illustration GCCC Photo Bob Moffatt

Fixed photography can also show beach width changes

November 2007

Greenmount Beach 2016

Photos Bob Moffatt and https://www.tweedsandbypass.nsw.gov.au/

This allows sand volume calculations on beaches to be made and maintained.

November 2007

Greenmount Beach 2016

Comparisons of volumes of pumped sand

https://www.tweedsandbypass.nsw.gov.au

Copyright statement

Google satellite images

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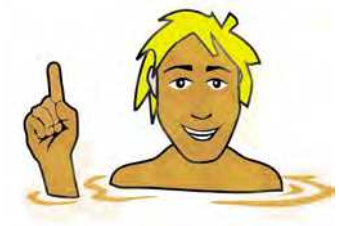


Question

How can satellite imagery, aerial photography and field research enable coastal engineers to observe changes occurring in marine environments caused by groynes, training walls and sand pumping jetties?

Draw a summary table to summarise your answer.

T023 How organisms populate areas

Syllabus statement

At the end of this topic you should be able to … **Identify** how organisms populate areas following changes in habitats (e.g. succession)

Identify

- Locate, recognise and name;
- establish or indicate who or what someone or something is;
- provide an answer from a number of possibilities;
- recognise and state a distinguishing factor or feature.

Question

State distinguishing features from the following marine habitats that allow scientists to determine **if** ecological succession has occurred.

A. Sand dunes

B. Coral cays

C. Mangrove estuary

Definition

Ecological succession

"Ecological succession" is the observed process of change in the species structure of an ecological community over time resulting in a stable climax community.

It is a phenomenon or process by which an **ecological** community undergoes more or less orderly and predictable changes following a disturbance or the initial colonization of a new habitat.

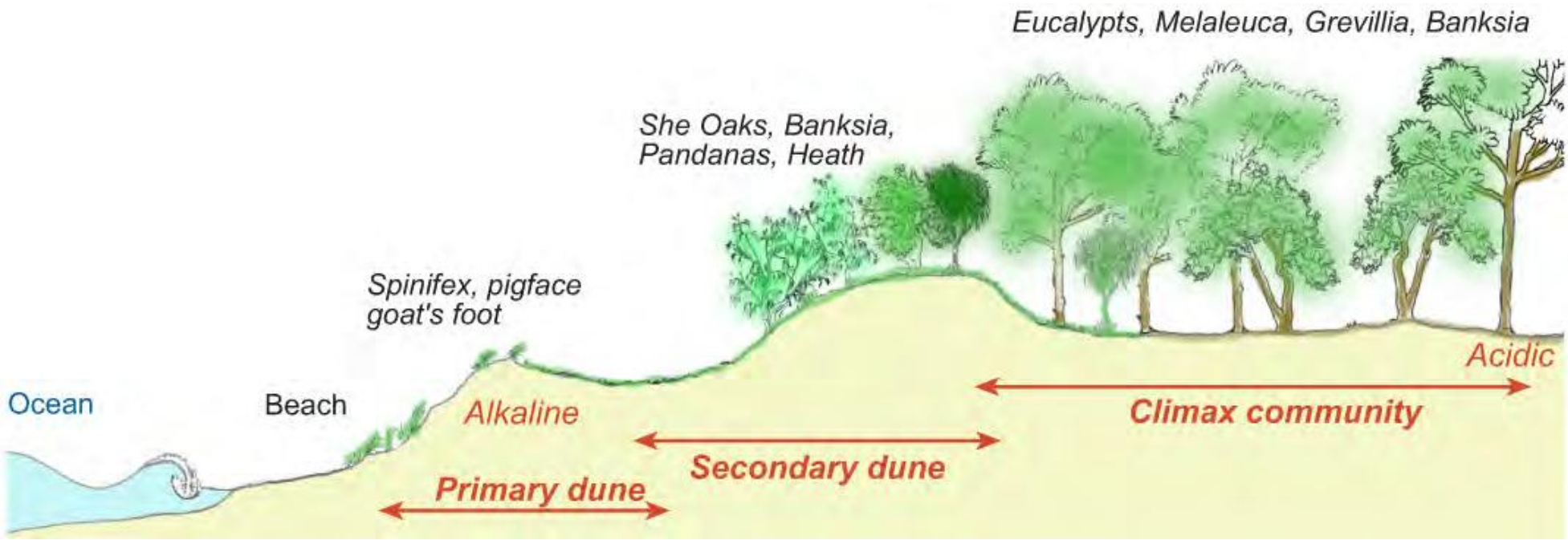
Sand dunes

A dune system provides an excellent example of plants that change in size from one place to another.

Dune system

Photo Bob Moffatt

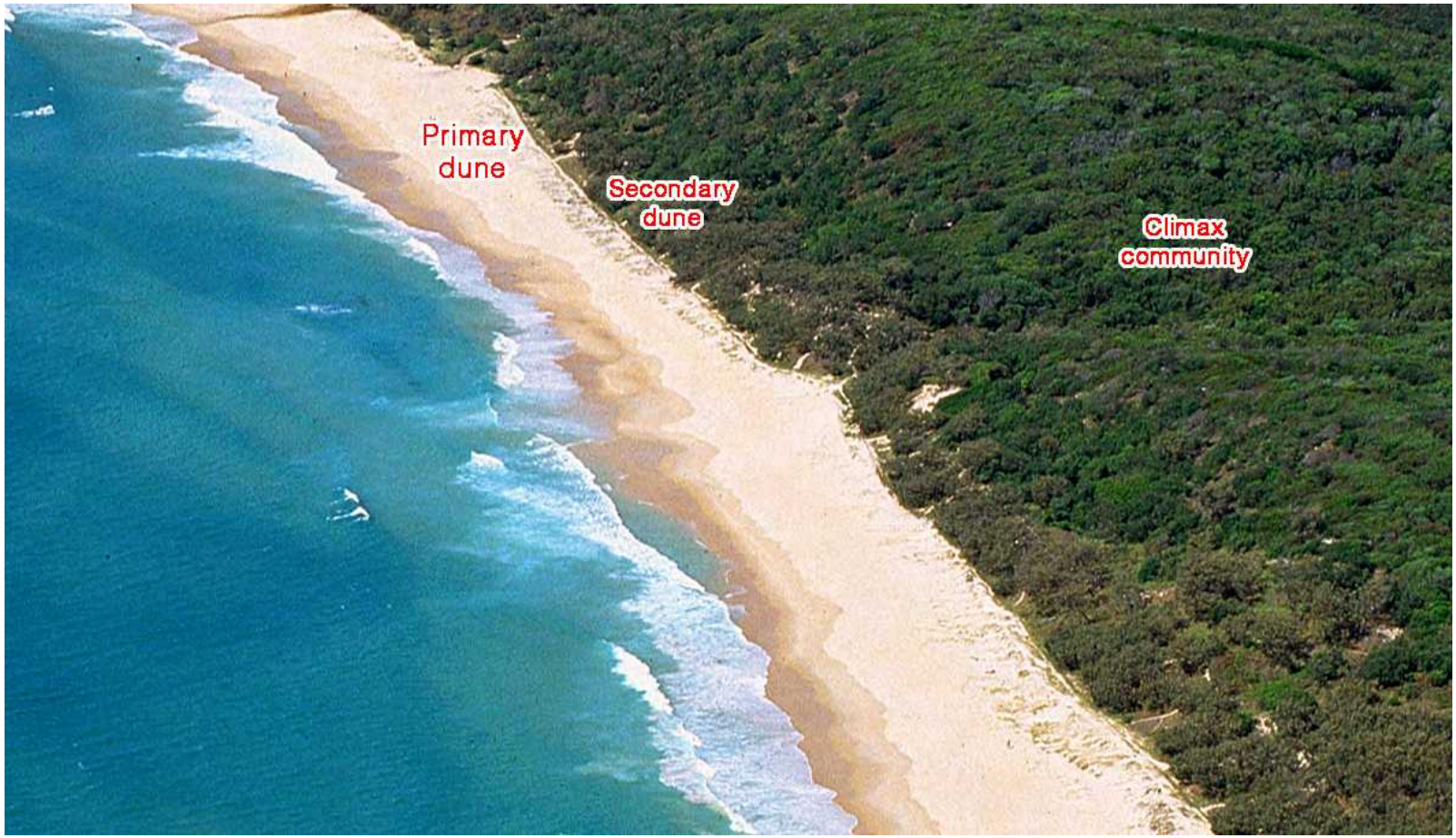
The smallest plants (spinifex) are called the pioneer community with a succession of plants (including she oak, banksia, wattle and pandanus) to a climax community of paperbarks.



Dune system showing succession

Illustration Bob Moffatt

Scientists know succession has occurred because of the study data collected from ground transect lines and easily identifiable in photographs.



Beach succession with climax community names

Photo Viewfinder and Bob Moffatt

In the primary dune system, biodiversity is low because only a specific type of salt tolerant plant can survive there.

Coastal spinnifex (L) and goats foot (R)

Photo Bob Moffatt

Aerial photos show that the distance between vegetation decreases as you move inland from primary and secondary dunes leading to a climax community.

Succession on a beach aerial

Photo Viewfinder and Bob Moffatt

In climax communities, biodiversity in species will be higher.

Climax community with gum trees

Photo Bob Moffatt

Coral cays

Succession on the Great Barrier Reef can take many years. In many cases sand begins to accumulate at the end of a submerged reef from wave refraction developing a cay.

Coral cay stage 1

Photo Bob Moffatt

Shortly after, sea birds arrive and fertilise the sand from their droppings

Birds arrive coral cay.

Photo Bob Moffatt

Birds make nests and raise their young.

As there are no predators, population sizes can increase rapidly.

Scientists count the birds to determine this.

Seeds from bird wings establish in the sediment.

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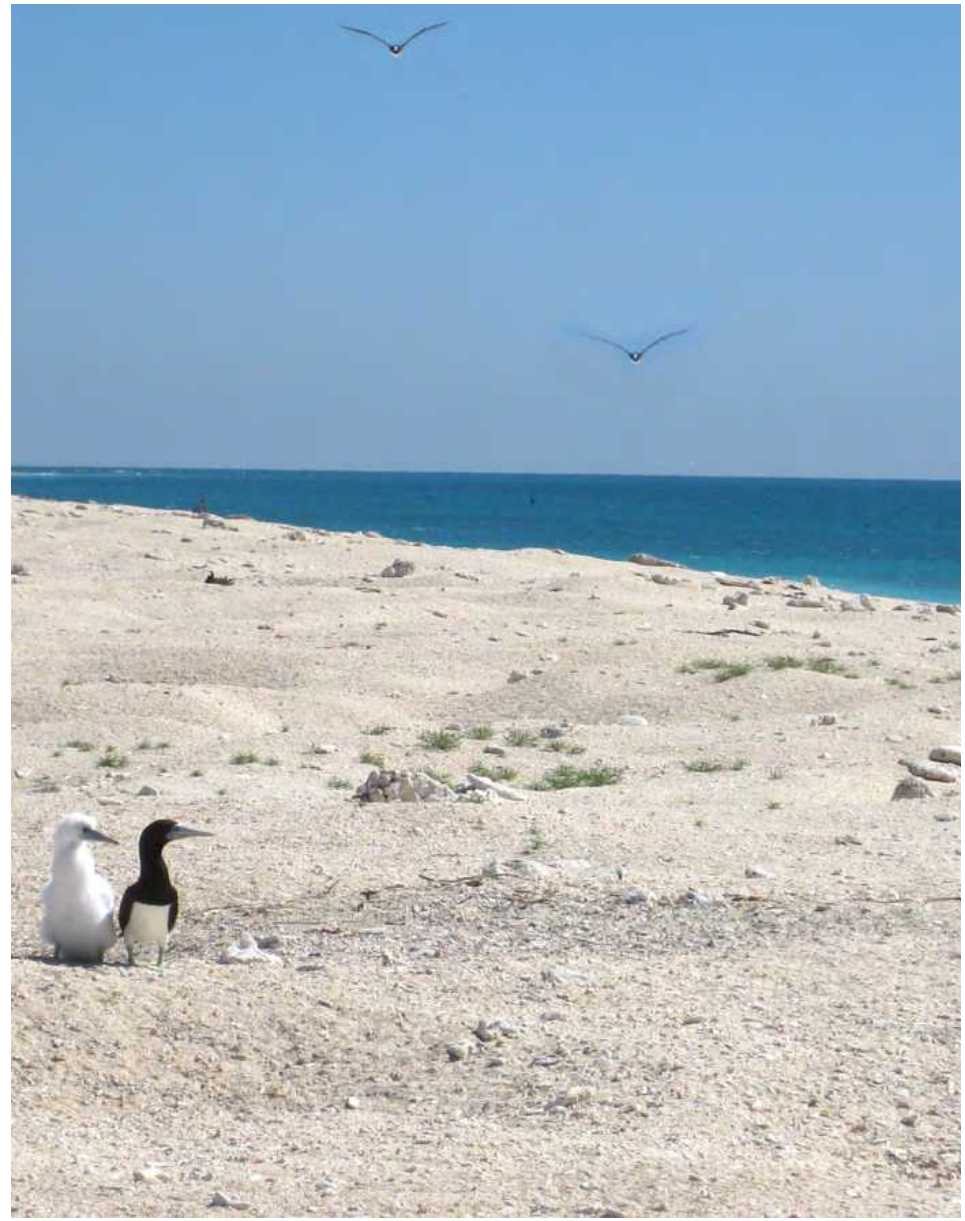


Birds arrive and make nests

Photo Bob Moffatt

Logs carrying seeds from adjacent islands are washed up onto the beach.

Plants arrive on logs

Photo Bob Moffatt

Plants that have been washed onto the shoreline from surrounding islands take hold.

Dune plants colonise cay

Photo Bob Moffatt

Primary dune vegetation gets established. Beach rock is formed by water flowing through sediments depositing limestone which cements sediment and rubble.

Primary dune vegetation on a coral cay

Photo Bob Moffatt

In time secondary vegetation grows due to increased nutrients in the sand.

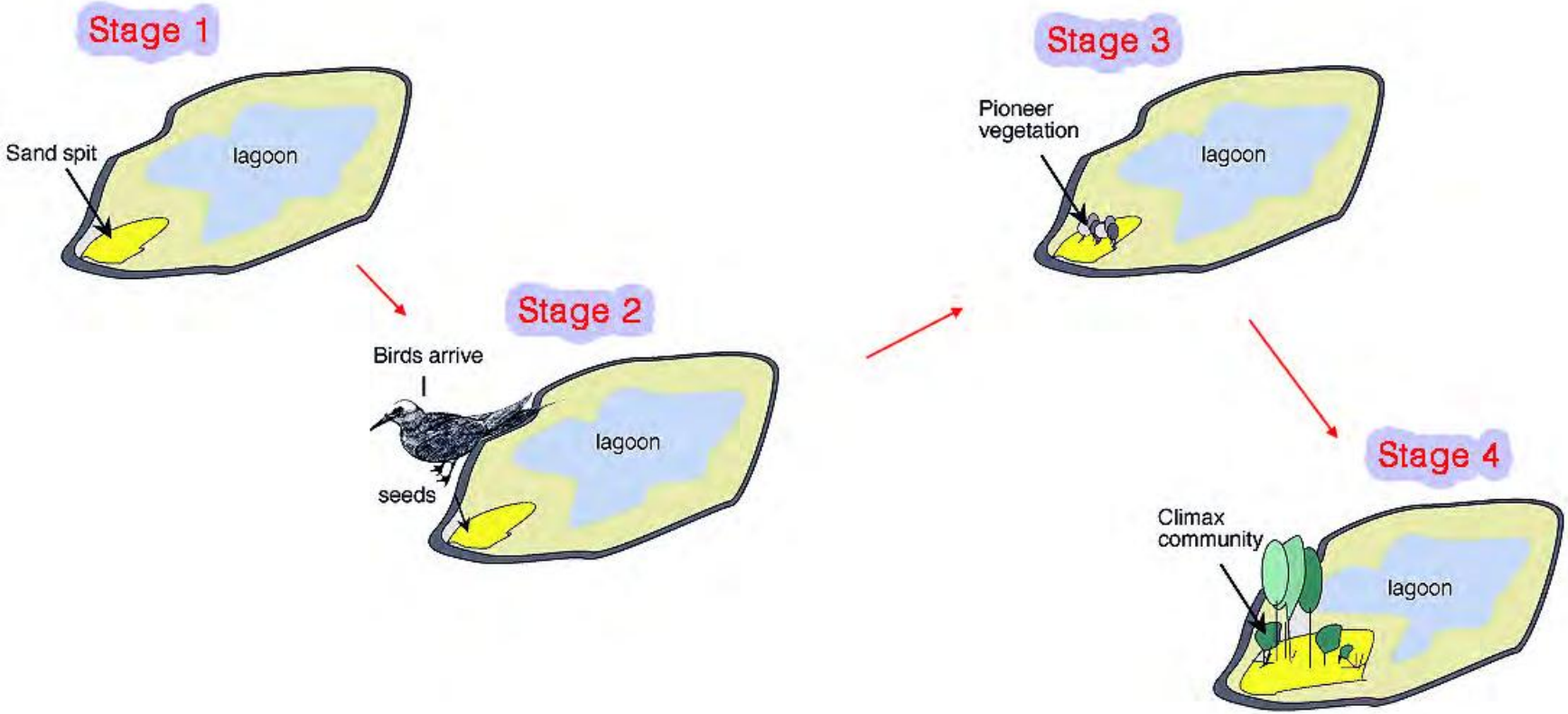
As the shrubs grow and die and as more humus develops in the newly established soil, larger trees can start growing such as she oaks and pisonia.

Insects, spiders, centipedes now arrive on the wings of birds or on driftwood. As these die, more is added to the humus.

North West Island Beach

Photo Bob Moffatt

These distinguishing features can be summarised in a diagram.



Succession on cay summary

Illustration Bob Moffatt

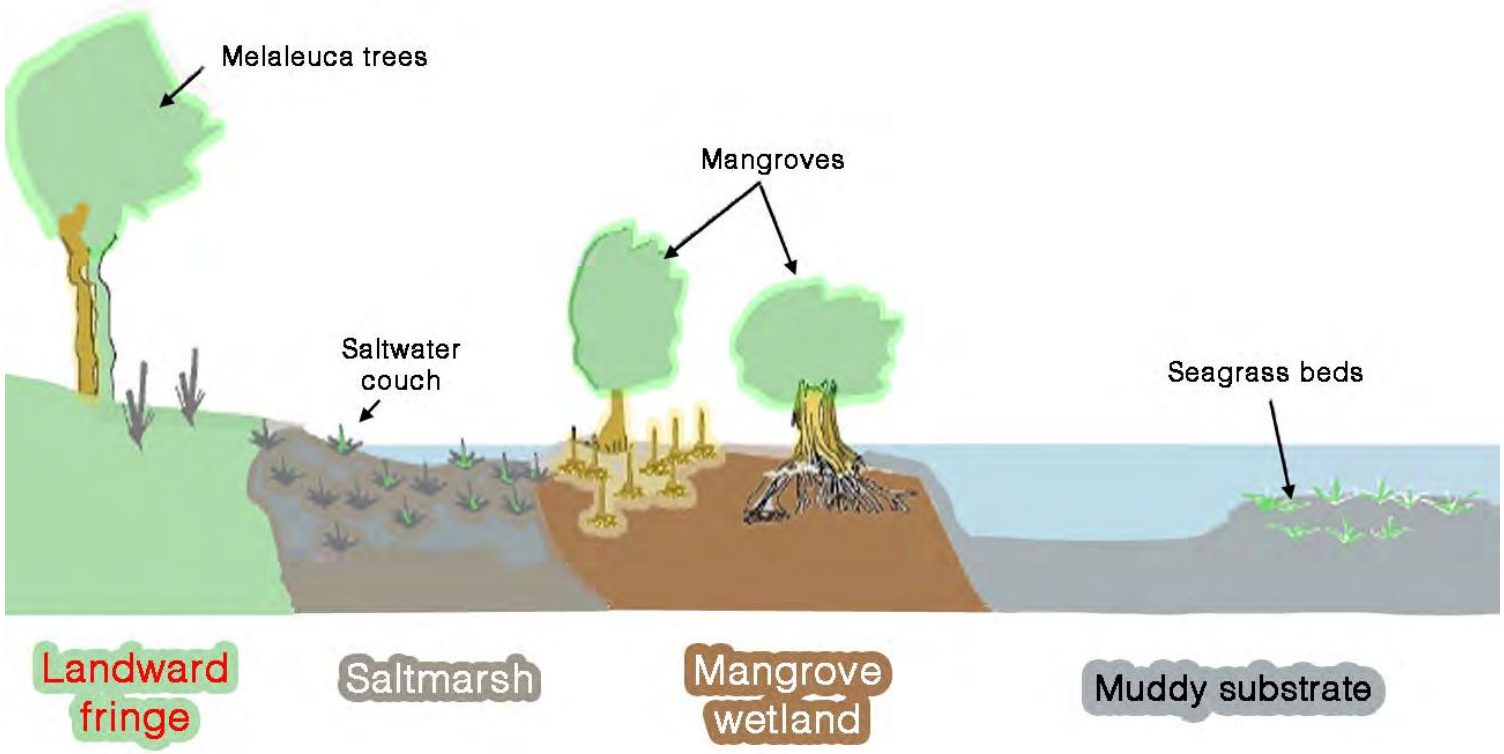
However cyclones can devastate an area causing the whole process to start again.

Cyclone Yazi damage

Photo Bob Moffatt

Mangrove estuary succession

The distinguishing features of a mangrove estuary come from a study from low tide to climax community.

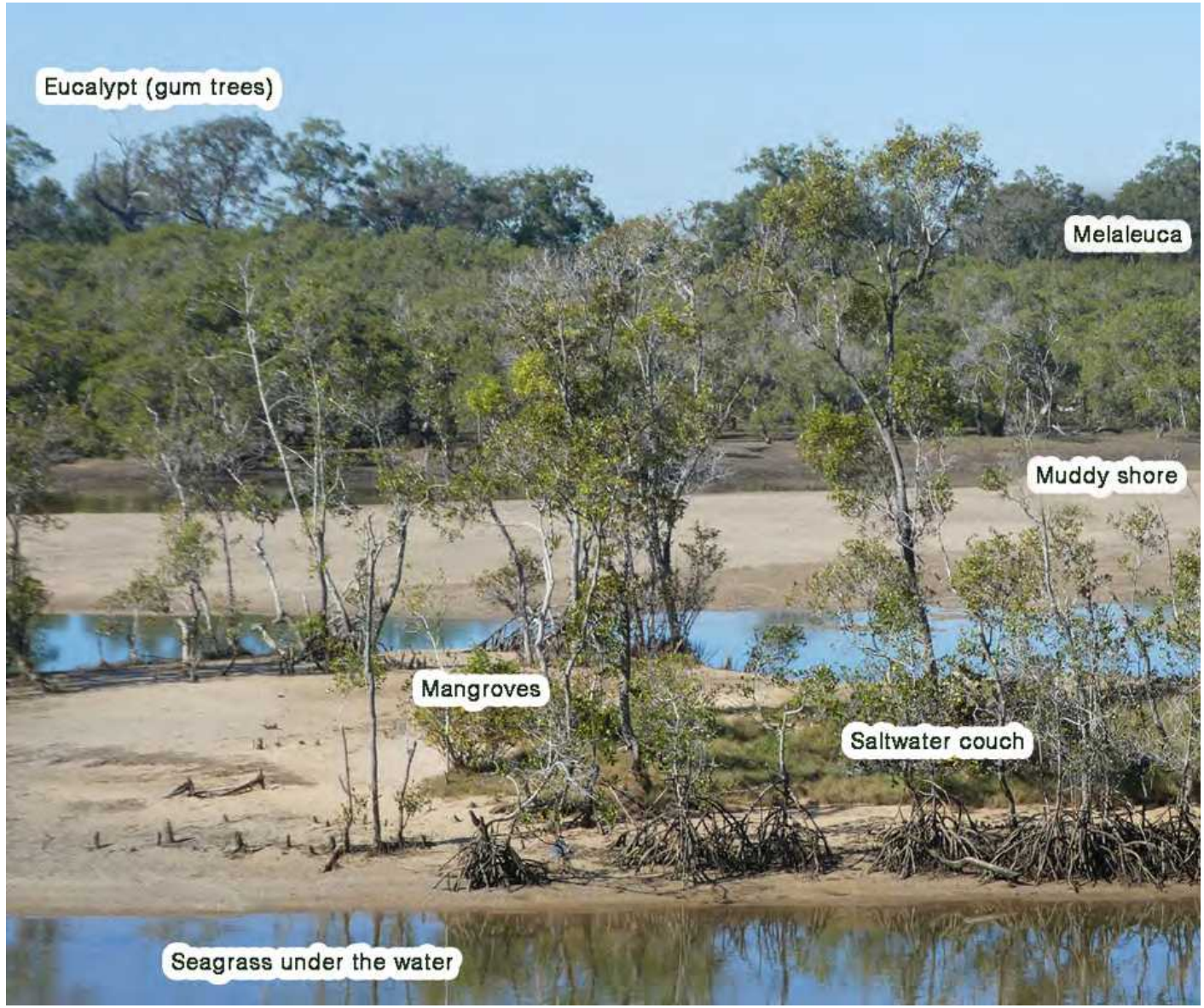


Mangrove cross section and succession

Illustration Bob Moffatt

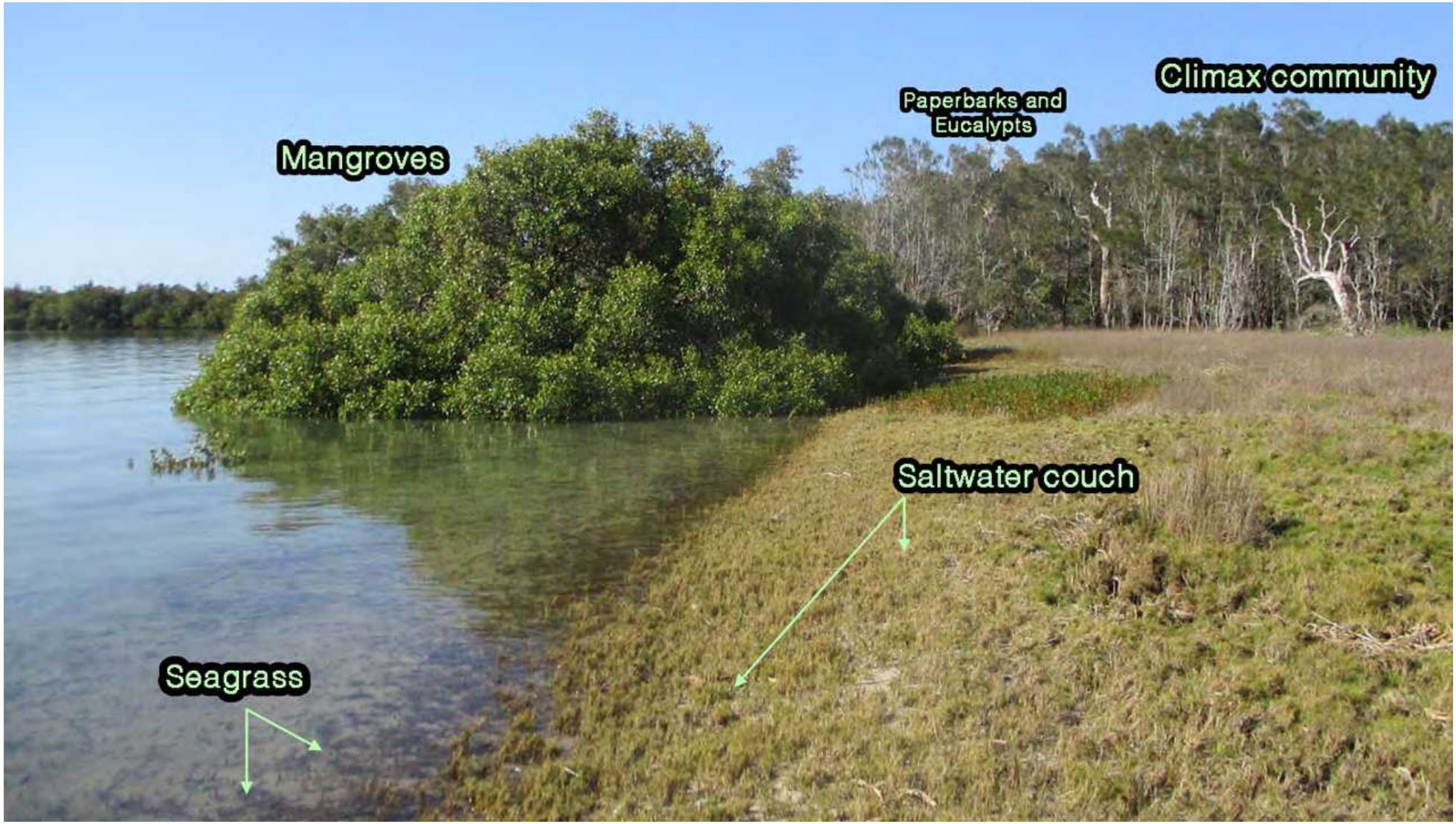
A mangrove ecosystem has different species at the water's edge compared to 200 metres inland.

Succession has said to occur from the water's edge to the well mature mangrove ecosystem.



Mangrove scene succession

Photo Bob Moffatt



Mangrove succession in an estuary

Photo Bob Moffatt

These distinguishing features can be seen from aerial photographs.

Sandon mangrove aerial shows succession

Photo NSW Parks and Wildlife

Marine plants populate mangrove ecosystems according to their tolerance of abiotic factors such as salt concentration and ability to withstand water inundation from tides.

Mangrove plants at waters edge

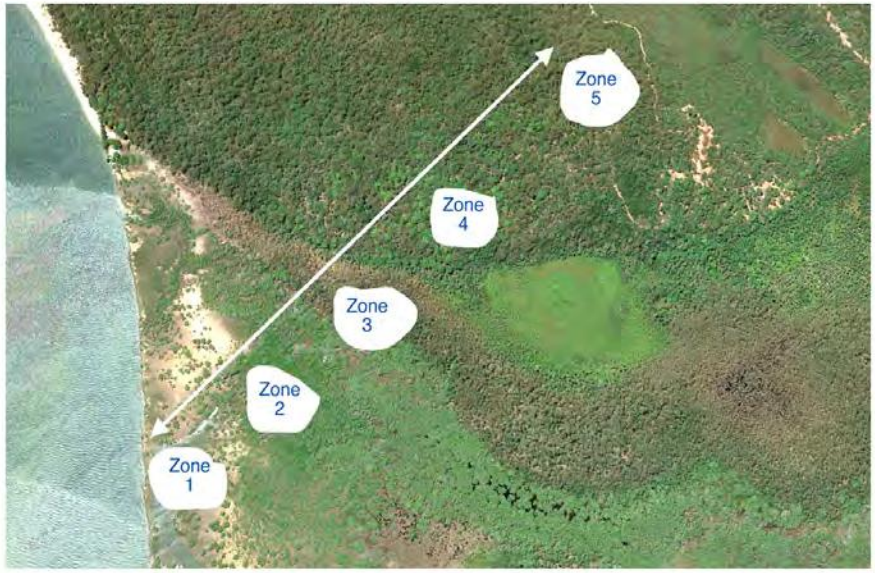
Photo Bob Moffatt

A transect from low tide to climax community will gather abiotic evidence that leads to questions about how organisms populate an area.

A common succession could be shown as follows:

Mangrove forest → Salt marsh → Casuarina forest → Melaleuca forest → Eucalypt forest

Measure out a 10 m quadrat and record the information detailed



Variable		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Major plant types						
Other plant types						
Light intensity						
Soil type, colour,texture moisture						
Percent ground cover						
Soil	Salinity					
	pH					
Temperature	Air					
	Soil					
Relative humidity						
Animals present						
Wind velocity	1 m above ground					
	canopy level					

Ways to determine mangrove succession

Illustration Bob Moffatt

Question

State distinguishing features from any one of the following marine habitats that would allow a scientist to determine **if** ecological succession has occurred.

A. Sand dunes

B. Coral cays

C. Mangrove estuary

T024 Population density data

Syllabus statement

At the end of this topic you should be able to … **Assess** population density data of coastal areas to identify the impact on the health of coastal water

Assess

- measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something.

Question

Using population density data, estimate the impact of coastal development on the health of coastal water using the following as examples.

A. Suburbs and cities

B. Farming and agriculture

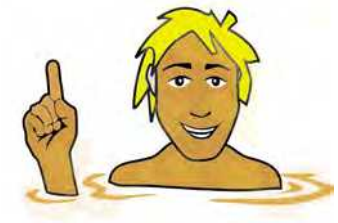
C. Manufacturing, retailing and the production of plastic

Definitions

For humans, population density is the number of people per unit of area, usually quoted per square kilometer or square mile (which may include or exclude, for example, areas of water or glaciers).

Commonly this may be calculated for a county, city, country, another territory or the entire world.

Population density (in agriculture: standing stock and standing crop) is a measurement of population per unit area or unit volume; it is a quantity of type number density. It is frequently applied to living organisms, and most of the time to humans. It is a key geographical term.



Suburbs and cities

Human population density is concentrated in cities as can be seen if a composite image of Earth is made at night.

World at night

By NASA Earth Observatory images by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center - NASA https://www.nasa.gov/feature/goddard/2017/new-night-lights-maps-open-up-possible-real-time-applications (image link), Public Domain, https://commons.wikimedia.org/w/index.php?curid=58037672

In Queensland, human population is concentrated in the South East which contains 3.5 million people out of the state's population of 4.8 million. Of this 80% are within an hours drive from the sea.

Coastline with high population density

Photo Murray Waite and Viewfinder

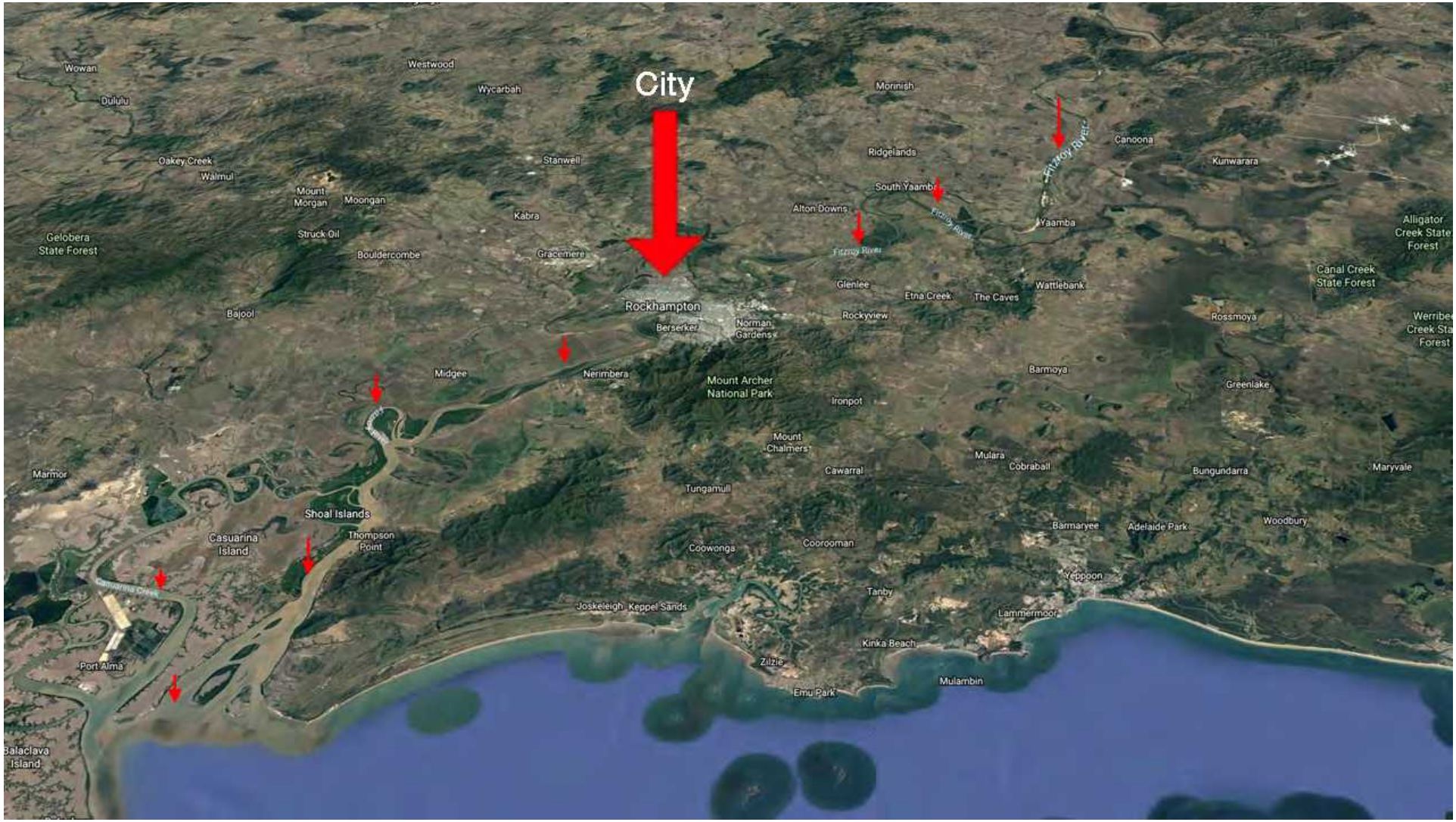
Major cities have been built on rivers which flow directly to the sea.

City and river

Photo Murray Waite and Viewfinder

Regional cities and suburbs have also been built of river catchments that feed directly to the sea impacting on the health of coastal water.

Townsville to Ayr Home Hill



Rockhampton

See separate statement at end of this powerpoint
https://www.google.com/intl/en/permissions/trademark/rules.html

Mackay catchment

See separate statement at end of this powerpoint

https://www.google.com/intl/en/permissions/trademark/rules.html

When cities and suburbs are built, concrete is used to build driveways, roads and footpaths.

Pouring concrete

Photo Bob Moffatt

Pouring a concrete drive way. This will speed up the flow of water to the local creek.

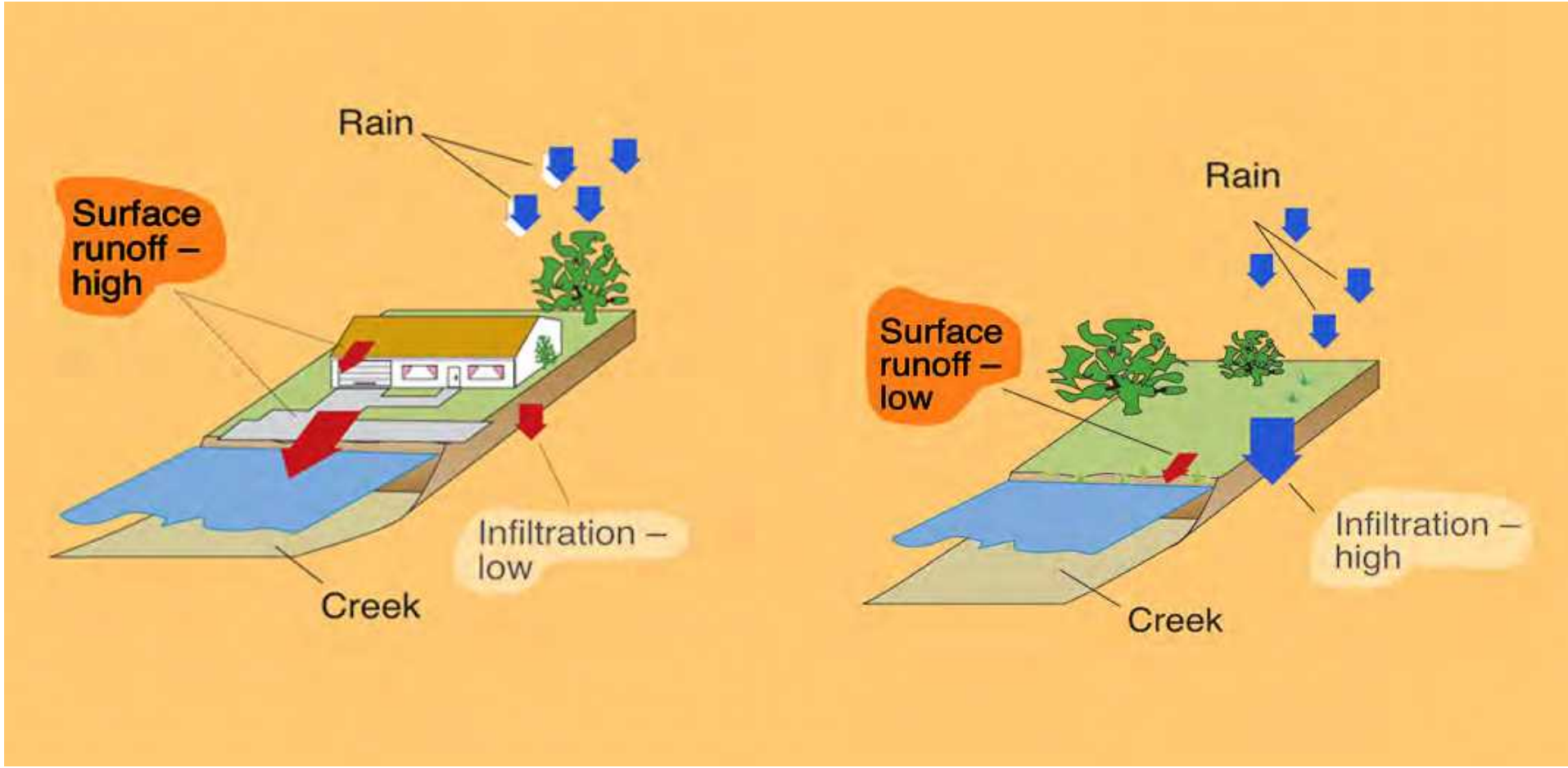
Photo Bob Moffatt

Asphalt, also known as bitumen is a semi-solid form of petroleum is used for roads and concrete for paths and buildings.

City bus and pollution

Photo Murray Waite and Viewfinder

The effect is to create a surface where water flows off quickly.



Water velocity hard surfaces compared to natural surfaces

Illustration Bob Moffatt

Hard surfaces street and footpath

Photo Murray Waite and Viewfinder

When new suburbs are built, stormwater pipes carry water form streets and footpaths to rivers and creeks.

Stormwater pipes new suburb

Photo Bob Moffatt

Stormwater pipe near beach

Photo Bob Moffatt

The nett effect is that pollution ends up in nearby waterways and then into the adjacent sea.

From street to ocean

Photo Murray Waite

Golf courses also use high volumes of fertilisers which can affect local rivers and creeks causing algal blooms.

Golf Course

Photo Murray Waite and Viewfinder

Households also use high volumes of pesticides and fertilisers in gardens for lawns, vegetables and fruit and ornamental trees

Fertilizer aisle

Photo Bob Moffatt

Farming and agriculture

Rainfall run-off and irrigation tail water can wash nutrients, pesticides and sediment into freshwater zones and coastal wetlands.

Drainage through agricultural soils can cause leaching of soluble nutrients and pesticides, which infiltrate groundwater and then reach downstream waters.

Cane farm and river

Photo Qld fisheries

High volumes of cane will increase these effects.

Cane farms satellite

Google

The use of pesticides also poses a risk to aquatic organisms, particularly in freshwater areas and inshore and coastal ecosystems.

Pesticide spraying in a field

Burning cane also release carbon dioxide into the atmosphere as well as creating fine ash which settles in nearby waterways.

Burning cane

Photo Murray Waite and Viewfinder

Manufacturing, retailing and plastic

Unfortunately we are now living in a ‘throw-away’ society. Most of the goods we buy have specialised packaging which cannot be re-used. The greater the population density the greater the pollution.

Plastic bags in trolley

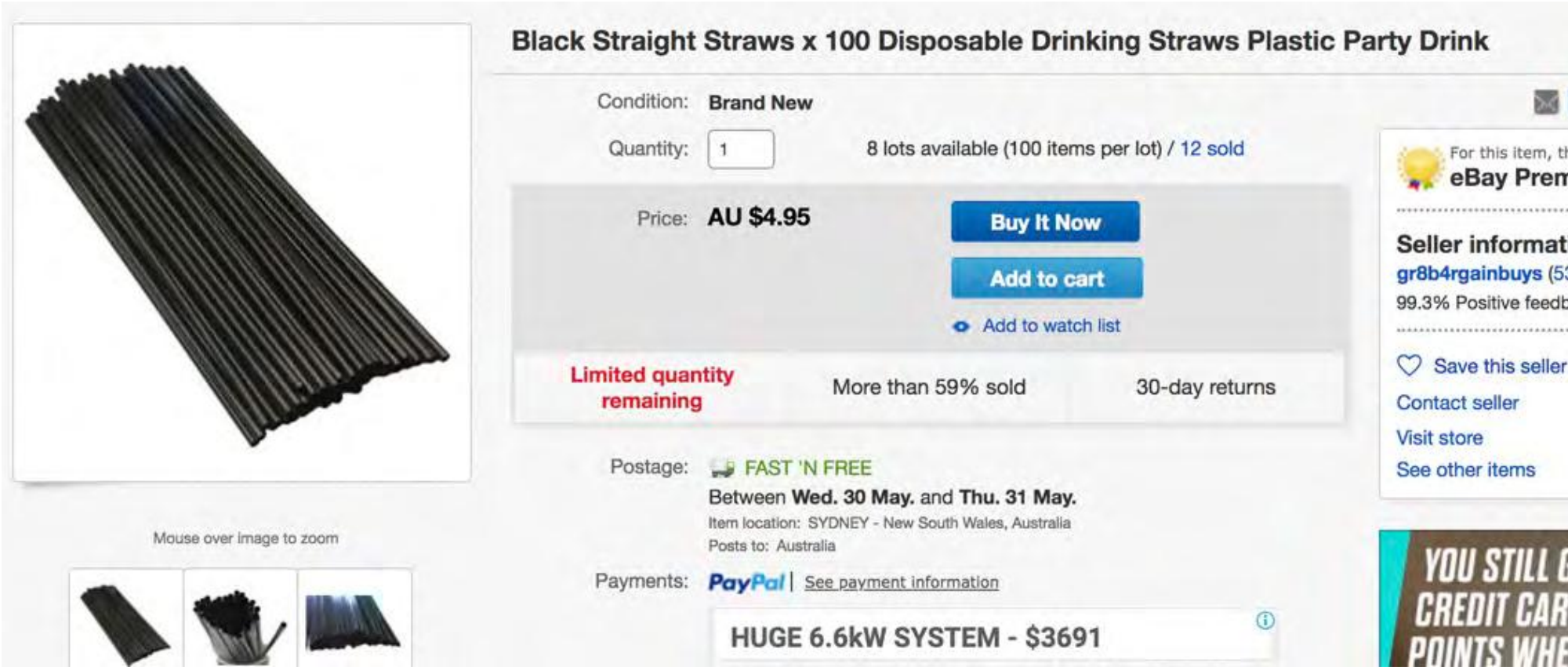
Photo credit: Global citizen

Many items we buy are packed in plastic, used once and then disposed of.

Packaged goods in supermarket trolley

Photo credit: Stuff.co.nz

Manufacturers make disposable items or cheap goods which have a short life, for example plastic straws.



Plastic straws ebay
Photo credit: https://www.ebay.com.au/

Others run advertising campaigns telling us our old models are inadequate or obsolete and that we need to purchase their new improved model.

But what are we going to do with our old model?

Mobile phone needed now

Photo credit: Unknown internet

The answer - it becomes trash.

Rubbish in a bin

Photo Bob Moffatt

Which ends up as landfill with millions of plastic bags.

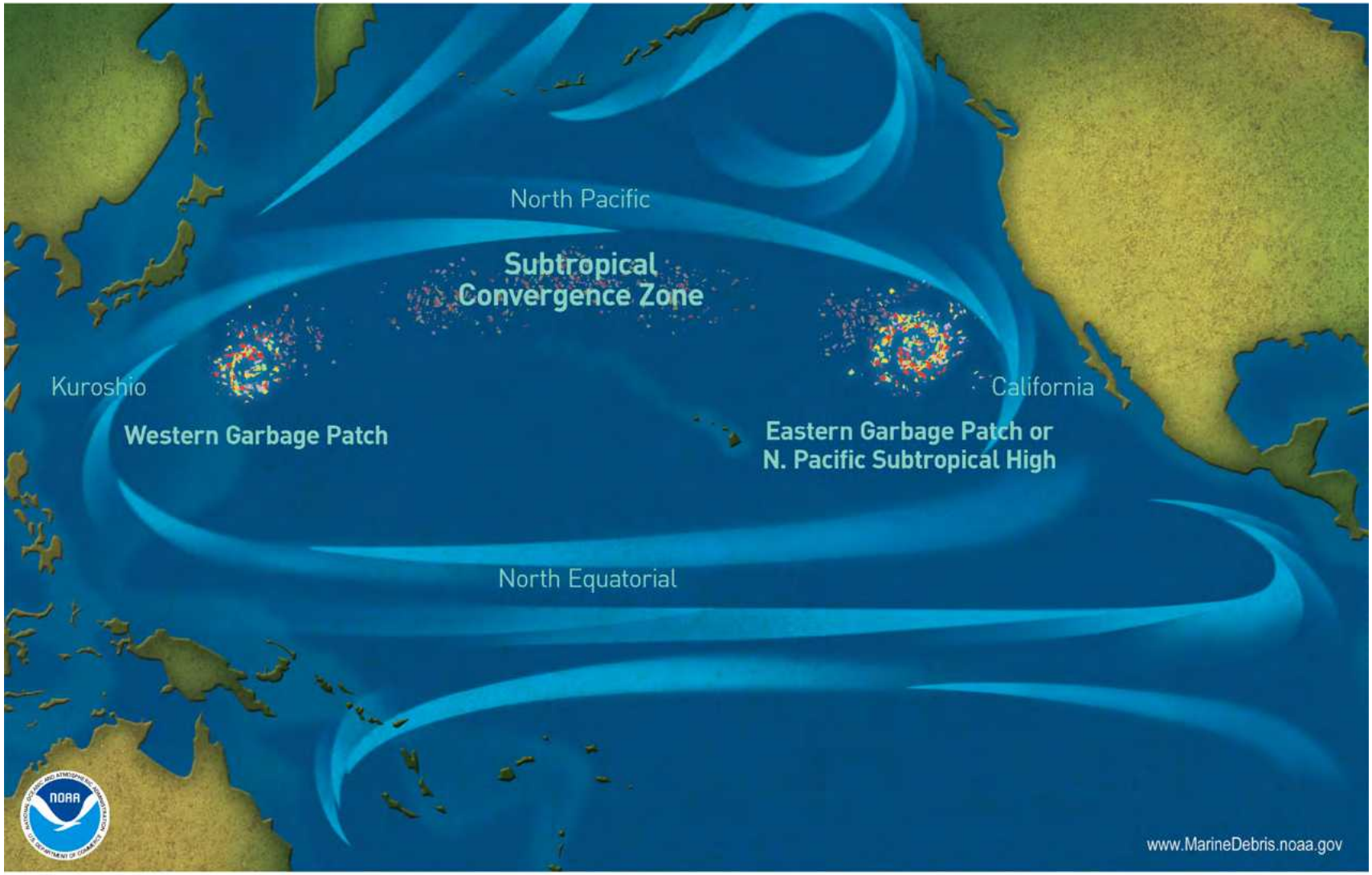
Which blow out to sea.

Plastic bag in wind
Photo Bob Moffatt

Which end up floating in the sea and then carried around the world ending up in huge oceanic gyres know as oceanic garbage patches.

Rubbish in the water

Photos Neville Coleman (L) Bob Moffatt (R)



Great Pacific Garbage patch

NOAA.jpg

Question

Estimate the impact of coastal development on the health of coastal water using the following as examples.

A. Suburbs and cities

B. Farming and agriculture

C. Manufacturing, retailing and the production of plastic

T025 Types of pollution

Syllabus statement

At the end of this topic you should be able to … **Recall** types of pollution of coastal zones, including organic wastes, thermal, toxic compounds, heavy metals, oil, nutrients and pesticides.

Recall

- remember;
- present remembered ideas, facts or experiences;
- bring something back into thought, attention or into one’s mind.

Definition

A pollutant is a substance or energy introduced into the environment that has undesired effects.

Pollution plastic on turtle

Marine Safety Queensland

Question

Recall reasons why each of following is classed as a pollutant:

A. Organic wastes

B. Hot water

C. Heavy metals

D. Oil

E. Nutrients

F. Pesticides

Organic wastes

Of importance are the nonbiodegradable organic wastes or persistent organic pollutants (POPs) are carbon-based chemicals that are resistant to environmental degradation through chemical, biological, and photolytic processes.

Plastic household items

Photo Wet Paper

Paint is resistant to environmental degradation.

Painting aisle trade warehouse

Photo Bob Moffatt

The organic waste stream is composed of waste of a biological origin such as paper and cardboard, food, green and garden waste, animal waste and biosolids and sludges.

Boom and rubbish

Photo AMSA

Organic waste is usually generated as a component of most waste streams and is collected by garbage trucks and disposed of in landfills.

Garbage truck

Landfill adjacent the ocean

Biodegradable organic wastes including kitchen waste and garden waste are derived from living organisms so they can be oxidized by naturally occurring microorganisms are usually **not** classed as pollutants.

Photo South Australian government

Thermal

Thermal pollution is the degradation of water quality by any process that changes ambient water temperature. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.

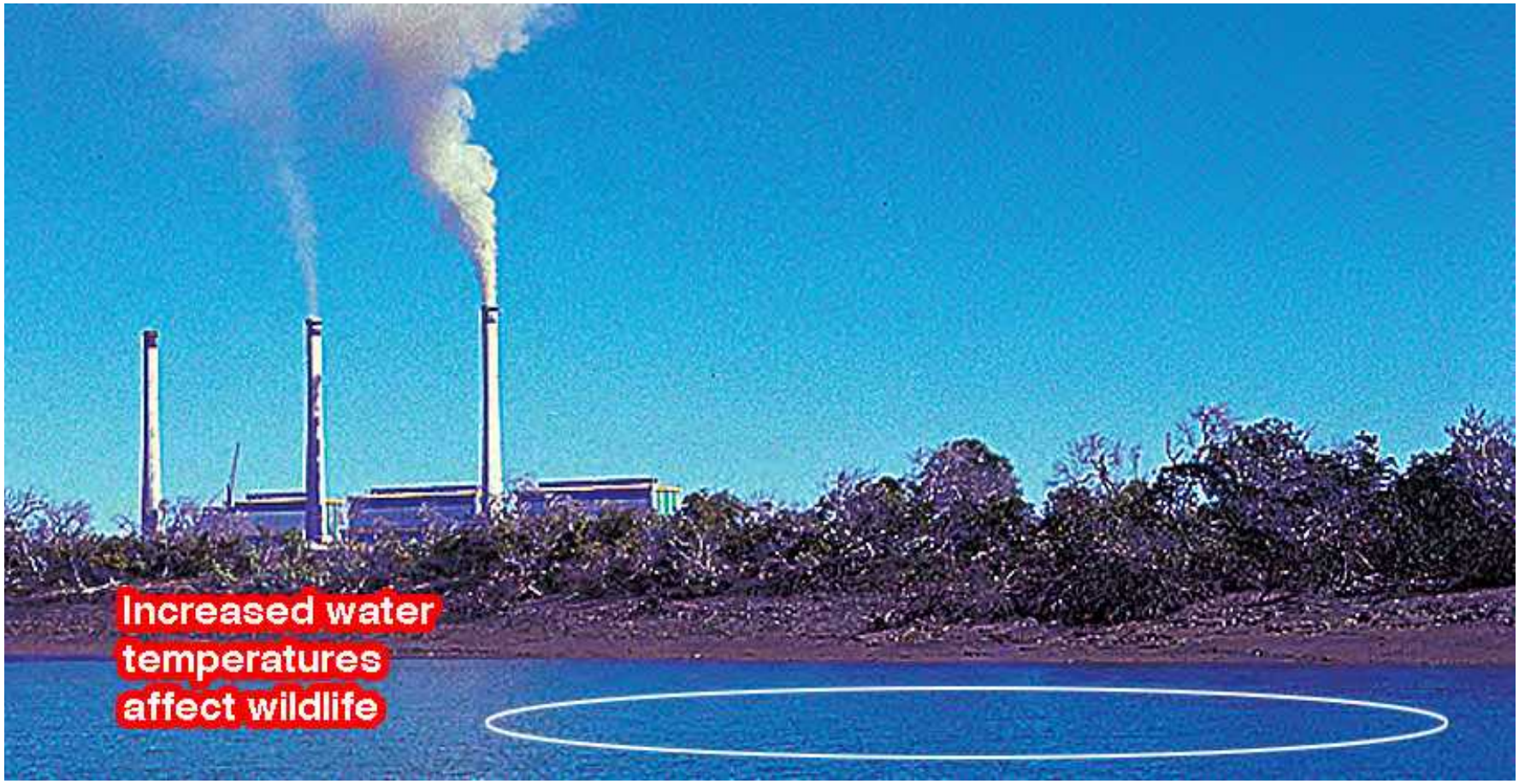
Coal fired power station

When water used as a coolant is returned to the natural environment at a higher temperature, the sudden change in temperature decreases oxygen supply and affects ecosystem composition.

Aerial power house water in and out

Photo Geoscience Australia

Fish and other organisms adapted to particular temperature range can be killed by an abrupt change in water temperature (either a rapid increase or decrease) known as "thermal shock."



Power station showing water temp increase

Photo Bob Moffatt

Heavy metals

A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity, especially in environmental contexts.

Element	Acute exposure *usually a day or less*	Chronic exposure *often months or years*
Cadmium	Pneumonitis (lung inflammation)	Lung cancer Osteomalacia (softening of bones) Proteinuria (excess protein in urine; possible kidney damage)
Mercury	Diarrhea Fever Vomiting	Stomatitis (inflammation of gums and mouth) Nausea Nephrotic syndrome (nonspecific kidney disorder) Neurasthenia (neurotic disorder) Parageusia (metallic taste) Pink Disease (pain and pink discoloration of hands and feet) Tremor
Lead	Encephalopathy (brain dysfunction) Nausea Vomiting	Anemia Encephalopathy Foot drop/wrist drop (palsy) Nephropathy (kidney disease)
Chromium	Gastrointestinal hemorrhage (bleeding) Hemolysis (red blood cell destruction) Acute renal failure	Pulmonary fibrosis (lung scarring) Lung cancer
Arsenic	Nausea Vomiting Diarrhea Encephalopathy Multi-organ effects Arrhythmia Painful neuropathy	Diabetes Hypopigmentation/Hyperkeratosis Cancer

Heavy metal effect

https://en.wikipedia.org/wiki/Toxic_heavy_metal

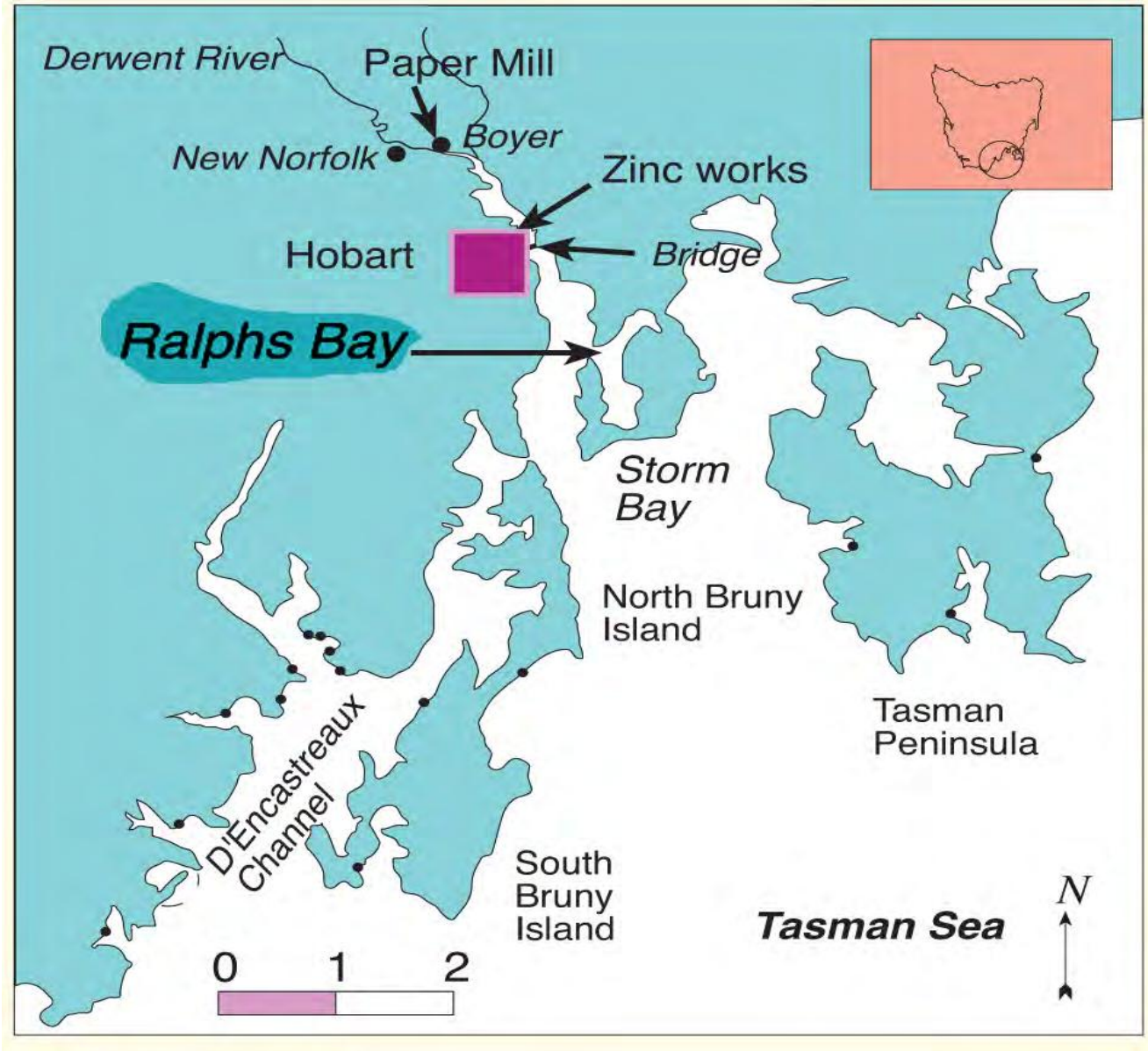
As an example a 7.6 m wall of coal fly ash contaminated a US river with arsenic, copper, barium, cadmium, chromium, lead, mercury, nickel, and thallium in samples of slurry and river water. Cleanup costs may exceed $1.2 billion.

Heavy metal pollution US waterway

https://en.wikipedia.org/wiki/Toxic_heavy_metal

In 1974 heavy metal pollution was discovered in the Derwent estuary, Tasmania.

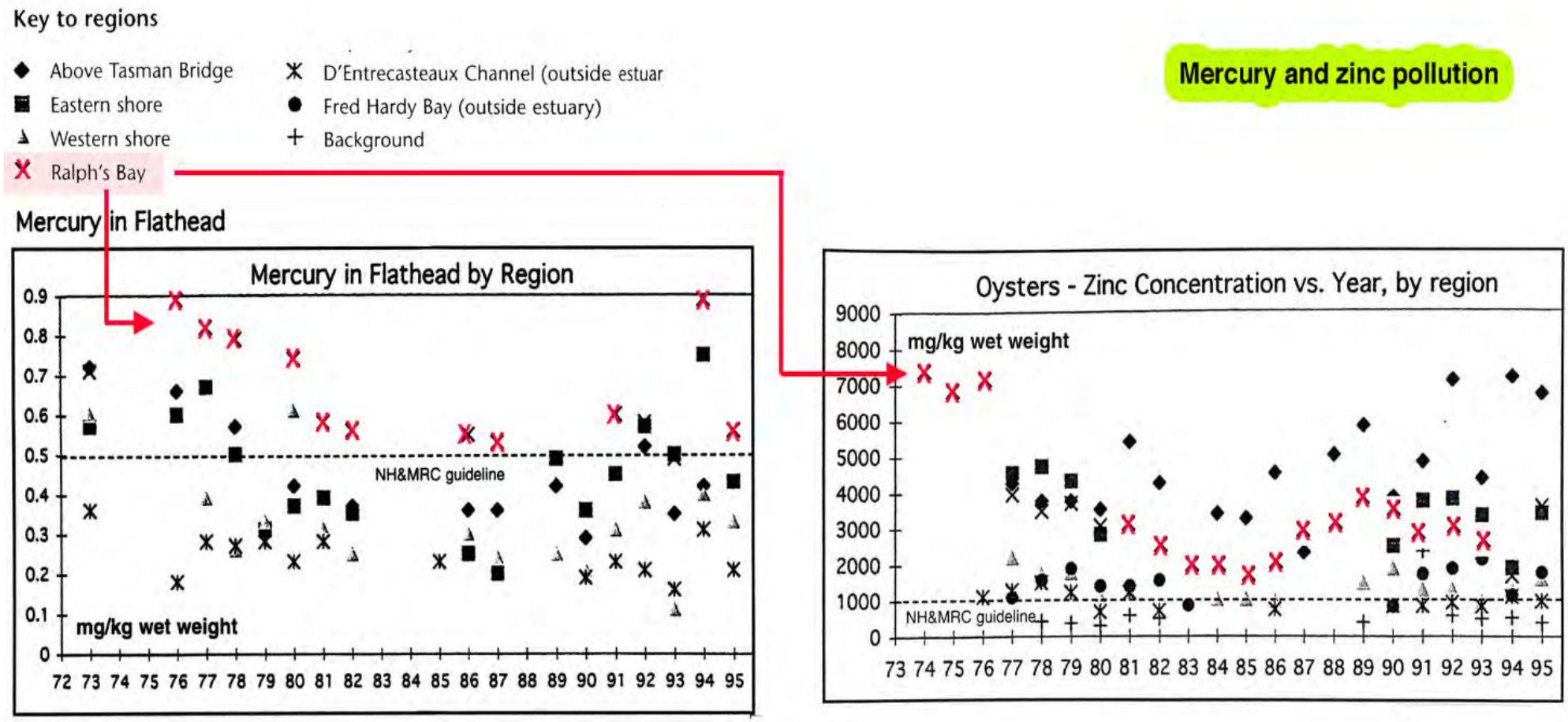
Four years earlier, people had become sick after eating oysters farmed in the lower estuary.



Ralphs Bay Tasmania

Illustration Bob Moffatt

CSIRO confirmed that zinc and cadmium levels in the oysters were a threat to human health. Excessive mercury levels were later found in certain species of fish.



Zinc and mercury data in Tasmania

Illustration and data CSIRO

Waste discharges from Electrolytic Zinc at Risdon, 15 kilometres upstream were blamed for the contamination. The metal plant was established in 1917 and is one of the world's largest producers of zinc, metals and alloys.

Derwent zinc smelter

Photo Bob Moffatt

Following the imposition of strict environmental guidelines,
there is no longer an issue with this type pollution in Tasmania.

By Public Domain
https://commons.wikimedia.org/w/index.php?curid

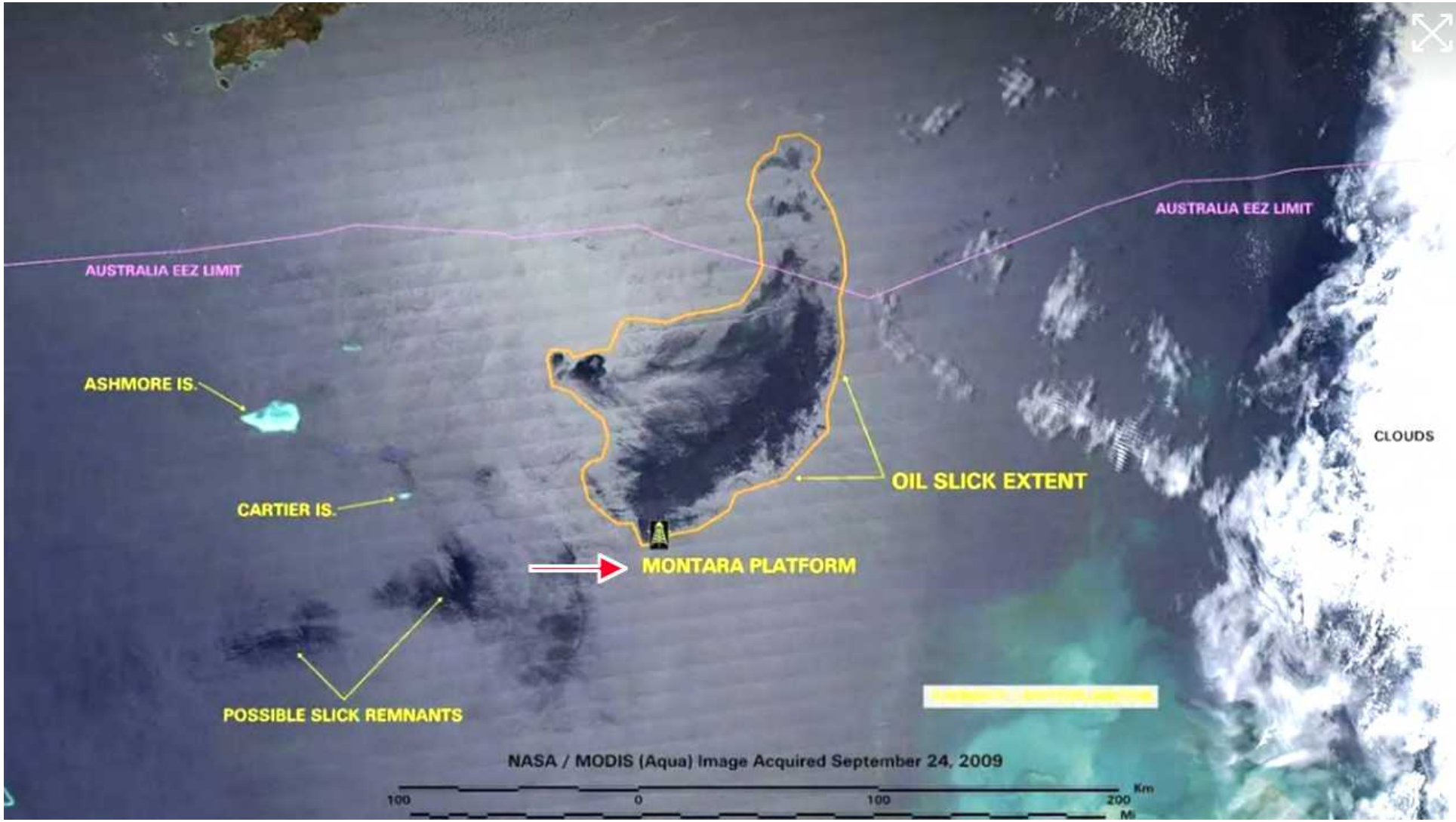
Oil

An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and is a form of pollution.

Oil spill and kelp

Australia's worst oil spill came from an offshore oil platform fire in 2009.

West Atlas Oil Spill



Montara oil spill Timor Sea

https://en.wikipedia.org/wiki/Montara_oil_spill#/media/File:Oil_Slick_in_the_Timor_Sea_September-2009.jpg

The effects of oil pollution on marine life is catastrophic

Seal, penguin and oil

Photos AMSA

Nutrients

Sewage is a complex complex organic waste and is mixture of chemicals, with many distinctive chemical characteristics.

Sewage treatment plan

Organic matter of sewage is measured by determining its biological oxygen demand (BOD) or the chemical oxygen demand (COD).

BOD test bottles

Sewage contains human faeces, and therefore often contains pathogens and treated discharges are monitored for both disease-causing and benign organisms.

Collecting effluent water samples

Sewage contains nutrients that may cause eutrophication of receiving water bodies. That is when a body of water becomes overly enriched with minerals and nutrients that induce excessive growth of plants and algae.

Bloom of cyanobacteria from nutrient

Pesticides

Pesticides are substances that are meant to control pests, including weeds.

Type of pesticide	Target pest group
Algicides or algaecides	Algae
Avicides	Birds
Bactericides	Bacteria
Fungicides	Fungi and oomycetes
Herbicides	Plant
Insecticides	Insects
Miticides or acaricides	Mites
Molluscicides	Snails
Nematicides	Nematodes
Rodenticides	Rodents
Virucides	Viruses

Types of pesticide
https://en.wikipedia.org/wiki/Pesticide

The most common of these are herbicides which account for approximately 80% of all pesticide use.
Most pesticides are intended to serve as plant protection products (also known as crop protection products), which in general, protect plants from weeds, fungi, or insects.

Sprayed weeds

Most pesticides are intended to serve as plant protection products (also known as crop protection products), which in general, protect plants from weeds, fungi, or insects.

Crop duster spraying pesticides

Although pesticides have benefits, some also have drawbacks, such as potential toxicity to humans and other species in the food web.

Label	Name	Level of toxicity	Oral lethal dose (mg/kg)	Listed chemicals
	Red label	Extremely toxic	1–50	Monocrotophos, zinc phosphide, ethyl mercury acetate, and others.
	Yellow label	Highly toxic	51–500	Endosulfan, carbaryl,[2] quinalphos,[2] and others.
	Blue label	Moderately toxic	501–5000	Malathion, thiram, glyphosate,[2] and others.
	Green label	Slightly toxic	> 5000	Mancozeb, oxyfluorfen, mosquito repellant oils and liquids, and most other household insecticides.

Toxicity label information

https://en.wikipedia.org/wiki/Toxicity_label

DDT was once used as a pesticide but has been banned since 1972 because it accumulated in the food chain.

nature
International weekly journal of science

nature news home | news archive | specials | opinion | features | news blog | nat

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Add to Digg

Published online 7 January 2010 | Nature | doi:10.1038/news.2010.4

News

Oceans release DDT from decades ago

Emissions of controversial pesticide are heading northwards.

Richard A. Lovett

A computer simulation of the environmental fate of DDT (dichlorodiphenyltrichloroethane) has revealed that substantial quantities of the pesticide are still being released from the world's oceans, despite widespread restrictions on its use during the 1970s.

The calculations show that although remaining DDT use today tends to be in the southern hemisphere, its concentrations are actually growing in the northern hemisphere as it moves through the world's oceans and atmosphere.

An estimated 1.5 million tonnes of DDT were used worldwide between the

Residues of the pesticide DDT may be heading northwards. *Corbis*

DDT Nature article

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

Question

Why are each of following classed as a pollutant?

A. Organic wastes

B. Hot water

C. Heavy metals

D. Oil

E. Nutrients

F. Pesticides

Ch 6 Coastal conservation and impacts

T026 Sustainable management

T027 Stakeholder education

T028 Pollution source comparisons

T029 Monitoring water pollution

T030 Biochemical oxygen demand

T031 BOD use in pollution

T032 Eutrophication

T033 Pollution practices

T034 Measuring pollution levels

T035 Bio-indicator examples

T036 Water quality testing

T026 Sustainable management

Syllabus statement

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

Define sustainable management practice

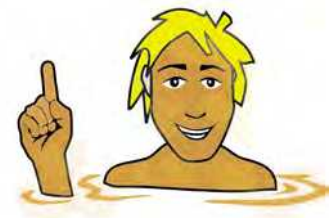
Define

- give the meaning of a word, phrase, concept or physical quantity;

- state meaning and identify or describe qualities.

Definition

“A sustainable management practice is the application and monitoring of practices and/or policies that are informed by the concept of sustainability”.



Question

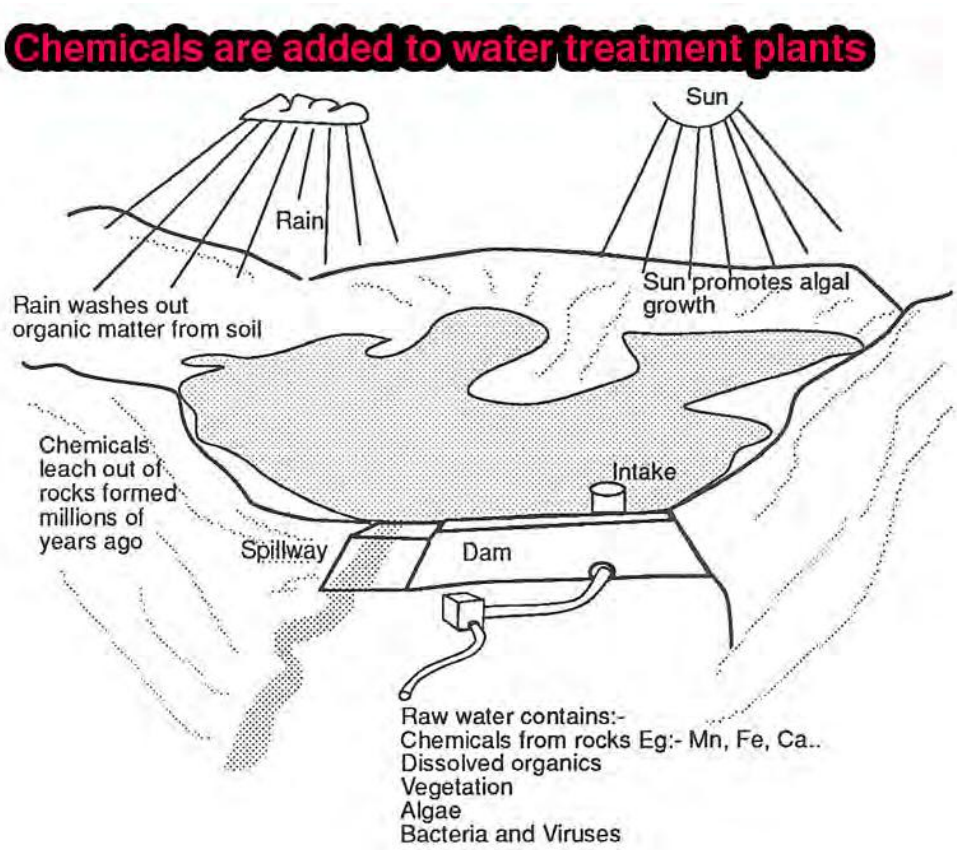
Using household water use and cane farming as examples, describe how policy and regulation are used in the application and monitoring of sustainability practices.

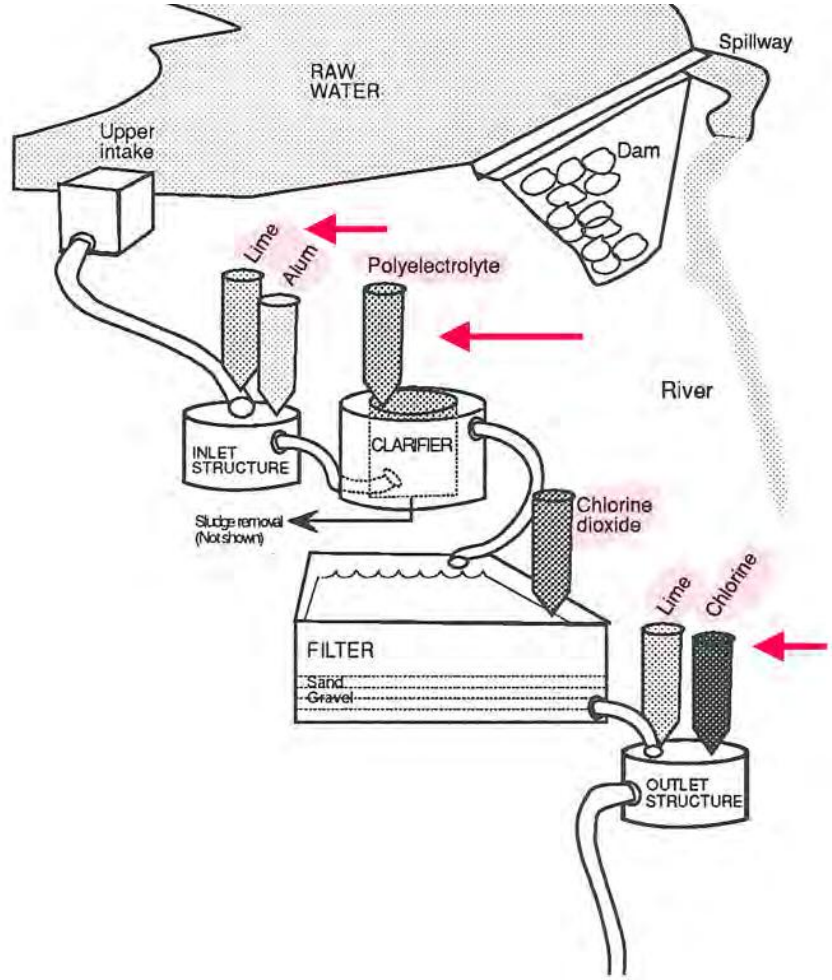
Policy - Household water use

Water is life. Without water our planet is non sustainable.

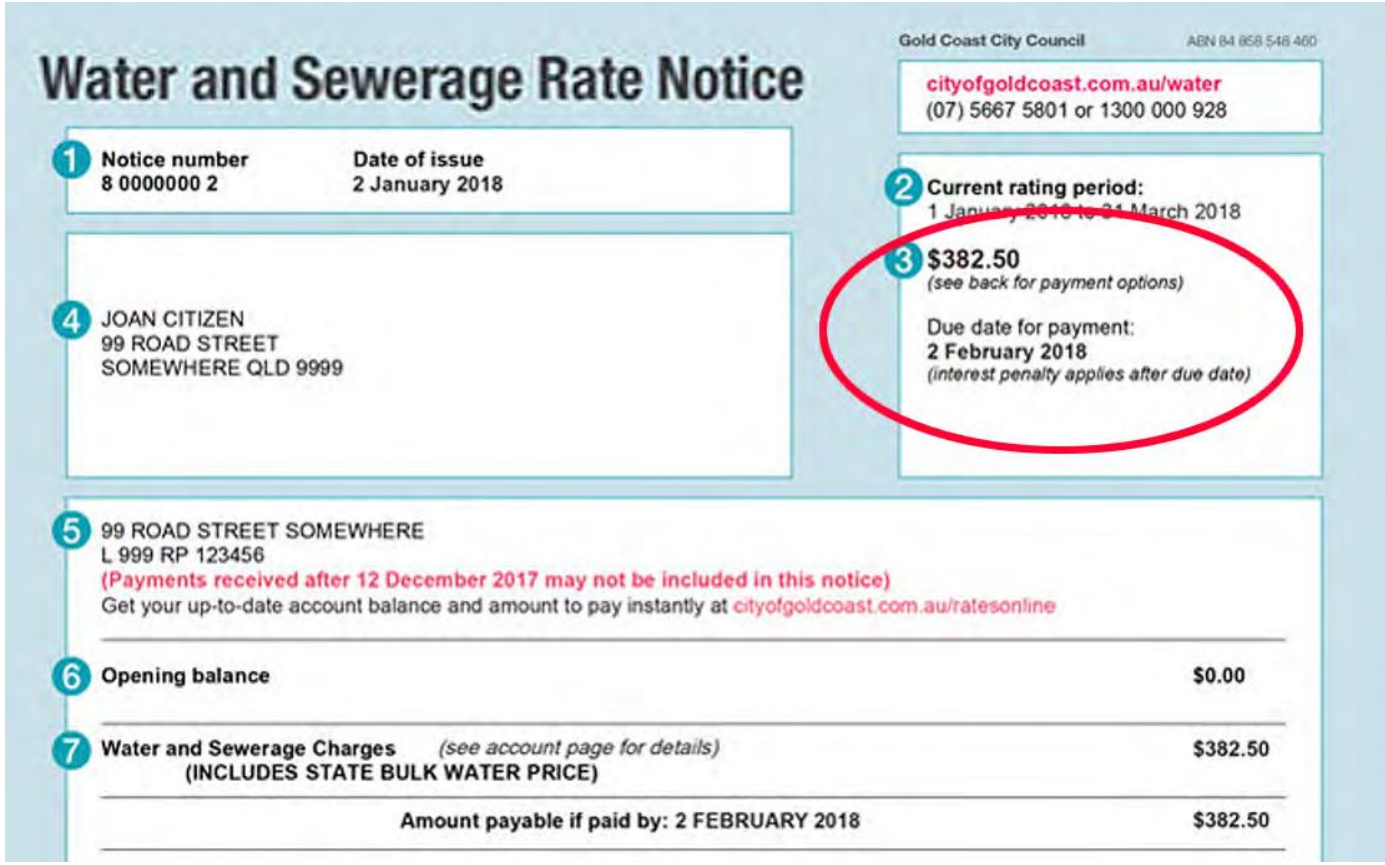
The water available for drinking on Earth is very small and requires a great deal of energy to acquire. Wells have to be drilled, dams and infrastructure built.

In the process greenhouse gases are produced, chemicals used and materials manufactured.





Thirty years ago a household water bill cost around $20. However due to policy changes it is over $300 and is an example of the application of a policy that has been informed by the concept of sustainability.



Water and Sewerage Rate Notice

Gold Coast City Council ABN 84 858 548 460

cityofgoldcoast.com.au/water
(07) 5667 5801 or 1300 000 928

1 **Notice number** 8 0000000 2 — **Date of issue** 2 January 2018

2 **Current rating period:** 1 January 2018 to 31 March 2018

3 **$382.50**
(see back for payment options)

Due date for payment:
2 February 2018
(interest penalty applies after due date)

4 JOAN CITIZEN
99 ROAD STREET
SOMEWHERE QLD 9999

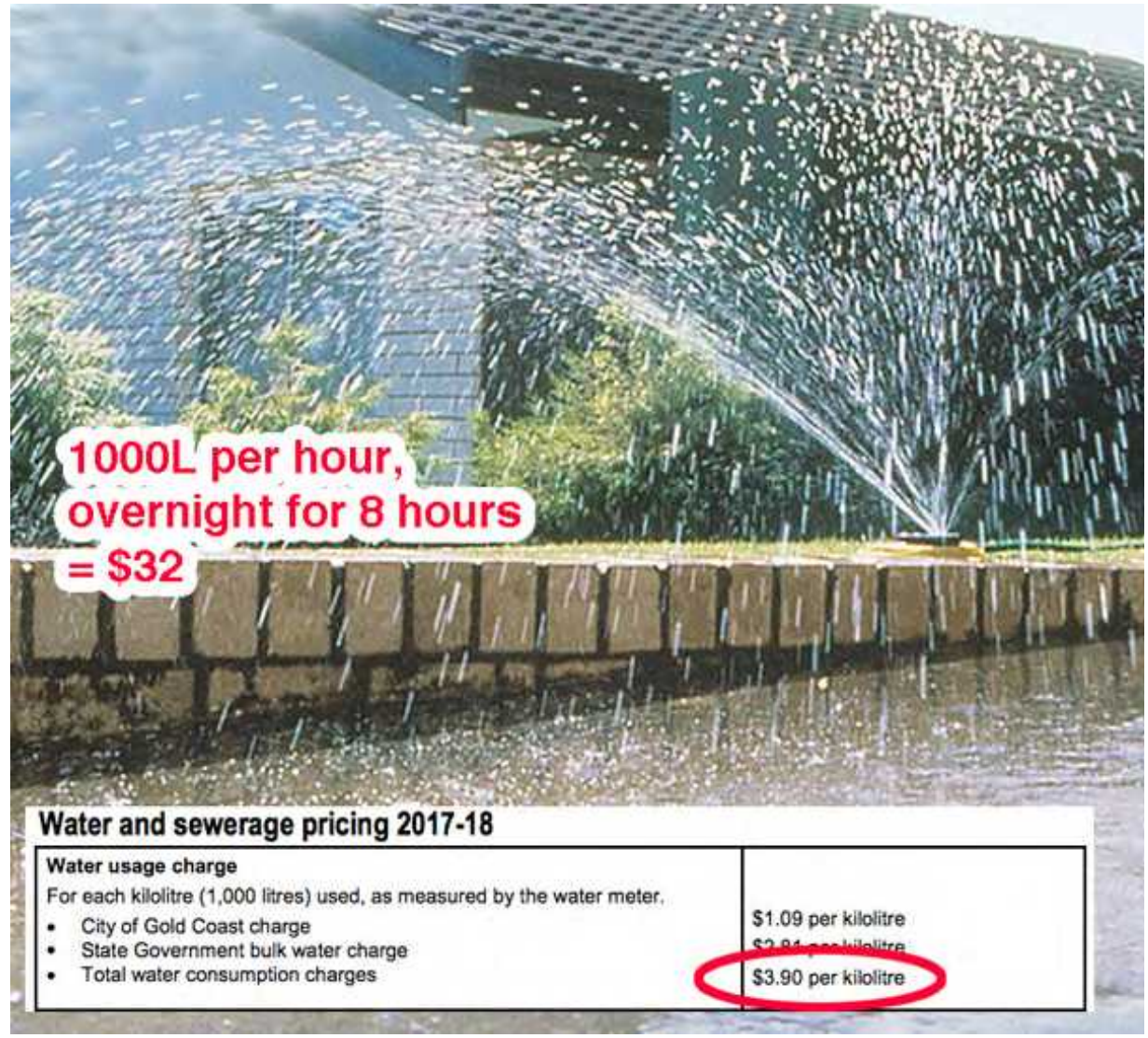
5 99 ROAD STREET SOMEWHERE
L 999 RP 123456
(Payments received after 12 December 2017 may not be included in this notice)
Get your up-to-date account balance and amount to pay instantly at cityofgoldcoast.com.au/ratesonline

6	**Opening balance**	**$0.00**
7	**Water and Sewerage Charges** *(see account page for details)* **(INCLUDES STATE BULK WATER PRICE)**	**$382.50**
	Amount payable if paid by: 2 FEBRUARY 2018	**$382.50**

Water bill 2018
GCCC

Thirty years ago households would waste water by allowing sprinklers to run all night or on driveways using about 8 kilometres.

If this practice occurred to day, the bill for a nights watering @ $4 a kilometre would be $32.



Sprinkler on a driveway and water bill

Bob Moffatt

Today water pricing policy is used to control sustainable use of water. For example showers.
Current policy is that water is charged at a rate of $4 per kilolitre

- An unsustainable use of water for a family of 4 with a shower rose using 25 litres per minute with each family member spending 10 minutes in the shower, two showers a day. At 2 kilolitres of water a day a year the family would use 730 KL per year.

- Under the pricing policy this would coast the family $2920 for showers.

Man in shower

Credit Wet Paper archives

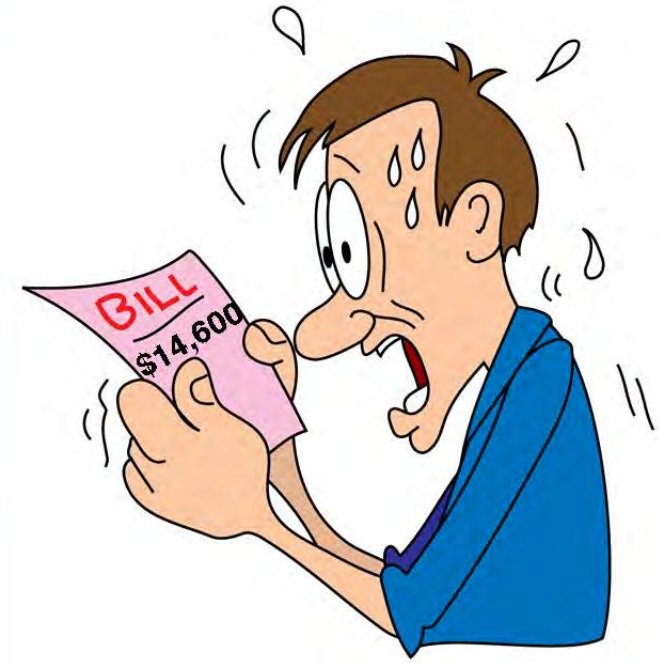
If the family sprinkled the lawn and continued to shower at this rate it would cost $14,600 per year

LOCAL GOVERNMENT DISTRIBUTION AND RETAIL PRICE

SEWERAGE SERVICE CHARGES	
Sewerage Access	$181.28
WATER SERVICE CHARGES	
Water Access	$53.02
WATER USAGE	
730 kilolitres charged at $1.09 (usage period 11/7/17 to 11/7/18)	$12,600
STATE BULK WATER PRICE	
WATER USAGE	
730 kilolitres charged at $2.81 (usage period 11/7/17 to 11/7/18)	$2051.30
TOTAL CHARGES INCLUDED IN THE RATE NOTICE	$14,600

WATER METER READINGS

Meter Number	Current Read Date	Current Reading	Previous Read Date	Previous Reading	#Days Charged	Cons (kL)
R12345678	13 OCT 17	144	10 JUL 17	106	95	38
					TOTAL (kL)	38



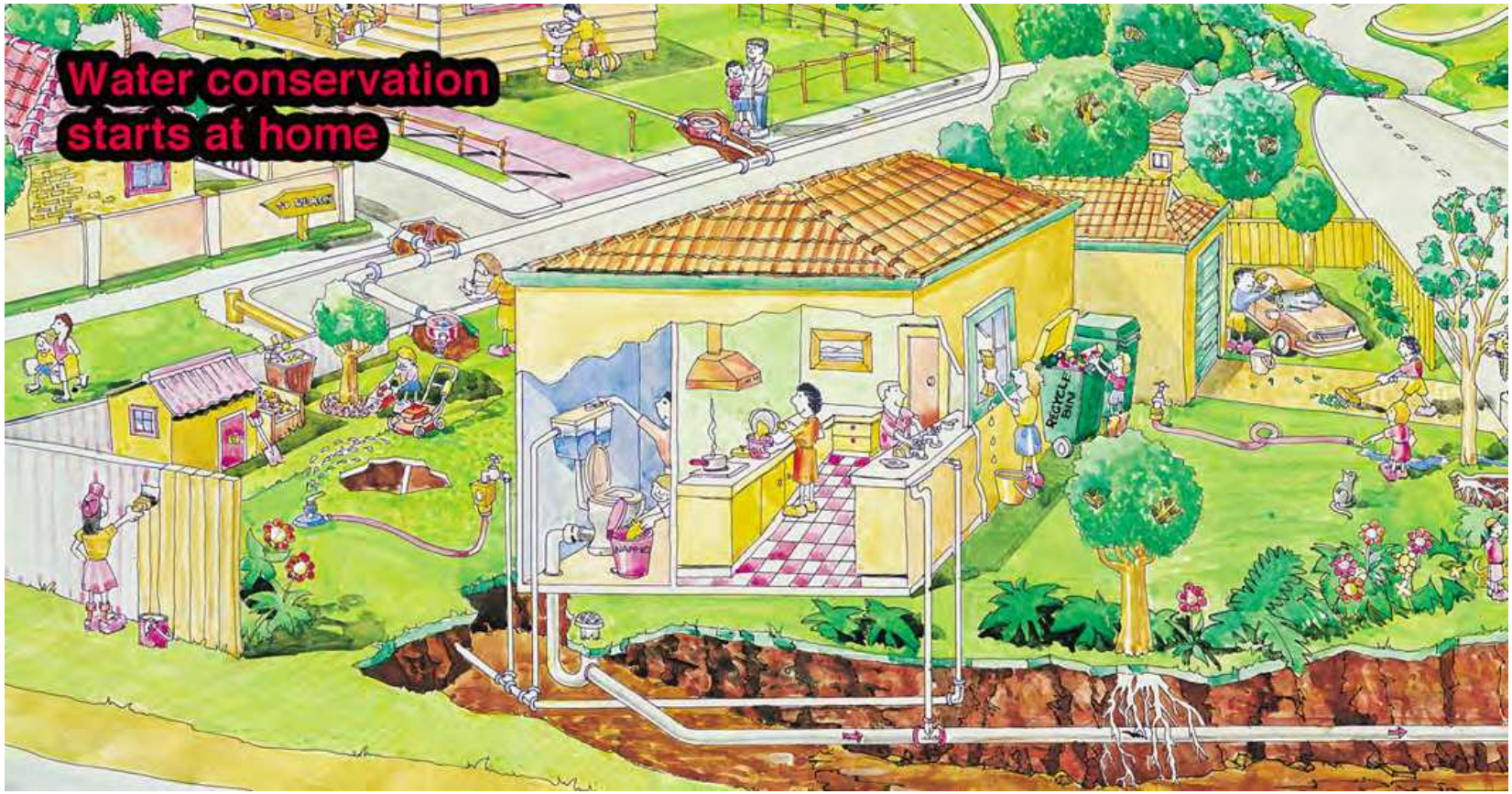
Man and fake water bill

Credit Wet Paper archives

The sustainable management practices sought by environmental stakeholders would be to:

a. Install water saving devices

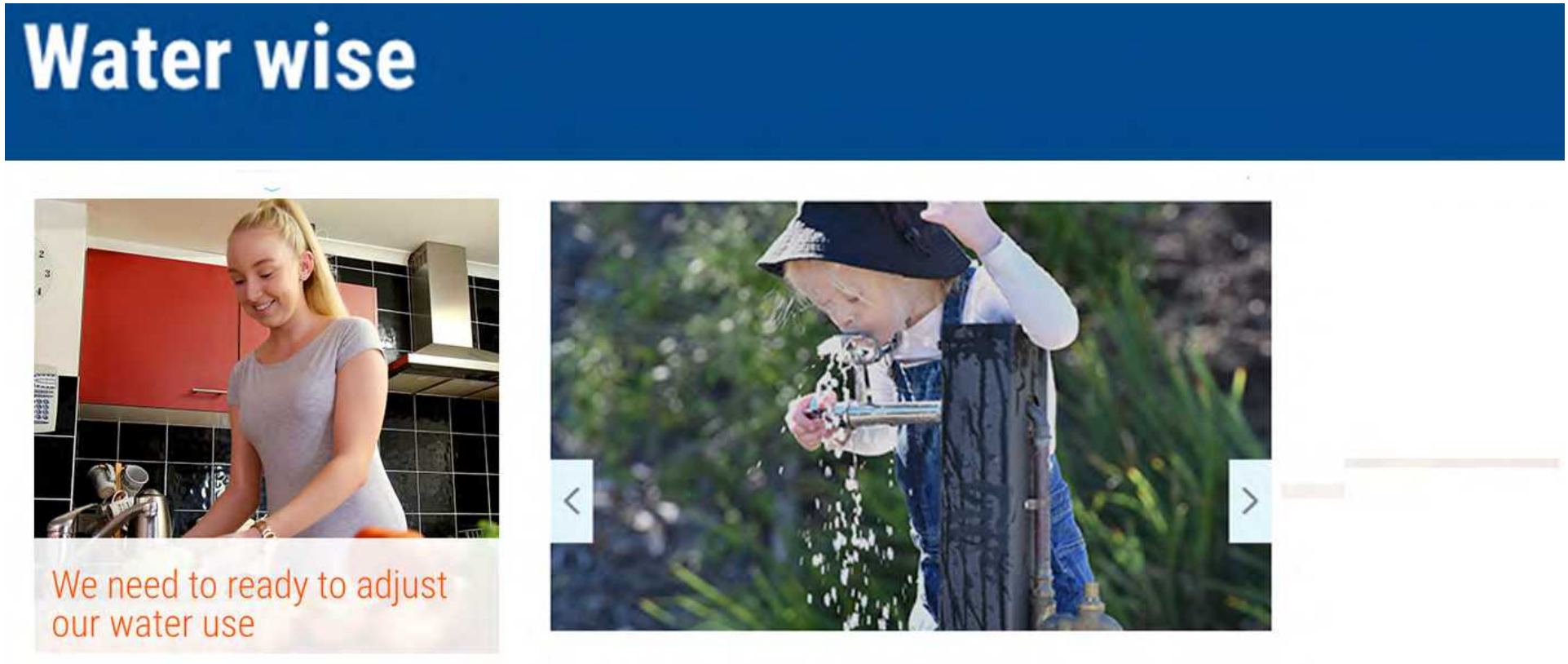
b. Change attitudes to length of showers



Waterwise education poster

Credit Wet Paper archives

So the example shows that policy is used to apply sustainability water conservation practices and the water bill is used to monitor the sustainable practice.

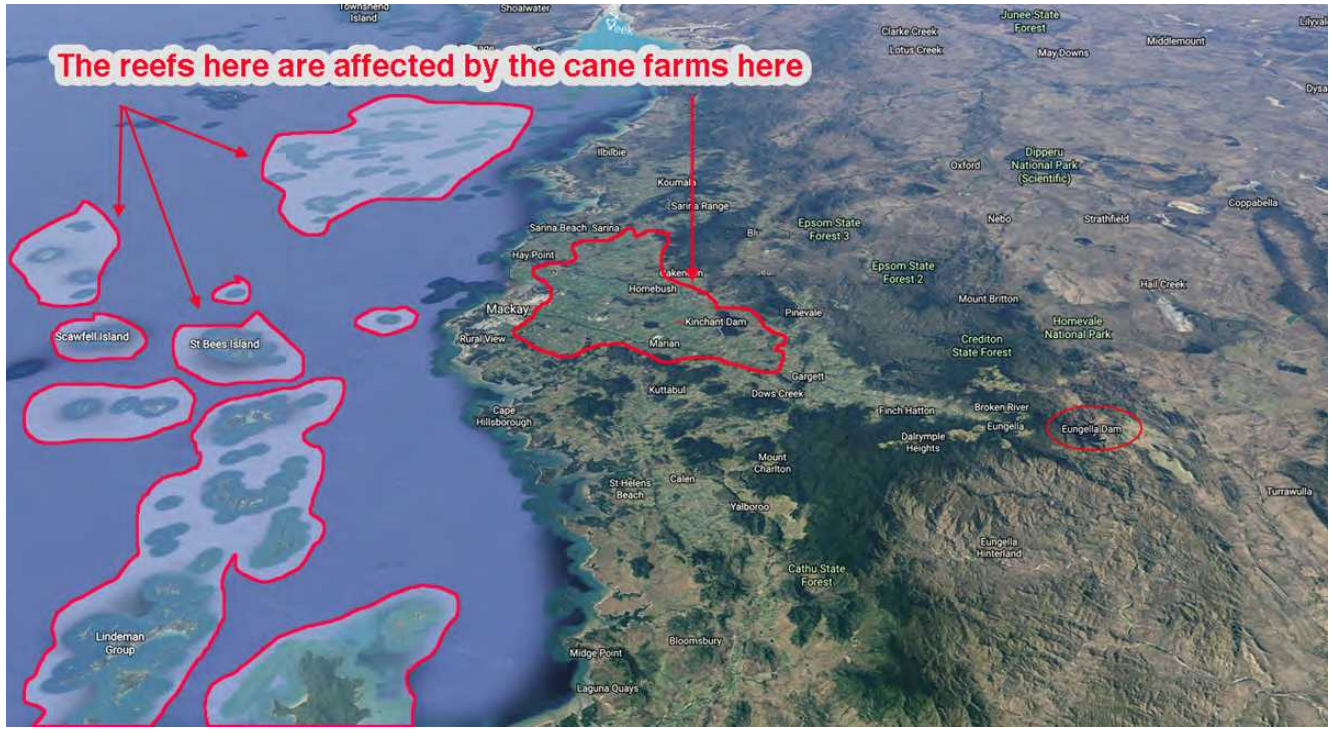


Water wise policy web site

http://www.seqwater.com.au/water-supply/water-wise

Regulation - Cane farm monitoring regulations for pesticides and fertilisers

The Great Barrier reef is impacted by pesticides and irrigation run off nutrients from cane farms.



Reef aerial affected by cane farms

Photo https://www.google.com/intl/en/permissions/trademark/rules.html

These impacts have been recognised by regulatory authorities such as the Queensland Government

Queensland Government

Impacts

Contact us

Search website

For Queenslanders Business and industry

Queensland Government home › For Queenslanders › Environment, land and water › Agriculture and primary industries

› Sustainable farming practices › Farming in reef catchments › Reef protection regulations

Print

Farming in reef catchments

:tion regulations

· Science Program

it Barrier Reef

rojects in Wet

in

Reef protection regulations

Impacts of nutrient and pesticide run-off from cane farming

The Great Barrier Reef is Queensland's most treasured ecosystem and is worth around $6 billion a year to the economy, supporting 69,000 jobs. Strong scientific evidence indicates increased quantities of nutrients and pesticides are entering the Great Barrier Reef lagoon and cane farming is one of the key sources.

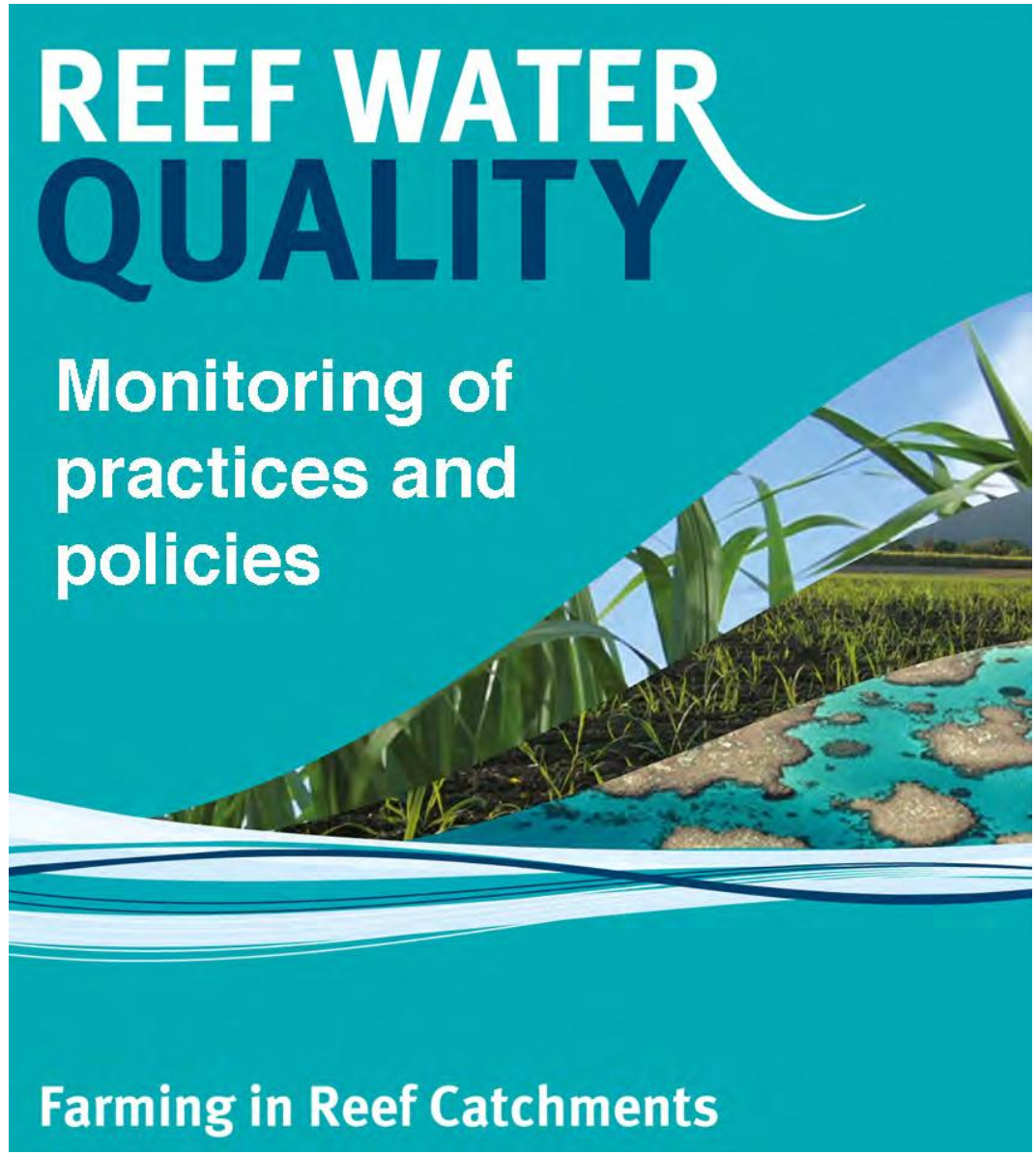
How are nutrient and pesticide losses damaging the reef?

Crown-of-thorns starfish

Cane farm impacts Qld Gov website

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

The application and monitoring of practices and policies can be seen in the regulations and reporting cane farmers have to do as part of running their farming business.



Farming in reef catchments brochure cover

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming

For example

a. Training records of competencies in the use of pesticides are required
b. Soil testing records for nitrate and phosphate levels have to documented and are audible. Fines apply if records are not made or are fabricated.

Sugarcane - Ground application of ametryn, atrazine, hexazinone or diuron

Since 1 July 2010, anyone in the Wet Tropics, Burdekin and Mackay-Whitsunday catchments intending to apply or supervise the application of these herbicides to sugarcane crops using ground equipment must hold a statement of attainment

Policy and sustainable management practice

- (A) AHCPMG301—control weeds
- (B) AHCCHM303—prepare and apply chemicals
- (C) AHCCHM304—transport and store chemicals

NOTE: Aerial application of herbicides containing tebuthiuron is NOT permitted between 1 November and 31 March.

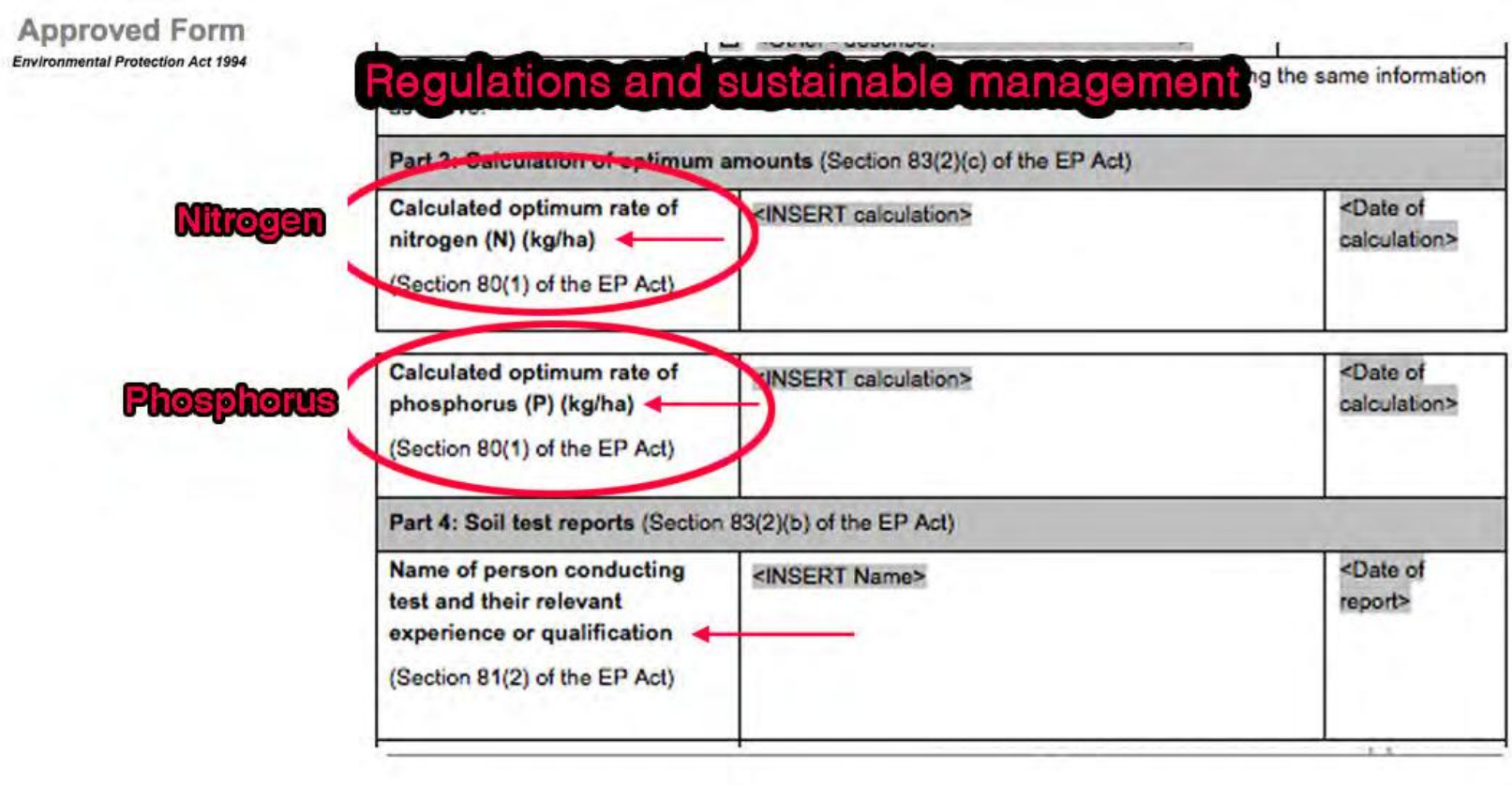
Policy

Cane farm education and regulation

From Training agricultural chemicals Qld Government

Training ensures chemicals are used in a way as to minimise impact on the reef.

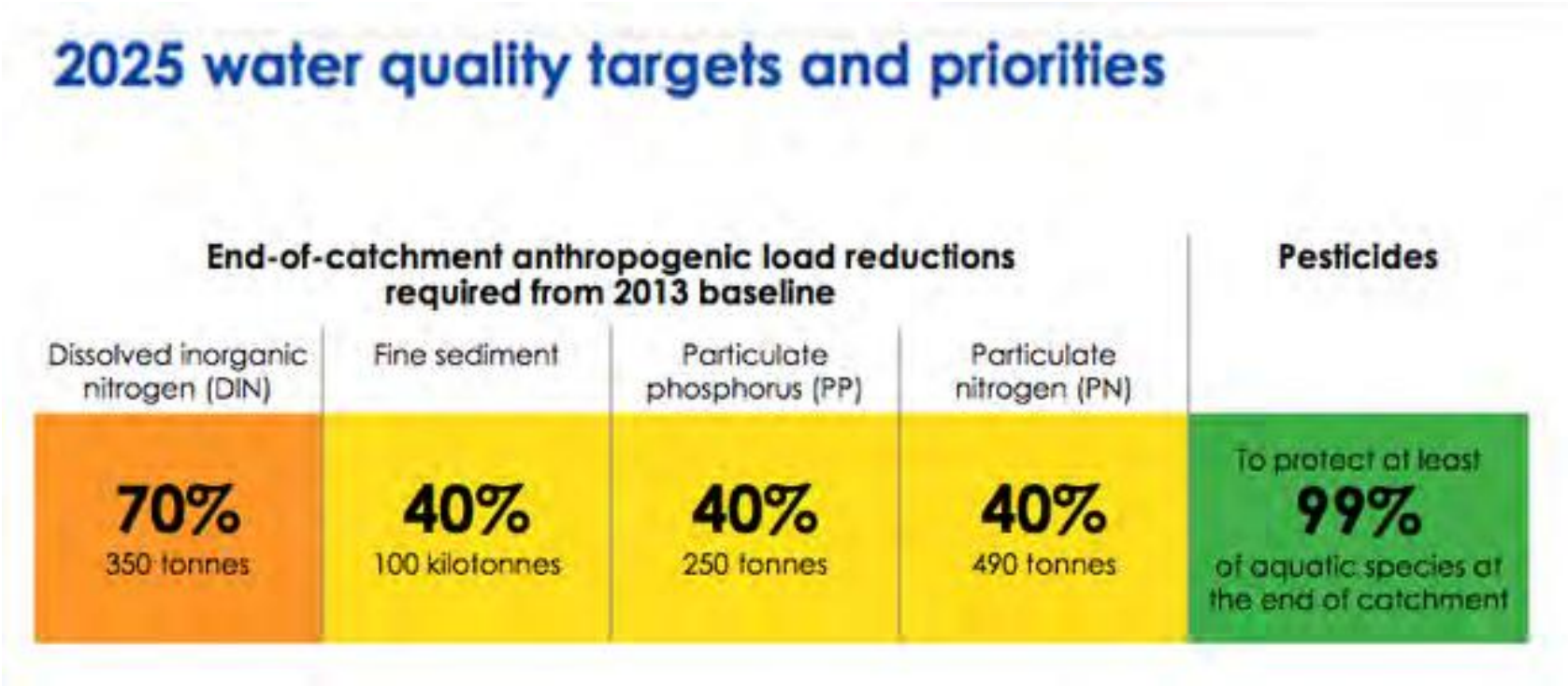
Record keeping is the method used to report on lowering nitrogen and phosphate levels required by targets set by policy makers.



Cane farming record keeping

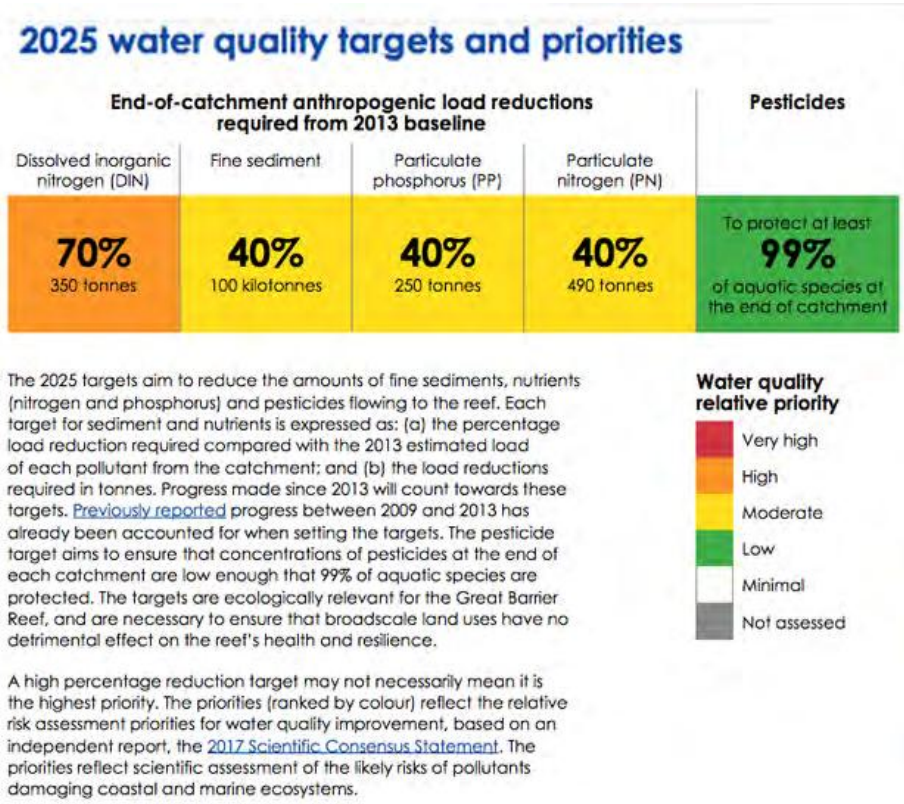
https://www.qld.gov.au/environment/assets/documents/agriculture/sustainable-farming/rwq-np-method.pdf

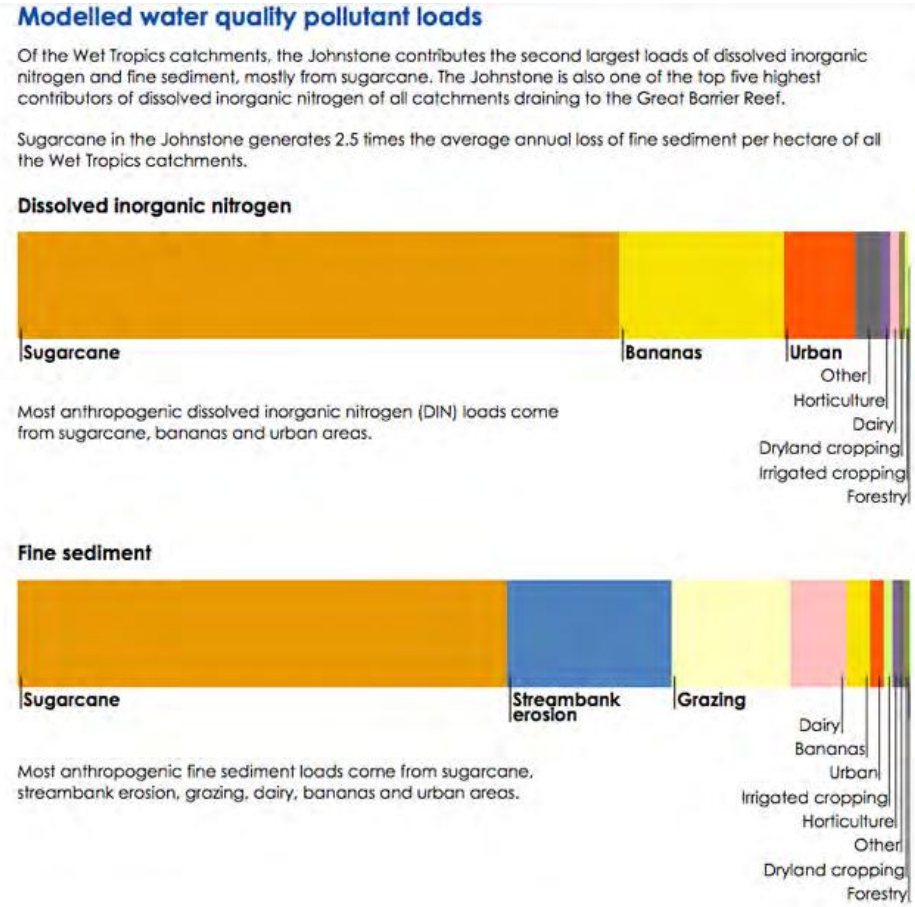
So regulation is by record keeping and training qualifications. These regulations are designed to meet the following water sustainable water quality targets.



Water quality target example

https://www.reefplan.qld.gov.au/about/assets/catchment-targets-wet-tropics-johnstone.pdf





Water quality target example

https://www.reefplan.qld.gov.au/about/assets/catchment-targets-wet-tropics-johnstone.pdf

Summary

1. Sustainable management takes the concepts from sustainability and synthesizes them with the concepts of management.

2. Sustainability has three branches: the environment, the needs of present and future generations, and the economy.

3. Using these branches, it creates the ability of a system to thrive by maintaining economic viability and also nourishing the needs of the present and future generations by limiting resource depletion.

4. From these concepts, sustainable management has been created.

Question

Use household water use and cane farming as examples to describe how policy and regulation are used in the application and monitoring of sustainability practices.

T027 Stakeholder education

Syllabus statement

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

Discuss that the education of stakeholders is essential to encouraging sustainable management practices

Discuss

- examine by argument; sift the considerations for and against; debate; talk or write about a topic, including a range of arguments, factors or hypotheses; consider, taking into account different issues and ideas, points for and/or against, and supporting opinions or conclusions with evidence

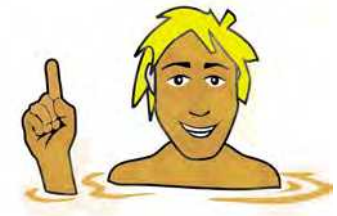
Definition

Stakeholder (Not defined in syllabus)

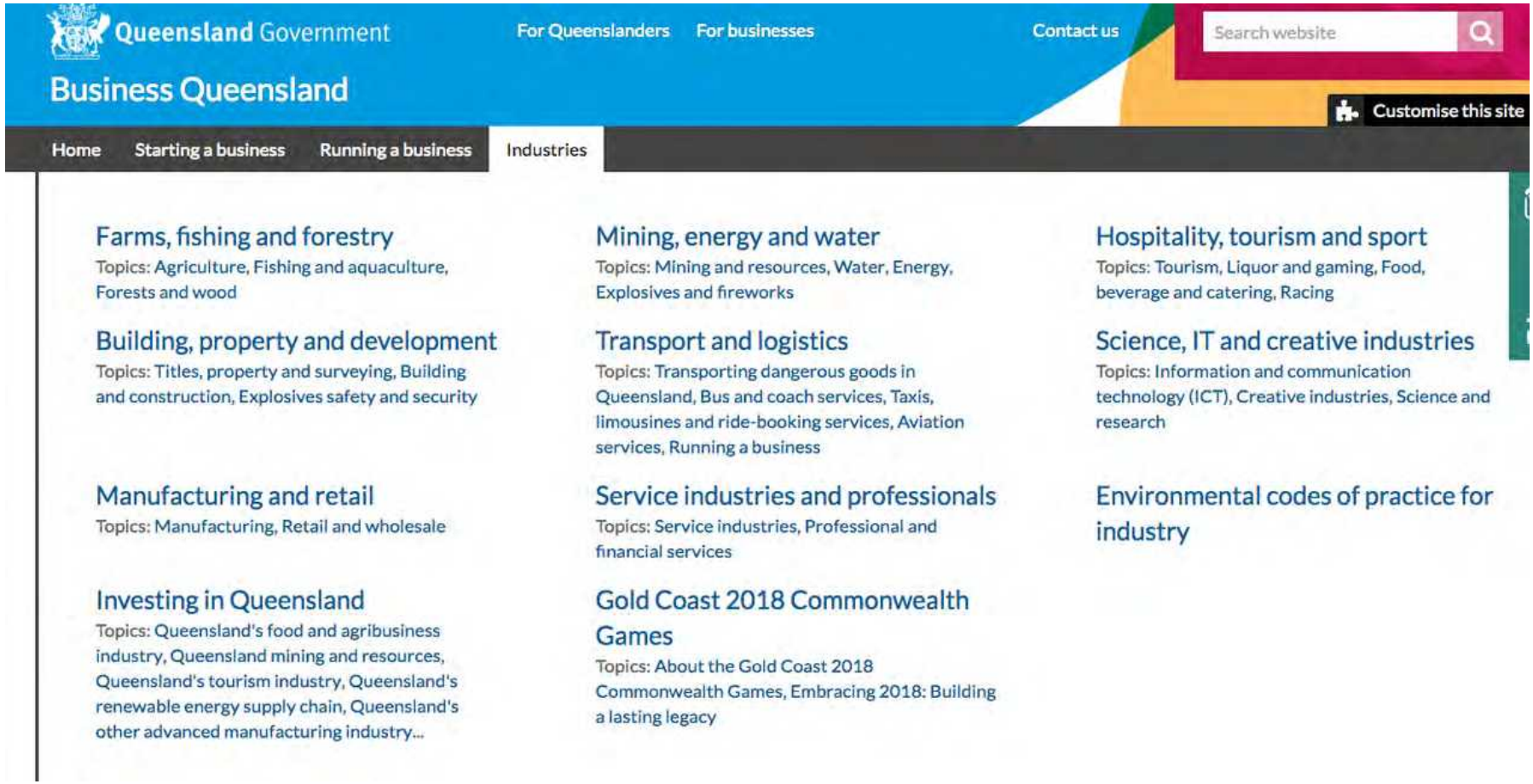
A stakeholder is anybody or group who can affect or is affected by an organisation, strategy or project. They can be internal or external and can be at senior or junior levels.

Sustainable management practice (Defined in syllabus)

Application and monitoring of practices and/or policies that are informed by the concept of sustainabilityIn this case - person or group that has an investment, share, passion or interest in the marine environment.



Business stakeholders



Stakeholder businesses in Qld

Photo: Qld Government

Question

Describe how the use of products and education programs for stakeholders leads to sustainable management practices.

Indicate how this has <u>worked in the past</u> using ocean outfalls and the reef as examples.

Stop sewage protest

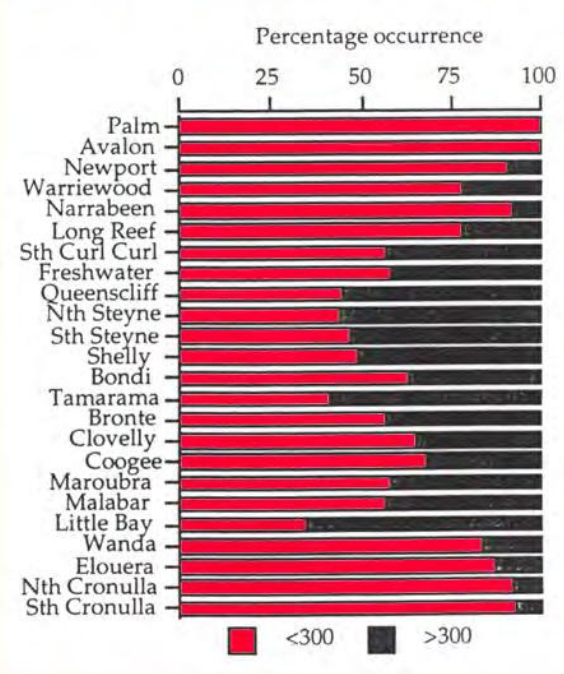
Photo Bob Moffatt

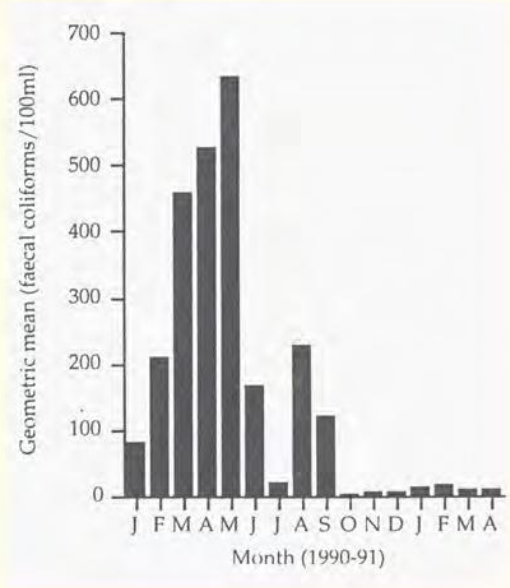
Historical case studies

In the late 1980's Sydney beaches were polluted with faecal coliform densities so great they failed Health Department bathing water quality guidelines more times than they passed.

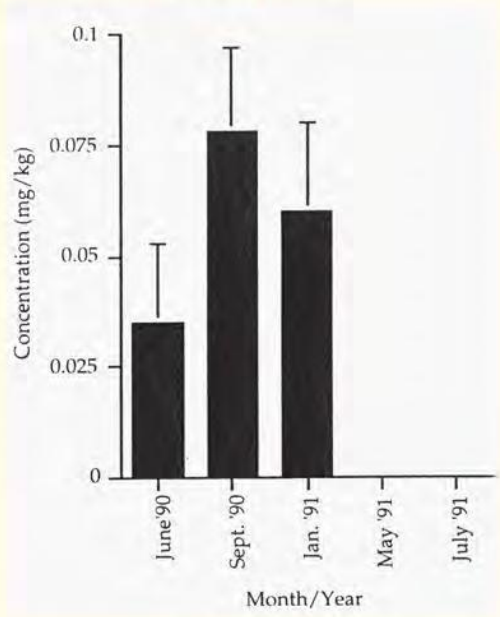
Sydney beach water quality data 1989 - 1990

Faecal coliform bactereia in the water off the beach





Chlordane in oysters

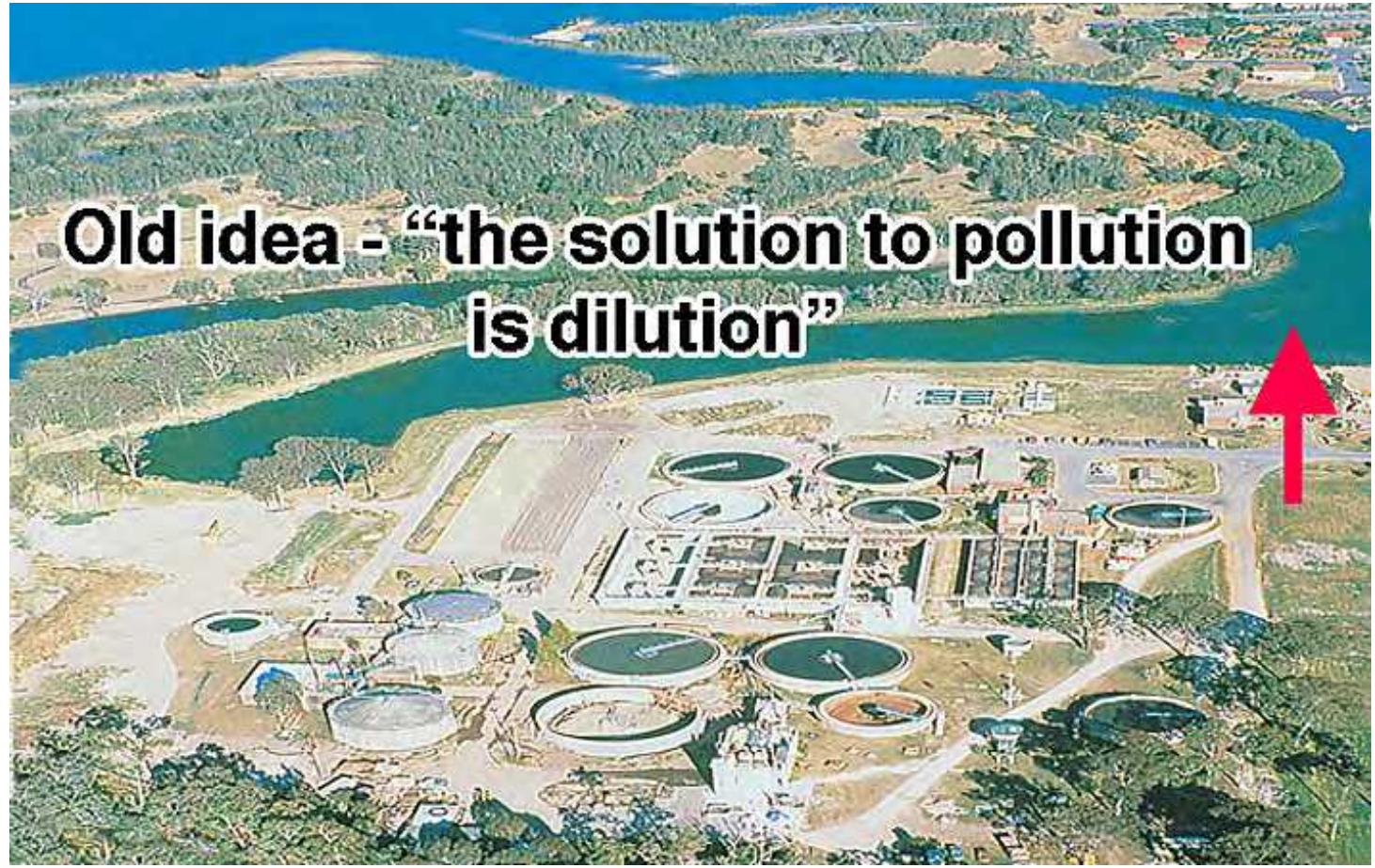


Historic Sydney beach water quality data

Data Surfrider foundation

Government agency stakeholders thought that the solution to pollution was dilution, by ocean outfalls from sewage plants discharging primary treated sewage.

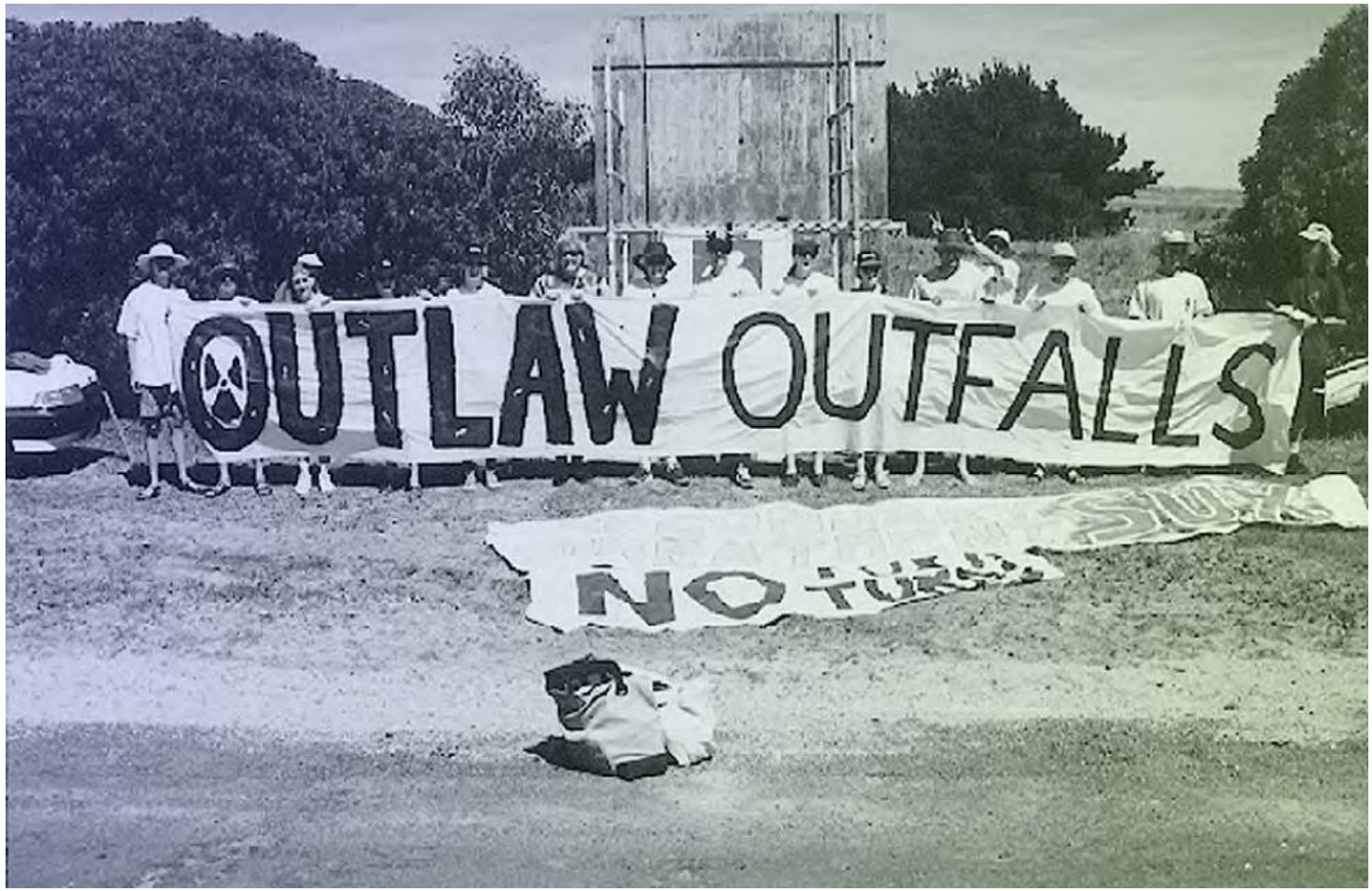
In the main these were senior members of organisations.



Sewage plant discharges to sea

Image Bob Moffatt Photoshop modified to show concept

Groups of environmental activists like the Surfrider Foundation and Greenpeace protested again this practice. In the main these were junior members of an organisation.



Outlaw outfalls rally banner 1992

Photo Surfrider Foundation

Greenpeace activists collect suspect toxic samples from polluters

Photo Greenpeace

Momentum grew for change and in 1996, every political party had a massive cleanup of ocean outfalls in their political policies

Political cartoon

Credit http://expresso.sapo.pt

The result was that State and Federal Governments legislated for change to outfall water quality standards and then budgeted for the upgrading of ALL Australian ocean outfalls to tertiary treatment.

Parliament House Canberra
Photo Murray Waite

Sydney beach today

Photo Murray Waite

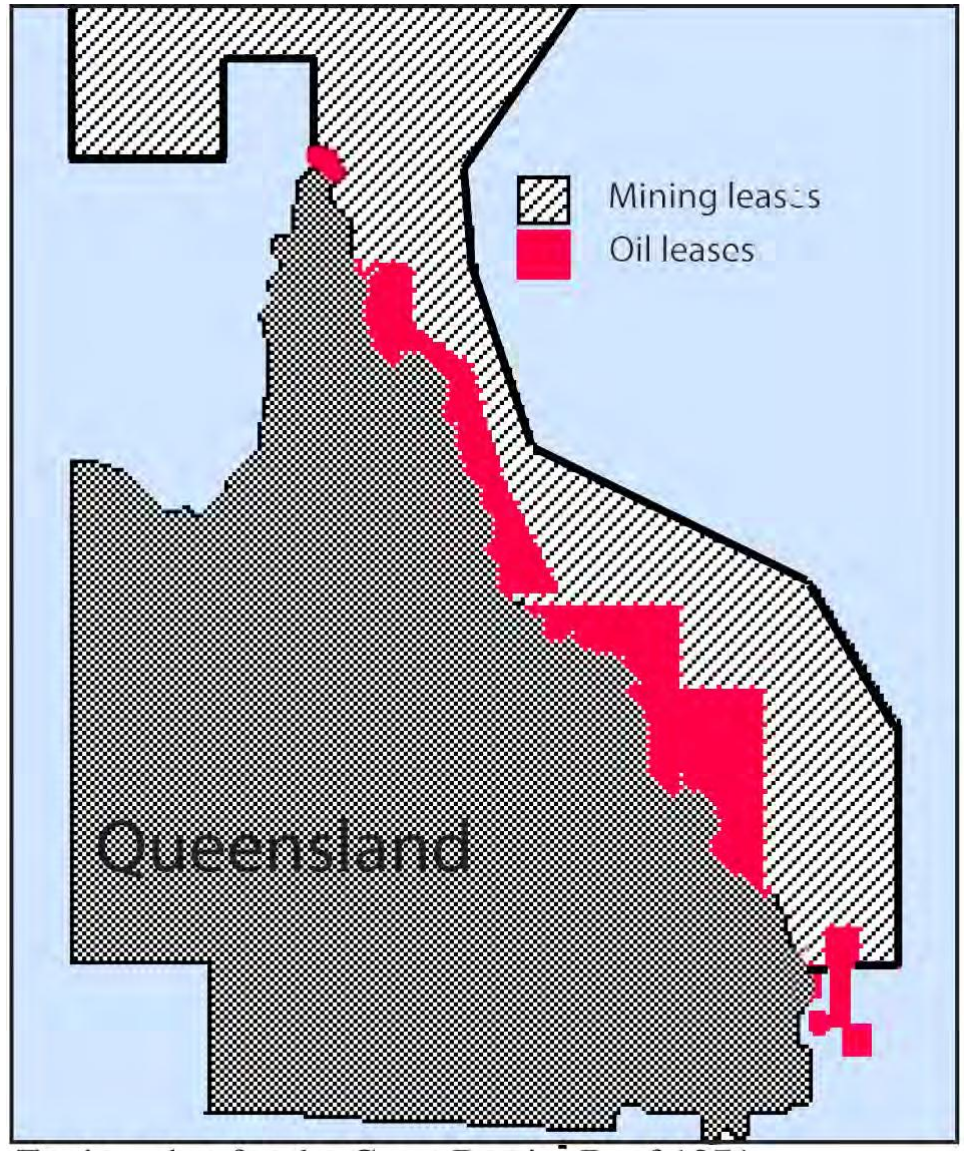
Education of reef stakeholders in encouraging sustainable management practices also has had a long history of successes.

Australian marine conservation society

https://www.marineconservation.org.au/pages/our-history.html

The original zoning plan by the Queensland Government of the day was to mine the reef for minerals and drill for oil.

The stakeholders in the main were senior politicians, mining and oil companies.



Zoning plan for the Great Barrier Reef 1971

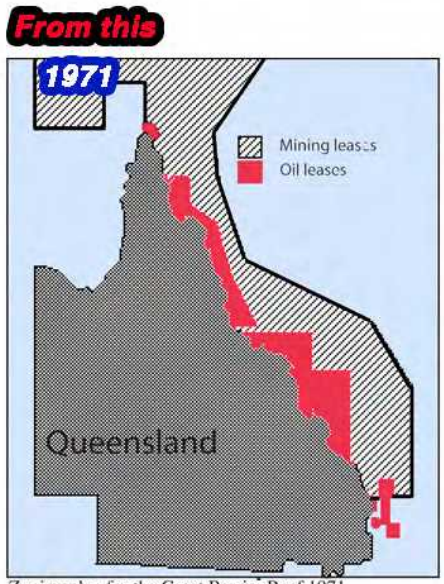
Zoning plan for reef 1971
Illustration Bob Moffatt

Again a group of activists from the University of Queensland formed a Save the Barrier Reef Campaign and with a groundswell of support for the reef, lead to the creation of the Great Barrier Reef Marine Park Authority - a political decision made by the Australian Government. In the main, the activists were junior members of organisations.

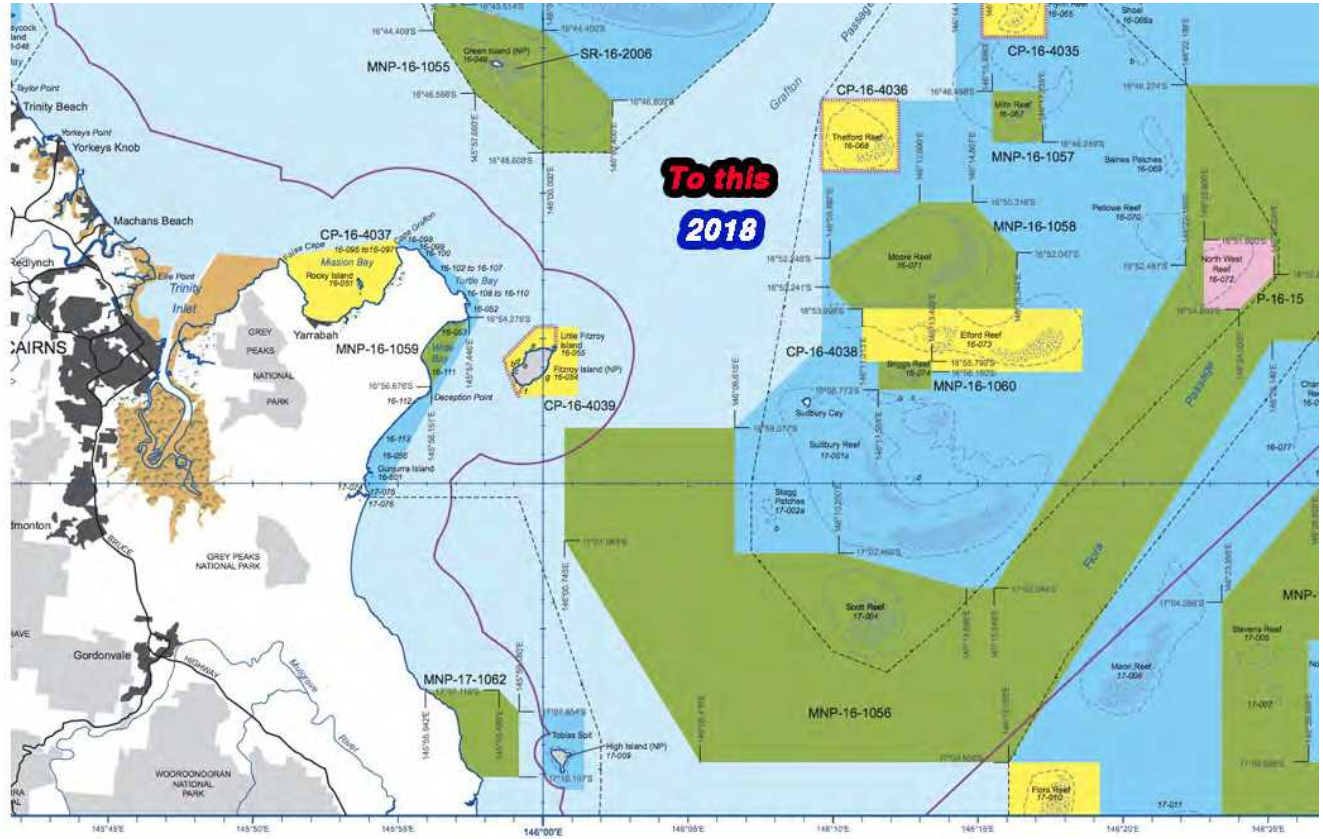
GBRMPA formation

Littoral society (now www.marineconservation.org.au), old and present GBRMPA logos

So these two examples show the different roles Junior and Senior members of organisations play in the education of stakeholders and the introduction of tertiary treatment of urban sewage and the formation of a Reef Authority charged with organising sustainable use practices on the reef and in reef catchments.



Zoning plan for the Great Barrier Reef 1971



Cairns zoning plan section

http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/604/4/Map5-EditionV-Cairns.pdf

Education of products that lead to sustainable use practices

Education lead to the closure of this coal fired power station, however much more needs to be done if we are to reduce greenhouse gases.

Power Station in Cape Town, Closed

Nuclear power plants supplement electricity production but produce toxic radioactive waste as a by product.

Nuclear power plant Japan

The Kashiwazaki-Kariwa Nuclear Power Plant, a nuclear plant with seven units, the largest single nuclear power station in the world, was completely shut down for 21 months following an earthquake in 2007.By D a - kariwa-npp2Uploaded by ChNPP, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=15172466

Three Gorges Dam, currently the largest hydroelectric power station, and the largest power producing body ever built is one way China is attempting to use clean energy.

Three Gorges Dam China 2009

Products aimed at reducing electricity use are now essential if we are to save our planet from global warming and climate change.

Reduce the source - reduce the emissions

https://www.co2.earth/global-co2-emissions

Educating Queenslanders of the need to design, build and install fittings in energy efficient way will reduce the need for electricity.

Energy efficient design

https://www.energy.gov/energysaver/energy-efficient-home-design

Planning and design of schools should optimise energy efficiency.

In addition to site conditions and climate, education should include occupant behaviour.

- How many lights are on in the classroom now?
- Are they on a timer?
- Are they LED?

Classroom technology

Another example is in the R-value given to wall insulation.
The greater the R-value, the greater the resistance, and so the better the thermal insulating properties of the object. A vacuum insulated panel will have a R value between 30 - 50 whereas cardboard 4-5. Do you know the R value for your house?

Wall Insulation batt with R Value

So in winter, knowledge of this sustainable practice reduces the need for heating and therefore reduces the electricity needed from power stations.

You can read much much more at

https://en.wikipedia.org/wiki/Building_insulation_materials

Daylighting is another sustainable management practice worthy of education.

Its the practice of placing windows, other openings, and reflective surfaces so that sunlight (direct or indirect) can provide effective internal lighting.

Skylight providing internal illumination

Energy savings can be achieved from the reduced use of artificial (electric) lighting or from passive solar heating.

Artificial lighting energy use can be reduced by simply installing fewer electric lights where daylight is present or by automatically dimming/switching off electric lights in response to the presence of daylight – a process known as daylight harvesting.

Dimmer switch in hallway

Photo credit: Micalighting (Altered)www.micalighting.com.au/lighting/ceiling-lights/led-panel-lights.html

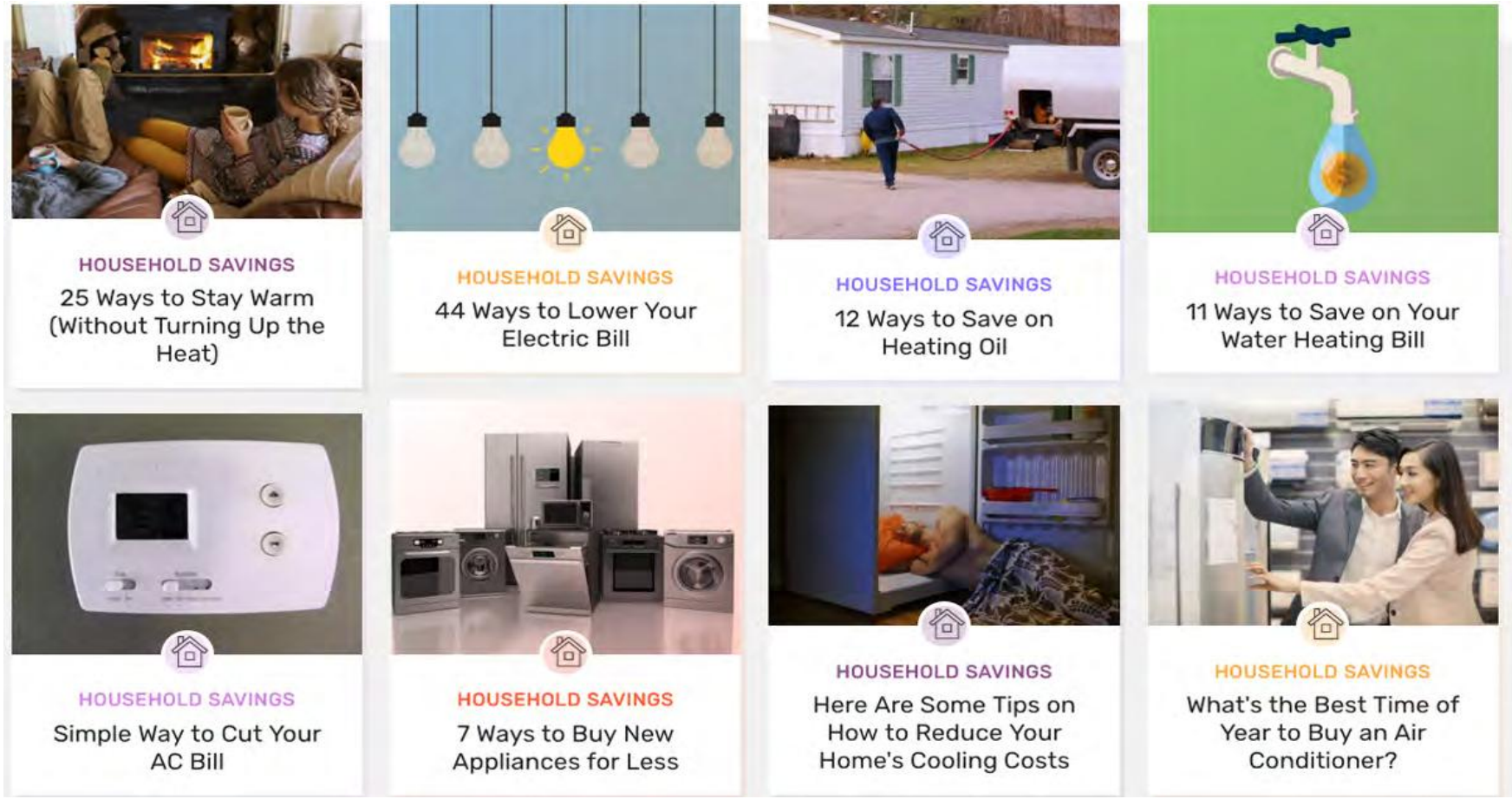
LED light savings and graph

Adapted from: Advantageair.com.au
https://www.advantageair.com.au/calculator/?gclid=EAIaIQobChMIrtWw26as2wIVzBOPCh3ZTQDSEAAYASAAEgL-_PD_BwE

A space heater is a device used to heat a single, small area. In contrast, central heating is used to heat many connected areas, such as all the rooms in a house.
Space heaters are powered either by electricity or by a burnable fuel like natural gas, propane, fuel oil, or wood pellets.
Portable space heaters are usually electric because a permanent exhaust is needed for heaters which burn a fuel.

Space heaters - 2 types
Photo credit: Hervey Norman Image modified

As electricity bills rise, education is based on consumers teaching themselves about savings.



Web site - Ways to save on energy costs

https://www.thebalanceeveryday.com/how-to-save-on-heating-costs-1388212

Natural cooling utilizes on-site energy, available from the natural environment, combined with the architectural design of building components (e.g. building envelope), rather than mechanical systems to dissipate heat.

Therefore, natural cooling depends not only on the architectural design of the building but on how the site's natural resources are used as heat sinks (i.e. everything that absorbs or dissipates heat).

Examples of on-site heat sinks are the upper atmosphere (night sky), the outdoor air (wind), and the earth/soil.

You can read more at

https://en.wikipedia.org/wiki/Passive_cooling

Wood-plastic composites (WPCs) are composite materials made of wood fibre/wood flour and thermoplastic(s).

Wood plastic composite floor board

In recent years, people in the flooring industry refer to WPC as a type of floor that has a basic structure of top vinyl veneer plus a rigid extruded core made without any wood fibre.

Educating industry to make use of products that protect rainforests is important.

Fibre deck

http://innowood.com/premium-fibre-deck/

Passive cooling is a building design approach that focuses on heat gain control and heat dissipation in a building in order to improve the indoor thermal comfort with low or no energy consumption.

Awnings provide shade over a window so that as the wind blows past. it cools the space under the window.

Window awnings

http://www.shadebuilder.com/Fabric-Awnings.html

For many years Queenslanders have been recycling, however in 2018 rising levels of contamination caused China to place an import ban on recycled materials.

Failure to educate in this

Leads to this

Recycling education failure

ABC and Wet Paper
http://www.abc.net.au/news/2018-04-18/ipswich-recycling-all-being-dumped-in-landfill/9672064

A solution is the introduction of reverse vending machines to collect waste plastics and glass so that high quality recycling can occur.

RVM Qld machine

https://www.ehp.qld.gov.au/waste/pdf/qld-container-refund-scheme-discussion-paper.pdf

Read more at

https://www.qld.gov.au/environment/pollution/management/waste/container-refund-about

The education of stakeholders will be collect and recycle only those items recycling plants can use without contamination

Eligible: Beer/ale/stout/wine cooler/ready to drink alcoholic beverages - bottles and cans between 150ml and 3L

Eligible: Fruit juice, vegetable juice bottles - between 150ml and 1L

RVM Eligible QLD

https://www.ehp.qld.gov.au/waste/pdf/qld-container-refund-scheme-discussion-paper.pdf

Non-eligible: Milk containers between 150ml and 3L

Non-eligible: Glass wine bottles and spirits bottles (that have contained pure grape-based wine, pure spirits) - between 150ml and 3L

RVM Non eligible QLD

https://www.ehp.qld.gov.au/waste/pdf/qld-container-refund-scheme-discussion-paper.pdf

Educating society to buy products and adopt attitudes that reduces climate change is

where you could get a JOB.

What to recycle:

All glass bottles and jars, no matter what colour or size are perfect for recycling. Just remove their lids and rinse them out.

All aluminium and steel cans such as soft drink, pet food and baked bean cans are acceptable. Please rinse first.

All plastic soft drink bottles, milk bottles and bottles marked with the symbol: ♳

Farm practice education to reduce pesticide and nutrient runoff to the reef and to meet targets

Records in your pocket with the new Smartcane app

Sugar cane is grown all over Queensland, is worth around $1.75 billion to the Australian economy and is a cornerstone of many Queensland regional communities

Sugar and growing locations

Photo Wet Paper

The sugar industry injects millions into regional communities each year and providing employment opportunities for many Queenslanders.

People having coffee

Photo Murray Waite

Deloitte Access Economics has valued the Great Barrier Reef with an economic contribution of A$6.4 billion per year with employment (as measured in full-time equivalent workers) of just below 69,000

Table 1: Economic contribution to Austraia of the Great Barrer Reef

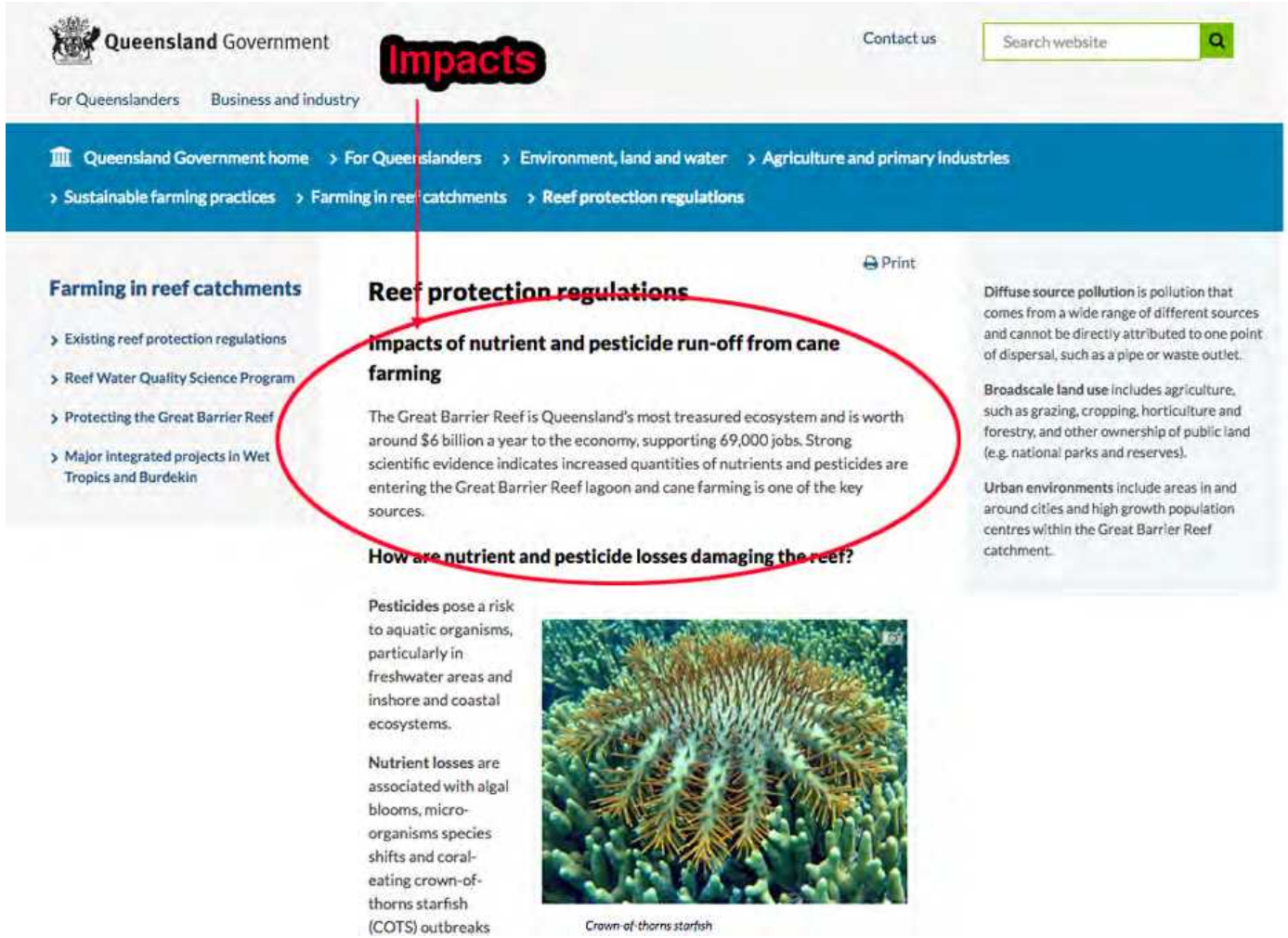
	Direct expenditure ($m)	Value-added ($m)	Employment (FTE)
Tourism	6,410.6	5,175.6	64,338
Recreation	332.4	243.9	2,785
Commercial Fishing	192.5	160.3	975
Scientific research & management	106.1	98.0	881
Total	**7,041.5**	**5,677.8**	**68,978**

Source: Deloitte Access Economics estimates

Value of reef

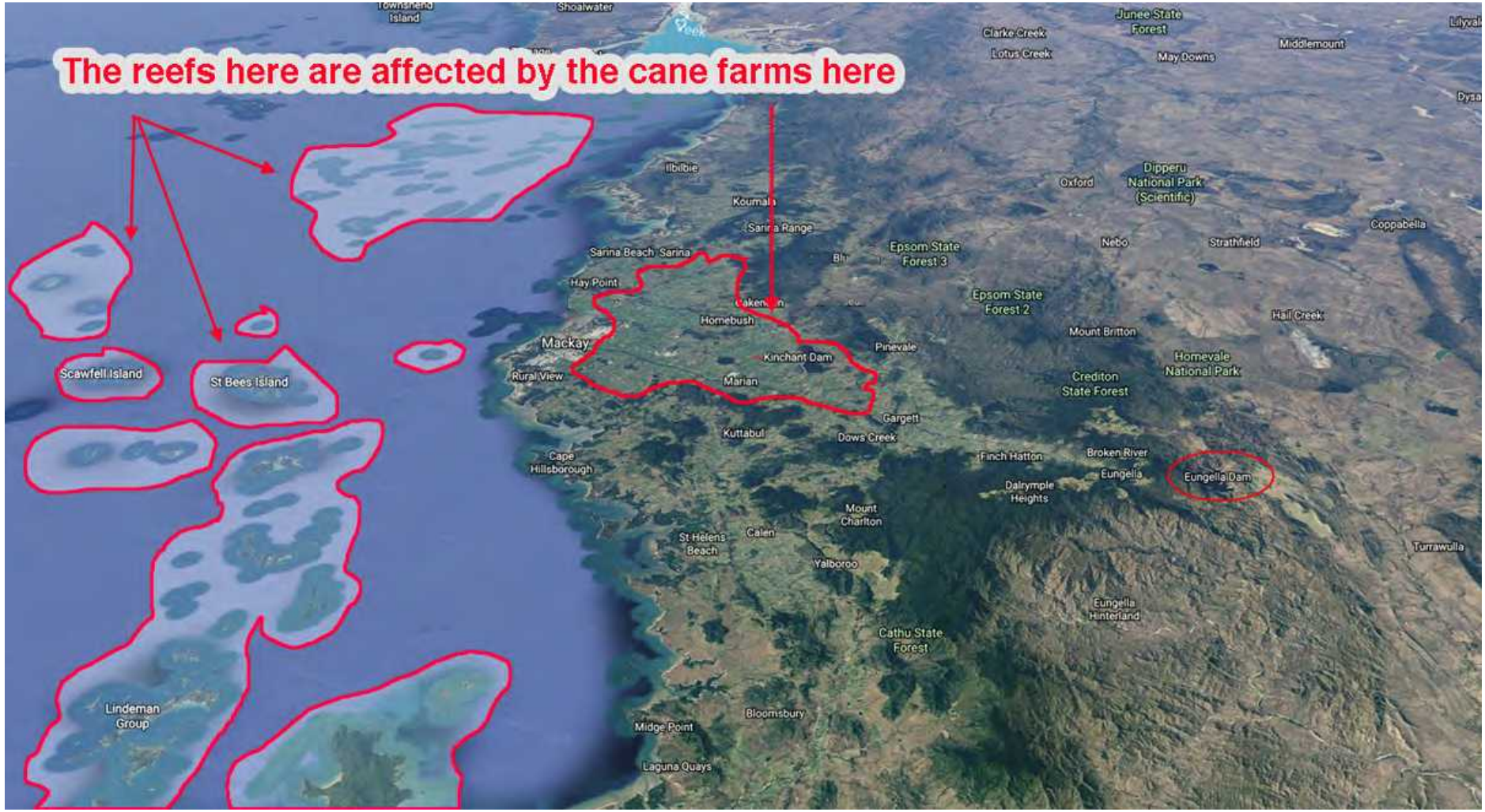
http://www.environment.gov.au/system/files/resources/a3ef2e3f-37fc-4c6f-ab1b-3b54ffc3f449/files/gbr-economic-contribution.pdf

The Great Barrier Reef is impacted by pesticides and irrigation run off nutrients from cane farms.



Cane farm impacts Qld Gov website

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#



Reef aerial affected by cane farms

Photo https://www.google.com/intl/en/permissions/trademark/rules.html

Cane farm sustainable management practices need to maintain the economic viability of cane farms and also protecting the reef.

CANEGROWERS Chairman Paul Schembri and his brother Joe receive their Smartcane BMP accreditation from facilitator John Turner.

Best practice farm team

Photo Queensland Cane growers annual report

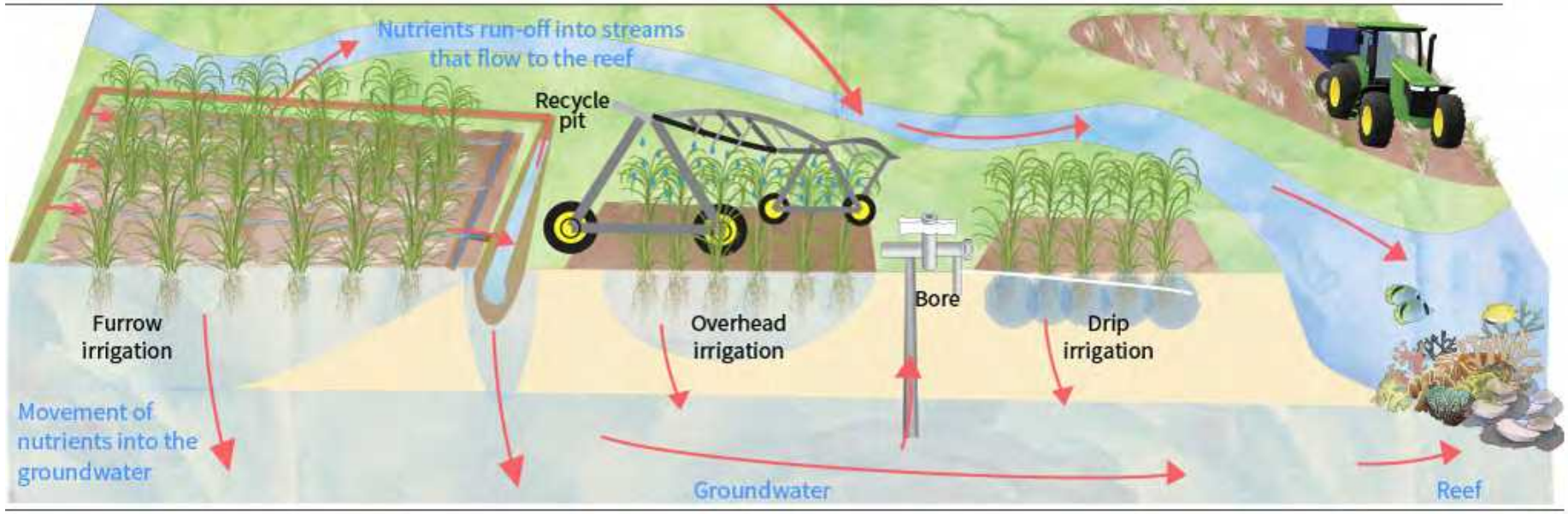
Irrigation and **pest control** are two sustainable management practices designed to protect the reef.

Centre pivot irrigation system

Irrigation

In furrow irrigated sugarcane, increasing irrigation efficiency (i.e. reducing over-application of irrigation) also reduces nutrient losses.

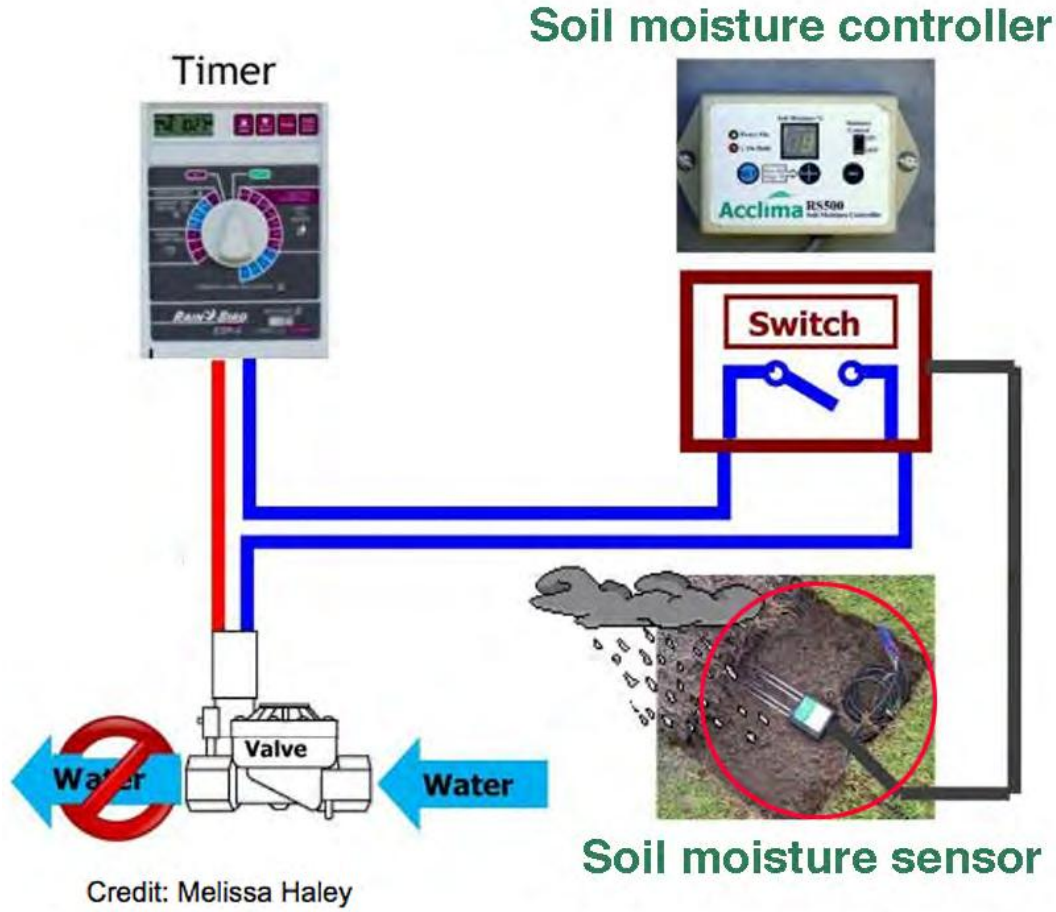
Efficiencies can be increased by better managing irrigation to crop demand or moving from systems with lower to higher efficiency (e.g. moving from furrow to drip irrigation)



Furrow overhead and drip irrigation

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

Education in the use tools (e.g. soil moisture probes, automation and irrigation software) that can help schedule and apply the right amount of irrigation water to match the water holding capacity of the soil.

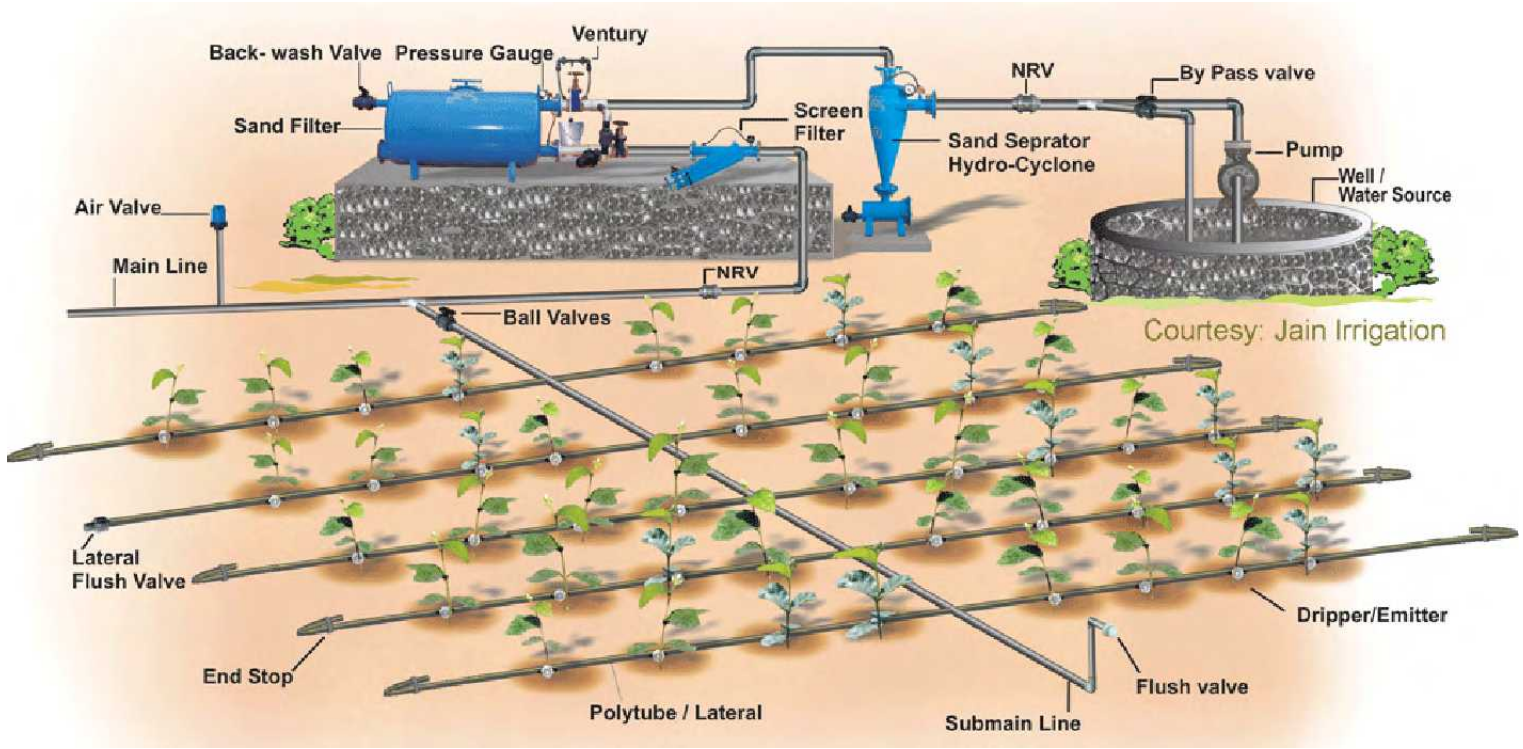


Soil moisture controller

http://edis.ifas.ufl.edu/LyraEDISServlet?command=getImageDetail&image_soid=FIGURE%201&document_soid=AE437&document_version=38250

Education in the use of drip irrigation or overhead irrigation may have better water use efficiency than furrow irrigation.

The shape and length of the furrow can minimise deep drainage and run-off. Recycle pits also capture run-off.



Farm drip irrigation system

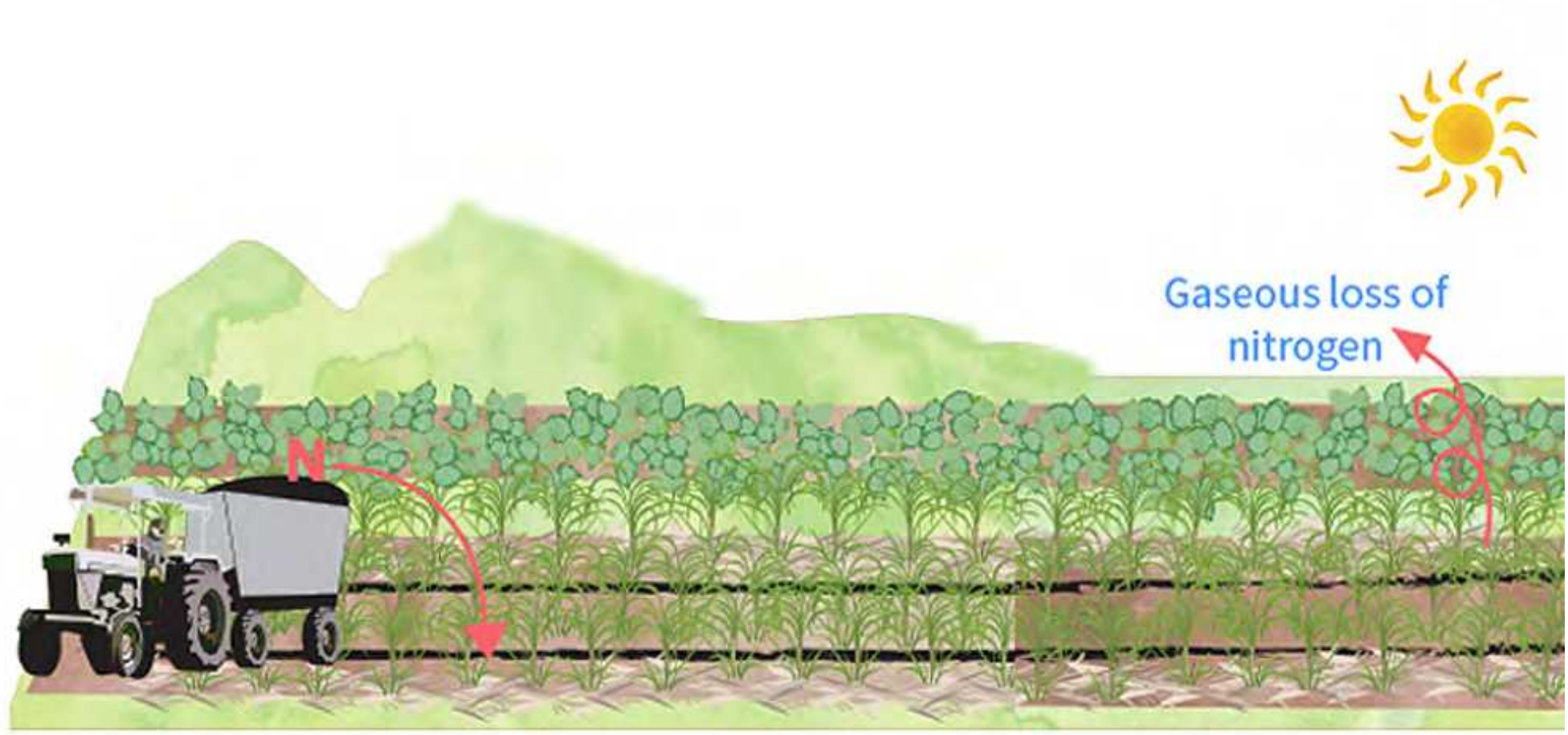
Education in the use of mill mud applied directly to cane rows, rather than being broadcast or applied to the inter-row, can reduce the amount of nutrients lost.

New applicator

New distribution on row

Mill mud applied directly to cane rows

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

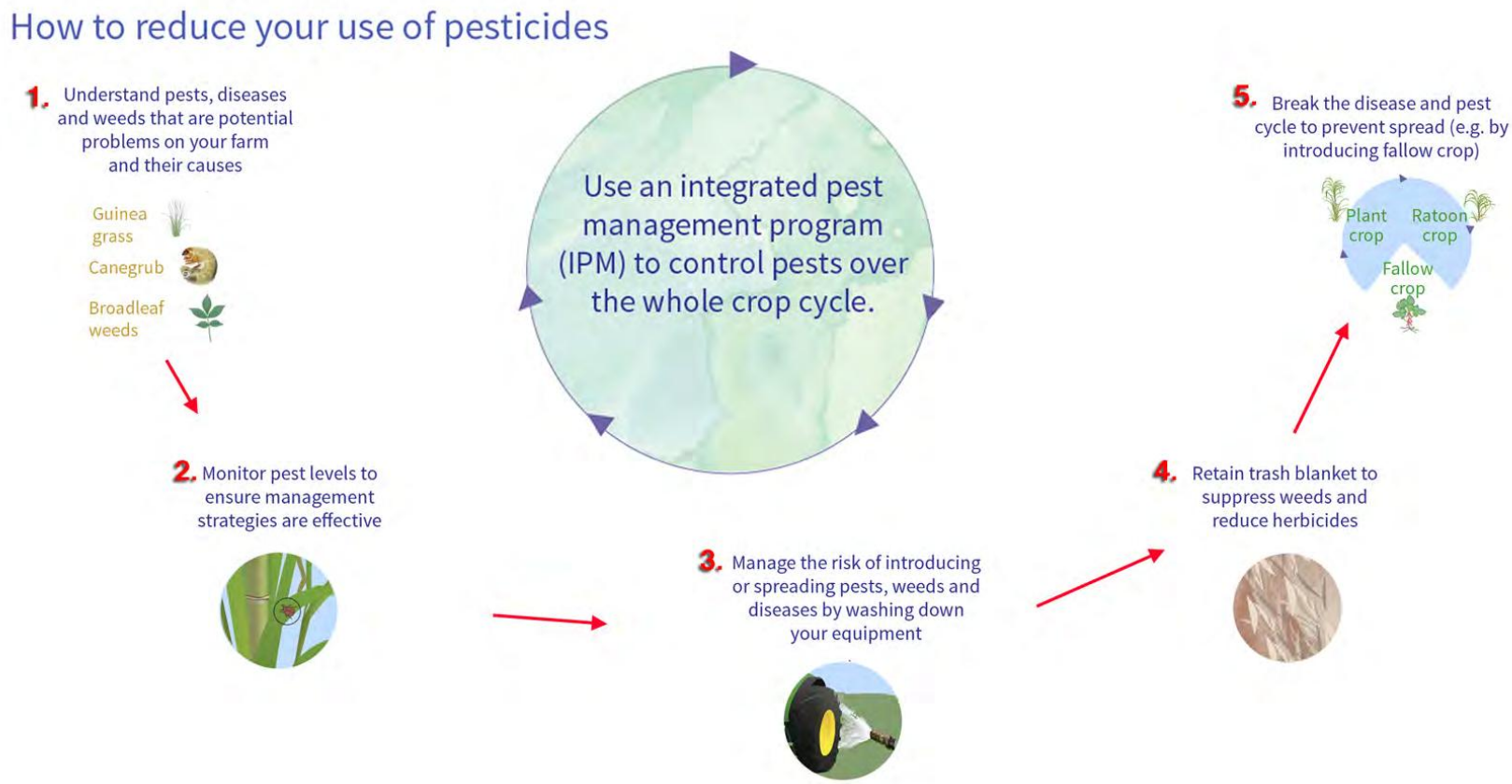


Mill mud applied directly to cane rows

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

Reducing losses of pesticide

In addition to following the label instructions for pesticides, the most effective way to reduce pesticide losses is to adopt practices for effective pesticide management



https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

Use an integrated pest management program (IPM) to control pests over the whole crop cycle

Break the disease and pest cycle to prevent spread (e.g. by introducing fallow crop)

Fallow crop rotation

By Lesław Zimny - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=4164384

Effective practices include better managing pesticide application timing (i.e. increasing the time between application and significant rainfall events or irrigation), placement and application method (e.g. banded spraying)

Banded spraying in rows

https://www.qld.gov.au/environment/agriculture/sustainable-farming/canefarming-impacts#

Summary

1. Environmental activism by the younger generation has been shown to be characteristic education distinction with older generations in encouraging sustainable management practices.

2. Education in the use of products which use less electricity is a way of encouraging sustainable management personal practices.
3.
4. Farm practices to pesticide and nutrient runoff reduction are two ways of encouraging sustainable management practices.

T028 Pollution source comparisons

Syllabus statement

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

Compare the terms point source and non-point source forms of pollution

Compare

display recognition of similarities and differences

and

recognise the significance of these similarities and differences.

Objective

Give examples to show similarities and differences between point source and non-point source forms of pollution recognising the significance of the differences.

Rubbish comparisons mangroves supermarket - which is easier to control?

Photos Dave Claridge, Bob Moffatt

Question

Complete the table below to compare the similarities and differences between point and non point source pollution.

Factor	Similarities - Point source and non point source pollution	
Cleanup expenses Environmental damage Legislation		
Differences	Point source	Non point
Definite single source vs no definite single source		
Local vs widely diffused		
Ease of preventing and controlling the pollution		
Levels of dilution		
Scale of measures needed to address the pollution		

Definition

Point source pollution is where the pollution comes from a specific point.

Non-point sources of pollution are sources of pollution that cannot be traced to a specific point.

Similarities between point and non point pollution could include

Cleanup expenses

Environmental damage

Legislation

Clean up expenses

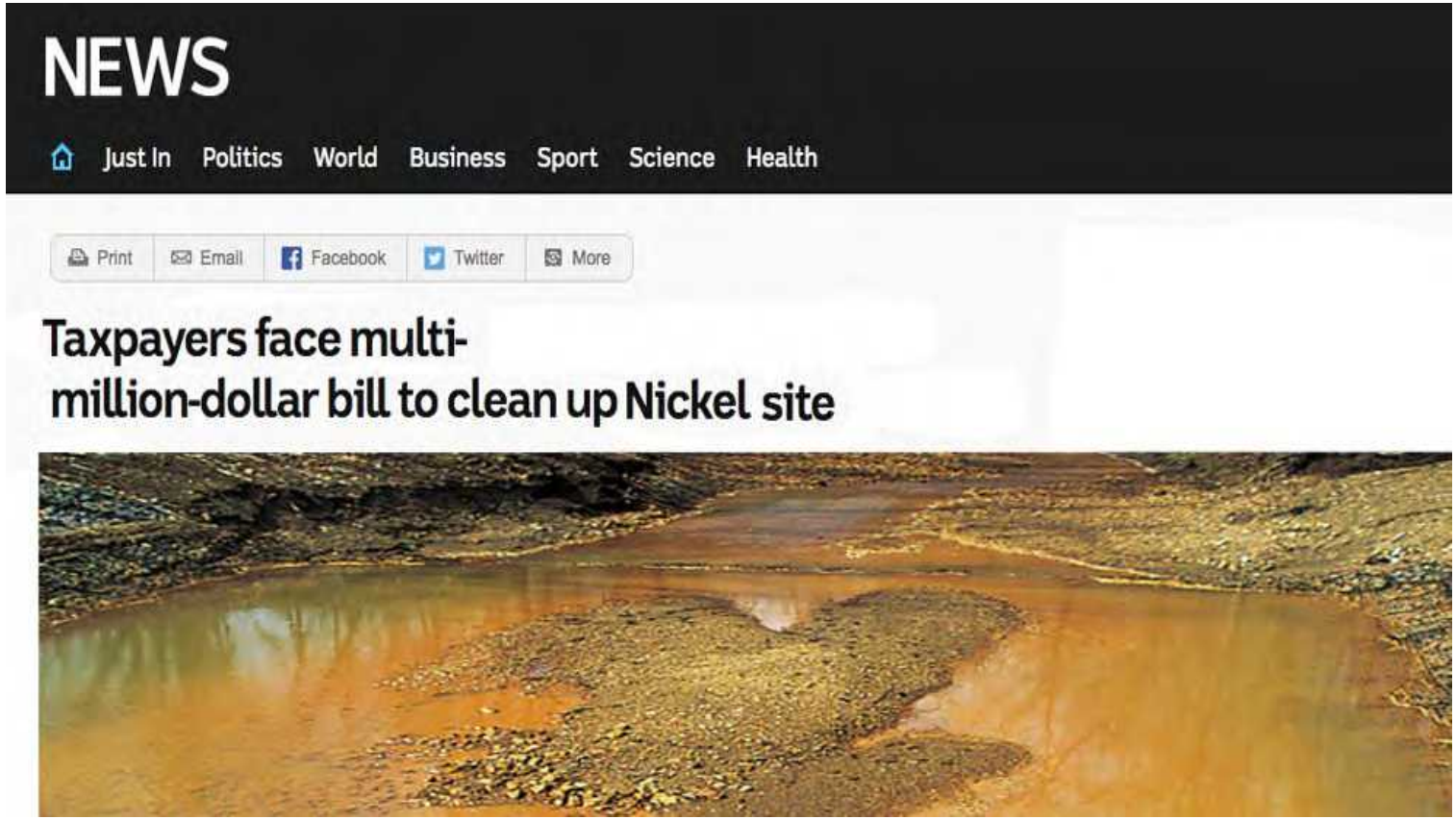
Cleaning oil from point and non point sources is expensive and time consuming. It doesn't matter where it comes from - its expensive.

Seal Penguin and oil

AMSA Oil pics

Significance – its expensive

Both are expensive to remedy. If treatment was easy it would be done. Neither is easy.



Nickel refinery cleanup.

Modified by Wet Paper from Image

By Walter Siegmund (talk) - Own work, CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=3413544

Environmental destruction

If pollutants are from a large area then it can be numerous ranges, farms, or residences.

Then significance is non point source pollution is much harder to remedy than for example, identifying a single factory that is dumping used motor oil into a stream.

Industry and diseased fish.

Photo: Gladstone Conservation Society

Significance – the damage is huge

Both kill marine life.

Albatross dying and dead from different pollution sources of pollution – can you name some sources?

Source: Chris Jordan (via U.S. Fish and Wildlife Service Headquarters) / CC BY 2.0 - Albatross at Midway Atoll RefugePhoto taken by Chris JordanUploaded by Foerster, Public Domainhttps://commons.wikimedia.org/w/index.php?curid=26762401

Both decreases biodiversity.

Point

Non point

Dead turtle and fish.

Photo: Maritime Safety Qld and Tim Ryan

Legislation

You can legislate for both.

Both are able to be legislated

Current EPA says no harmful chemical is to be discharged into the environment, but how do you clean your paint brushes, or stop cigarette smoke?

Wash up paint in a container

Pic: Bob Winters

Significance

You can prosecute law breakers

Birds and longline fishing

Differences between point and non point pollution

1.Definite single source vs no definite single source

2.Local vs widely diffused

3.Ease of preventing and controlling the pollution

4.Levels of dilution

5.Scale of measures needed to address the pollution

Definite single source vs no definite single source

An oil spill from a boat is easy to prosecute, but paint from which factory and is it paint?

Oil from boat compare paint in creek
MSQ (L). Public Domain (R.)
https://commons.wikimedia.org/w/index.php?curid=128947

Non point - difficult to locate

Nonpoint source pollution is widely diffused whilst point source pollution will often remain concentrated close to the source of the pollution.

Creek with oil

Photo Bob Moffatt

Local vs widely diffused

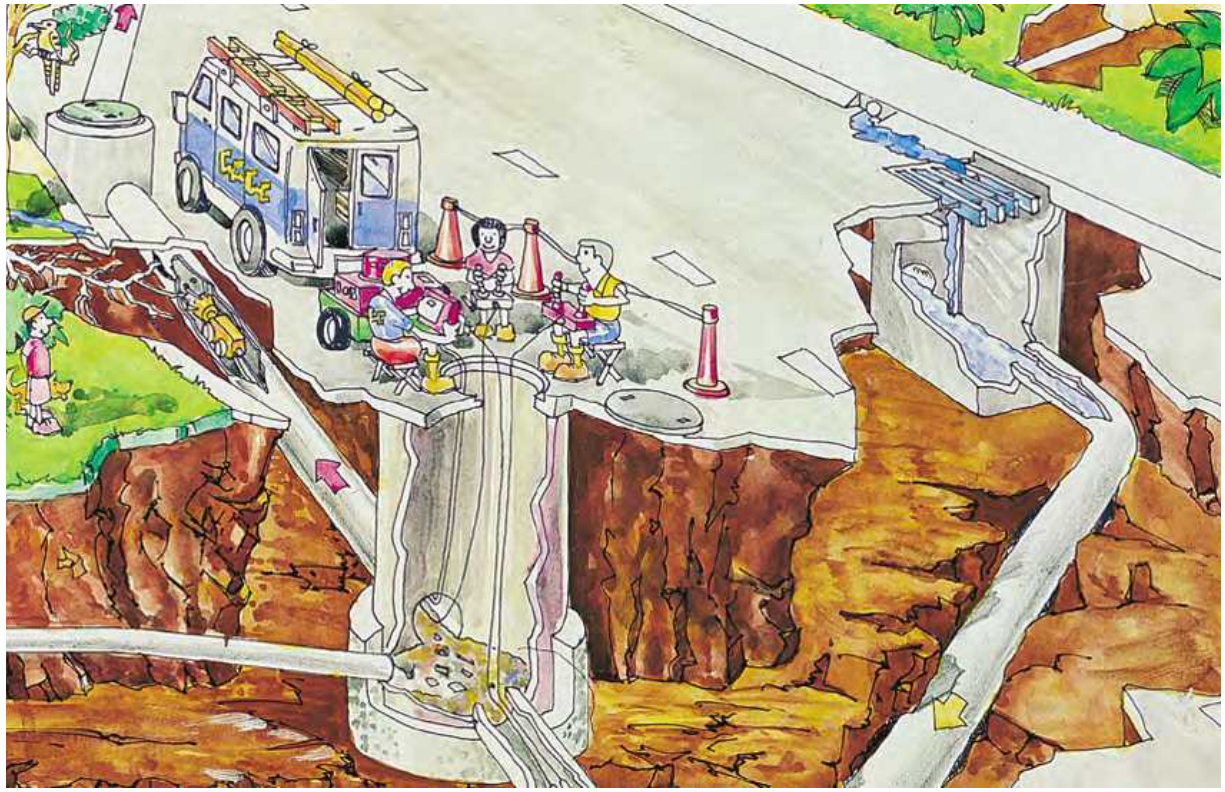
In urban areas, the provision of reticulated sewerage systems and adequate street cleaning by local government controls pollution.

Sewer town.

Illustration: Merv Vincent

Ease of preventing and controlling the pollution

For example, if a pipe is leaking chemicals into a river, the pipe can be located and the leak stopped.



Sewer town.
Illustration: Merv Vincent

Nonpoint source pollution is widely diffused whilst point source pollution will often remain concentrated close to the source of the pollution.

Significance

This is right at the heart of the other differences.

Point source source is easily identifiable the ability to fix the problem is easier than not knowing where the source is.
The source on building sites can be controlled.

Right and Wrong building methods
Illustration Kerry Kitzelman

Significance

Non point source pollution is harder to prevent.

Albatross dead from different sources of pollution

Levels of dilution

Point source pollution is concentrated around the source of the pollution. Eg An industrial estate

Traders way industrial estate

Photo Bob Moffatt

Point source is concentrated

Photos Bob Winters and Bob Moffatt

Nonpoint source pollution tends to be more diluted

Nonpoint source pollution tends to be more diluted than point source pollution.
Eg Fumes from aerosol cans spread all over the globe.

Significance

Very difficult to control. But the fire extinguisher industry did ban types of chemicals.
Car emissions are controlled.

Qld Fisheries

Scale of measures needed to address the pollution

Action within a single community is usually enough to stop point source pollution. Prosecution is easy.

Oil from boat point source pollution

Photo MSQ

Nonpoint source pollution is often tackled through global action

– for instance, by asking factories and car users throughout the world to reduce their CO2 emissions.

Significance

The issue becomes political and individuals need to push the green vote.

No nukes rally

Surfrider foundation

The ability to pay to fix the problem

Taxpayers usually pay for the clean up for non point source pollution.

Courts impose fines on polluters from point source pollution.

Summary

Factor	Similarities - Point source and non point source pollution	
Cleanup expenses Environmental damage Legislation	Expensive to clean up Cause death or serious environmental damage Governed by laws	
Differences	Point source	Non point
Definite single source vs no definite single source	Can be located and controlled	Cannot be located. Significance Nonpoint source pollution is widely diffused whilst point source pollution will often remain concentrated close to the source of the pollution.
Local vs widely diffused	Point source pollution is more of a localized pollution (for instance, it comes from a single leaking sewage pipe)	Nonpoint source pollution is widely diffused whilst point source pollution will often remain concentrated close to the source of the pollution. Significance This is right at the heart of the other differences that are listed below.
Ease of preventing and controlling the pollution	Easy - because point source pollution can be traced back to a single point. That way, the pollution can be stopped at source. For example, if a pipe is leaking chemicals into a river, the pipe can be located and the leak stopped.	There is no single source of the pollution that can be tackled. This can make it difficult to control by means of a single 'quick fix' solution. Significance Non point source pollution is harder to prevent.
Levels of dilution	Point source pollution is concentrated around the source of the pollution. Eg Tanker oil spill	Nonpoint source pollution tends to be more diluted than point source pollution. Eg Fumes from aerosol cans spread all over the globe. Significance Very difficult to control. But the fire extinguisher industry did ban typs of chemicals. Car emissions are controlled.
Scale of measures needed to address the pollution	Action within a single community is usually enough to stop point source pollution. Prosecution is easy.	Nonpoint source pollution is often tackled through global action – for instance, by asking factories and car users throughout the world to reduce their CO2 emissions. Significance The issue becomes political and individuals need to push the green vote.

Significance

Significance
Nonpoint source pollution is widely diffused whilst point source pollution will often remain concentrated close to the source of the pollution.

Significance
Non point source pollution is harder to prevent.

Significance
Very difficult to control. But the fire extinguisher industry did ban typs of chemicals. Car emissions are controlled.

Significance
The issue becomes political and individuals need to push the green vote.

Question

Use a table to ….

Compare the terms point source and non-point source forms of pollution

And state

Signficance (from the verb)

T029 Monitoring water pollution

Syllabus statement

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

Describe two direct methods of monitoring water pollution levels using an abiotic test (e.g. nitrate, phosphate, heavy metals) or a biotic test (e.g. faecal coliform)

Describe

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

Definition

Monitoring water pollution levels involves quantitative assessment collecting data to measure the physical, chemical and biological water quality and river health parameters.

Biological - Macroinvertebrates, Habitat assessments, Riparian (riverbank) assessments, Macrophytes (aquatic plants) survey, Microbiological and Faecal coliforms/E. coli

Chemical - Available phosphate and Dissolved oxygen

Physical - pH, Electrical conductivity, Temperature, Turbidity, Flow and Bank assessments

Reference

Ref: http://www.nswwaterwatch.org.au/resources

Question

From the instruction manuals provided, give a summary of the method used for the following water quality monitoring tests.

A. Nitrate - abiotic

B. Phosphate - abiotic

C. Faecal coliform - biotic

QUANTOFIX® Nitrate / Nitrite

Pack content:
1 aluminum container with 100 test strips

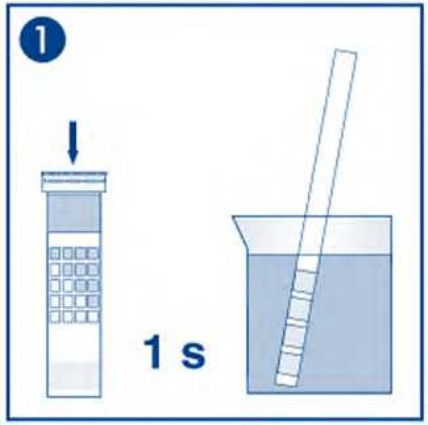
Measuring range:

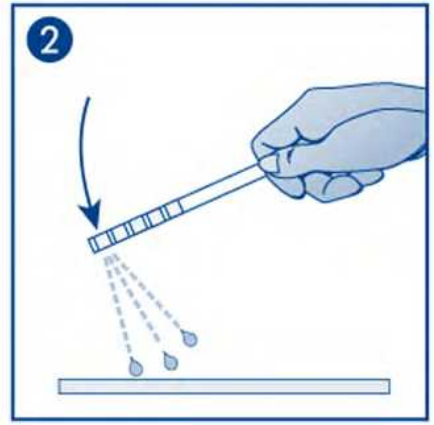
Visually	Reflectometrically
10–500 mg/L NO_3^-	10–500 mg/L NO_3^-
1–80 mg/L NO_2^-	0.5–80 mg/L NO_2^-

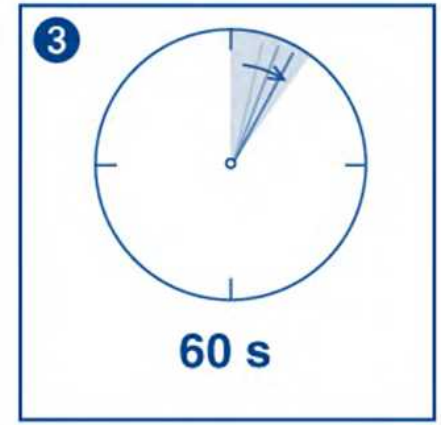
Color gradation:
0 · 10 · 25 · 50 · 100 · 250 · 500 mg/L NO_3^-
0 · 1 · 5 · 10 · 20 · 40 · 80 mg/L NO_2^-

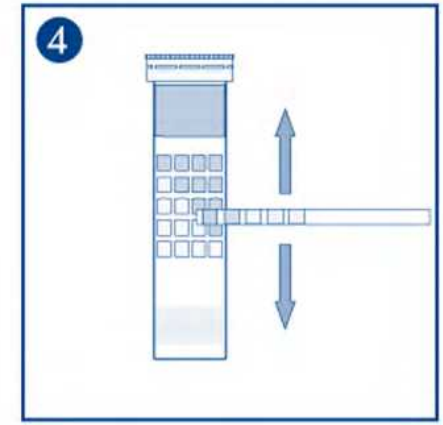
General indications:
Remove only as many test strips as are required. Close the container immediately after removing a strip. Do not touch the test fields.

Instructions for use:
1. Dip the test strip with both fields into the test solution (pH 1–9) for 1 s.
2. Shake off excess liquid.
3. Wait 60 s.
4. Compare with the color scale. If nitrate ions are present, the lower test field (at the end of the strip) will turn red-violet. The upper test field will show the nitrite concentration.









The kit is QUANTOFIX Nitrate/nitrite kit with the following summary:

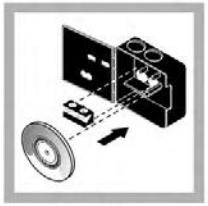
a. The sample to be tested is poured into a beaker.
b. A test strip is dipped into the beaker, removed and shaken for a set time.
c. The colour on the strip is then compared to a chart in the kit and the mg/litre of nitrate recorded.

Total Phosphate Test Kit

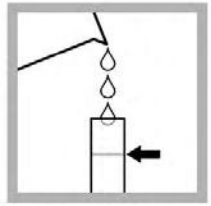
PO-24 (225001)

DOC326.97.00079

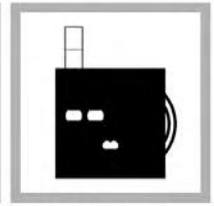
Test procedure—Orthophosphate low range (0–0.8 mg/L PO_4)



1. Install the long-path adapter in the color comparator box.



2. Fill a tube to the top line with sample.

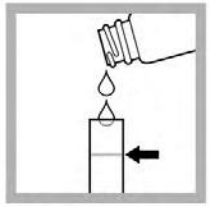


3. Put the tube into the left opening of the color comparator box.

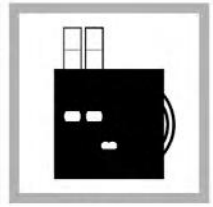
4. Fill the bottle to the 20-mL mark with sample.

5. Add one PhosVer 3 Phosphate Reagent Powder Pillow. Swirl to

6. Wait 2 minutes. A blue color develops. Read the result within 10 minutes.

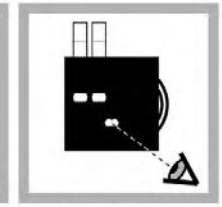


7. Fill a second tube to the top line with the prepared sample.



8. Put the second tube into the color comparator box.

9. Hold the color comparator box below a light source. Turn the color disc to find the color match.



10. Read the value in the scale window. Divide the value by 50 to get the result in mg/L.

Photo Bob Moffatt

The kit is the HACH total phosphate test kit 0-.8mg/litre with the following summary:

a. A phosphate colour disc is inserted into a colour comparator box.

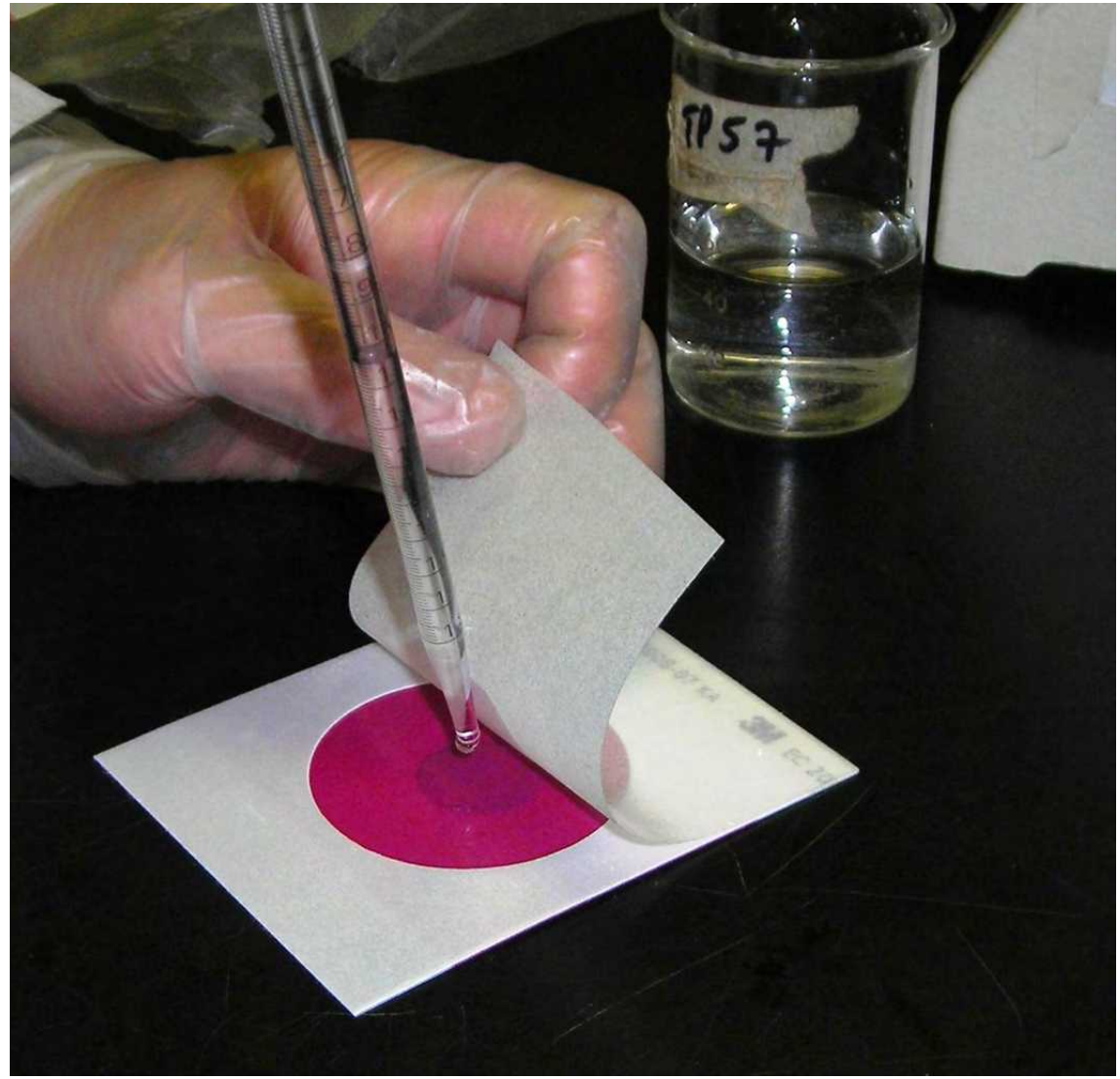
b. The sample to be tested is poured into a vial and placed on the other side of the comparator box.

c. A small bottle is filled with a second sample, a reagent added and the bottle swirled for a set time to make a solution called a prepared sample.

d. A second vial is filled with this prepared sample, placed into the comparator box and held up to sunlight.

e. The colour disc rotated until the two colours match and the value from the colour disc gives the phosphate level.

Faecal coliform



Inoculating petrifilm plate

CAROLINA
trained with teachers

BZ-4020

3M™ Petrifilm™ E. coli/Coliform Count Plates

Storage

Refrigerate unopened packages at ≤8°C (≤46°F). Use before expiration date on package.

To seal an opened package, fold the end over and tape it shut (fig. 1).

Figure 1

Method A. Inoculation with liquid sample

Inoculate and spread each Petrifilm plate before going on to the next plate.

1. If a Petrifilm plate pack has been stored in the refrigerator, let the package come to room temperature before opening it. This step prevents condensation from forming inside the package.
2. Place the Petrifilm plate on a level surface, with the gridded side down. Lift the top film (fig. 2).

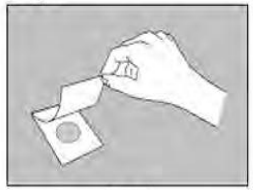


Figure 2

3. With pipet perpendicular to the Petrifilm plate, place 1 mL of sample onto the center of the bottom film (fig. 3). If necessary, samples can be diluted with distilled water, liquid culture medium, or buffers with pH between 6.6 and 7.2.* If antibiotics are to be added to the medium, add them to the inoculating liquid at the working concentration.

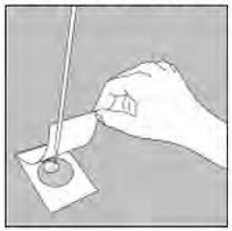


Figure 3

4. **Roll** the top film onto the bottom film. Do not drop the top film down (fig. 4).

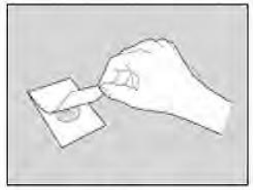


Figure 4

5. With the flat side down (not the side with the circular ridge), place the spreader on the top film over the inoculum (fig. 5).

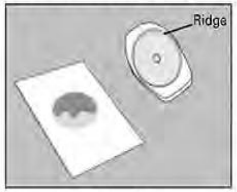


Figure 5

6. **Gently** apply pressure on the spreader to distribute the inoculum over a circular area. Do not twist or slide the spreader (fig. 6).

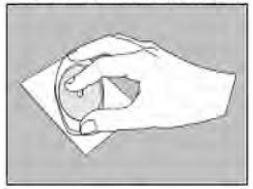


Figure 6

7. Lift the spreader. Wait at least 1 minute for the gel to solidify (fig. 7).

Figure 7

8. Incubate plates with the gridded side down in stacks of up to 20 plates. Incubation time and temperature will vary according to the application and equipment available.
9. Colonies on Petrifilm plates can be counted on a standard colony counter or other light source (fig. 8). Bacterial colonies on Petrifilm EC plates are red or blue because of the indicator dyes in the medium. Refer to the Interpretation section on pg. 8 and 9 for more details.

Figure 8

10. Colonies may be isolated for further study or to inoculate additional cultures. Lift the top film and pick the colony from the gel. The medium will adhere to the top film (fig. 9).

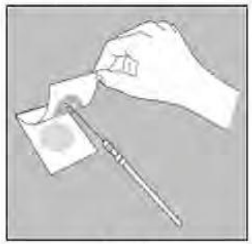


Figure 9

11. Disinfect before disposal. Petrifilm plates can be disinfected by autoclaving or by soaking in 20% bleach for 1 hour. Then, they can be placed in the trash. Alternatively, they can be taken to a facility such as a hospital or given to a school nurse for disposal with other biohazardous material.

*Do not use diluents that contain citrate or sodium thiosulfate because they can inhibit growth on the Petrifilm plates. These substances are not found in common microbiological media such as Luria broth or nutrient broth.

Interpretation

Petrifilm EC plates appear red with no gas bubbles, coliform colonies appear red with gas bubbles, and *E. coli* colonies appear blue with gas bubbles.

Sometimes gas bubbles are trapped when the inoculate is spread on Petrifilm plates. These bubbles are irregularly shaped and not associated with a bacterial colony, while gas bubbles produced by lactose-fermenting bacteria are associated with a colony (see fig. 11.)

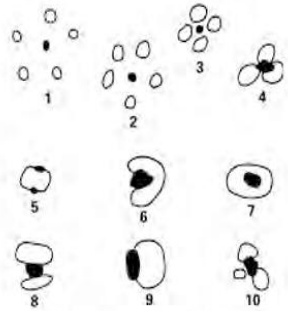


Figure 11. Gas bubbles produced by colonies

Sample Plate

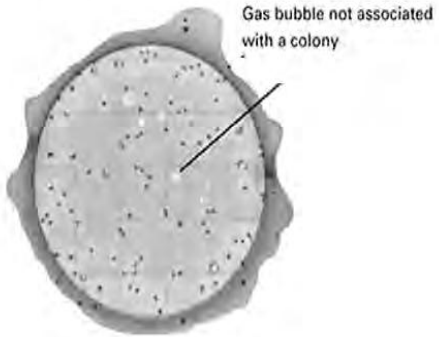


Figure 12.

The method

uses gloves, sterile Schott bottle or pre-sterilised disposable container, Petrifilm E. coli plates, disposable sterile plastic pipette or syringe, a small glass (heat resistant) beaker and an incubator.

a) Unused Petrifilm E. coli plates are placed in a sealed plastic container in the freezer. The sample is collected in a sterile Schott bottle and the incubator is set to reach 44° C ± 1° C.

b) After the collection bottle has been shaken vigorously, the pipette is used to draw of 1mL of sample. You then lift up the top clear film of the Petrifilm E. coli plate and follow the instructions so that 1mL ends up in the centre of the plate.

c) The top film is rolled back onto the sample so as to minimise bubbles, the gel allowed to set and then placed in the incubator clear side up. It is important that the incubator maintains 44° C ± 1° C for 24 hours

d) Results are by counting the colonies. As the Petrifilm plates only use 1mL the number of colonies needs to be multiplied by 100 to give colonies /100mL

A complete set of tests is described in

T036 Water quality testing

1. Dissolved oxygen
2. Faecal coliform
3. pH
4. BOD
5. Temperature change
6. Phosphorus
7. Nitrate
8. Turbidity
9. Total dissolved solids

T030 Biochemical oxygen demand

Syllabus statement

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

Define the term biochemical oxygen demand (BOD)

Define

- give the meaning of a word, phrase, concept or physical quantity;

- state meaning and identify or describe qualities.

Definition

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.

The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 ° C and is often used as a surrogate of the degree of organic pollution of water.

Question

State the meaning and significance of the term biochemical oxygen demand and identify the equipment and techniques used to test it.

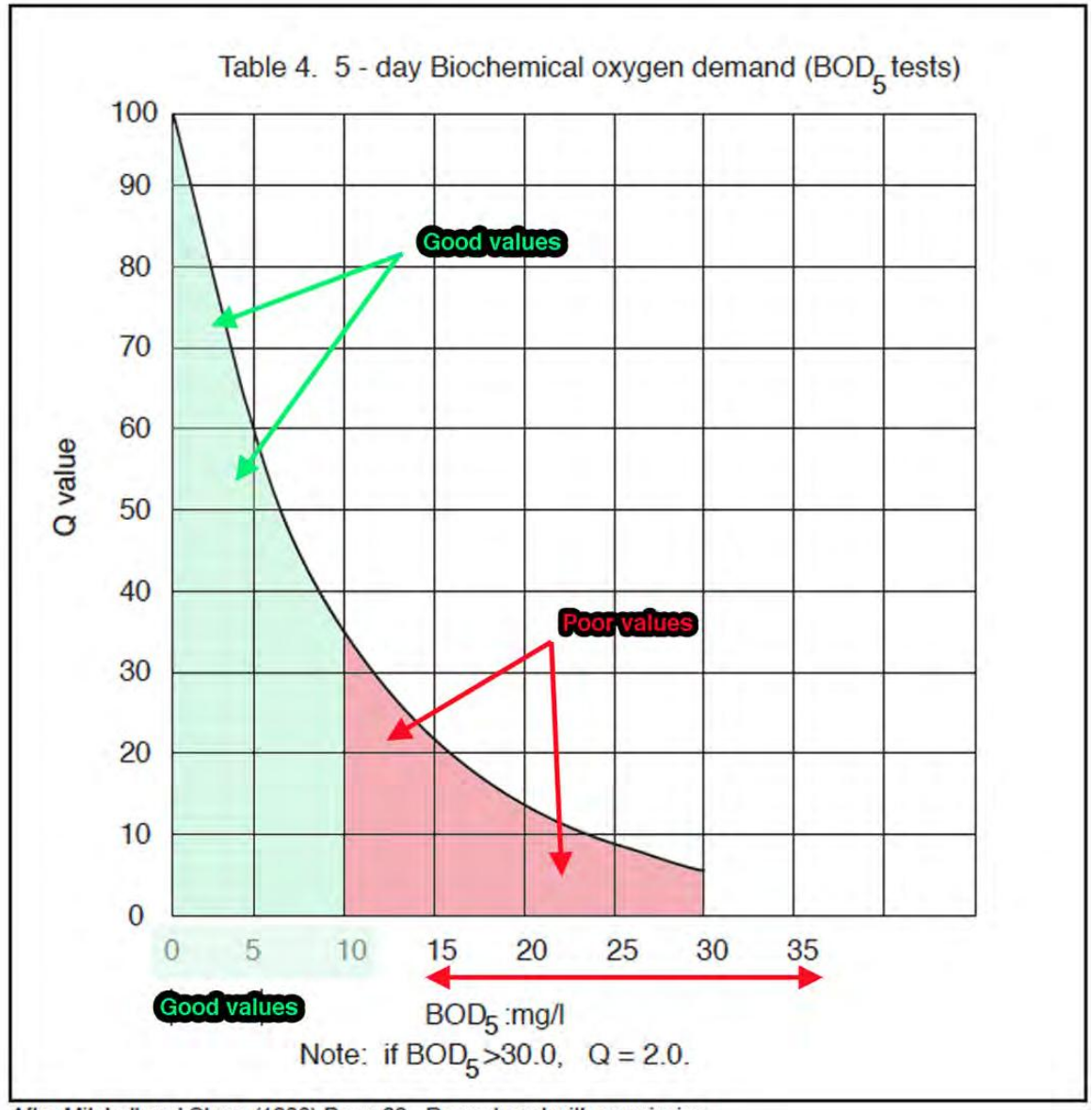
Biochemical oxygen demand

The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation.

Incubation at 20°C

Selbys scientific

BOD is often used as an indicator of the degree of organic pollution of water where pollution tables are drawn for community groups.



After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

BOD Q table

Credit Bill Stapp

Equipment and techniques used to measure BOD

A chemical test for dissolved oxygen using a kit is most common in schools.

Selbys Scientific

The method involves collecting two samples in a DO bottle and wrapping one in alfoil and placing it in a cupboard.

Powder reagents from the kit are added to first bottle bottles and by using a liquid reagent in an eye dropper to create an "end point", the mg/L of dissolved oxygen can be recorded.

Photo Bob Moffatt

Dissolved Oxygen Test

0.2 to 4 and 1 to 20 mg/L O_2
For test kit 146900 (Model OX-2P) DOC326.98.00014

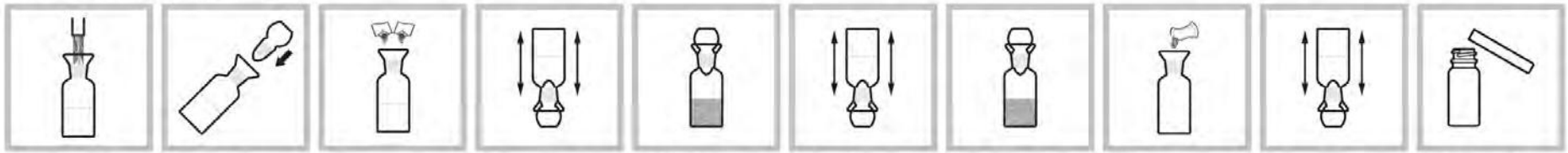
Additional copies available on www.hach.com

Test preparation

- Rinse tube with the sample water before testing. Rinse tube and bottles with deionized water after testing.
- To check reagent accuracy, use a standard solution in place of the sample (see Optional items).
- When titrating, hold the dropper vertically. The dropper should not contact the bottle.
- Use clippers to open powder pillows.
- To remove interferences from activated sludge samples, follow the steps under Sample pretreatment for activated sludge, then proceed with the test procedure.
- To increase sensitivity with the low range test, titrate the sample in step 2. until the color changes to a pale yellow. Add 2 drops of Starch Indicator Solution (see Optional items) and mix. The color will turn blue. Continue adding drops of sodium thiosulfate until the color changes from blue to colorless. Count all drops of sodium thiosulfate (before and after starch solution) when determining the result in step 3.

CAUTION: Handle chemical standards and reagents carefully. Review Material Safety Data Sheets for safe handling, storage and disposal information.

High range (1 to 20 mg/L) test procedure



1. Fill the BOD bottle (round bottle with glass stopper) with sample water by allowing the sample water to overflow the bottle for 2–3 minutes. Avoid turbulence and bubbles in the sample while filling.

2. Incline the bottle slightly and stopper the bottle carefully to avoid trapping air bubbles. If bubbles become trapped, discard the sample and repeat the test.

3. Remove the stopper and add one Dissolved Oxygen 1 Reagent Powder Pillow and one Dissolved Oxygen 2 Reagent Powder Pillow. Stopper the bottle carefully to avoid trapping air bubbles.

4. Invert the bottle several times until the powders are dissolved. Flocculent (floc) precipitate will form. Brownish-orange precipitate indicates oxygen is present.

5. Wait for floc to settle to approximately half the bottle volume. Floc will slowly settle if high concentrations of chloride are present. In this case, wait 4–5 minutes before proceeding.

6. Invert the bottle again to mix.

7. Wait for floc to settle to approximately half the bottle volume. Floc will slowly settle if high concentrations of chloride are present. In this case, wait 4–5 minutes before proceeding.

8. Remove the stopper and add one Dissolved Oxygen 3 Reagent Powder Pillow. Stopper the bottle.

9. Invert the bottle several times. Floc will dissolve and the sample will turn yellow if oxygen is present.

10. Add one full measuring tube of sample to the bottle.

Note: *Save the rest of the prepared sample for the low range test, if necessary.*

Hatch DO kit instructions
Credit https://www.hach.com/dissolved-oxygen-test-kit-model-ox-2p/product?id=7640219538#

After 5 days, the second bottle is tested and the mg/L of dissolved oxygen recorded. By subtracting the two values the BOD is obtained.

25 - 5 = 20mg/L BOD

25 5

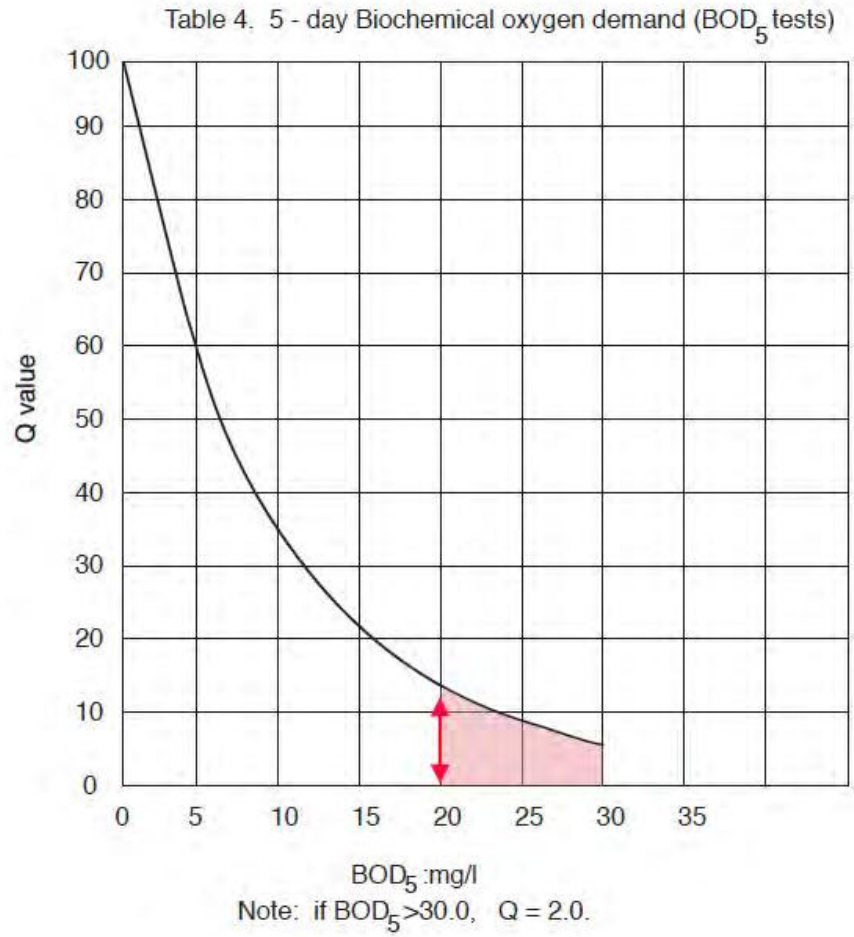


Photo Bob Moffatt Graph Boll Stapp

BOD Level

BOD Level *(in ppm)*	Water Quality
1 - 2	**Very Good** There will not be much organic waste present in the water supply.
3 - 5	**Fair: Moderately Clean**
6 - 9	**Poor: Somewhat Polluted** Usually indicates organic matter is present and bacteria are decomposing this waste.
100 or greater	**Very Poor: Very Polluted** Contains organic waste.

Question

What does the term biochemical oxygen demand mean and describe the method used to obtain values.

Draw a graph used by community groups to interpret it and explain how this is interpreted.


T031 BOD use in pollution

Syllabus statement

At the end of this topic you should be able to ... **Describe** describe how BOD is used to indirectly assess water pollution levels.

Describe

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

Definition

Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.

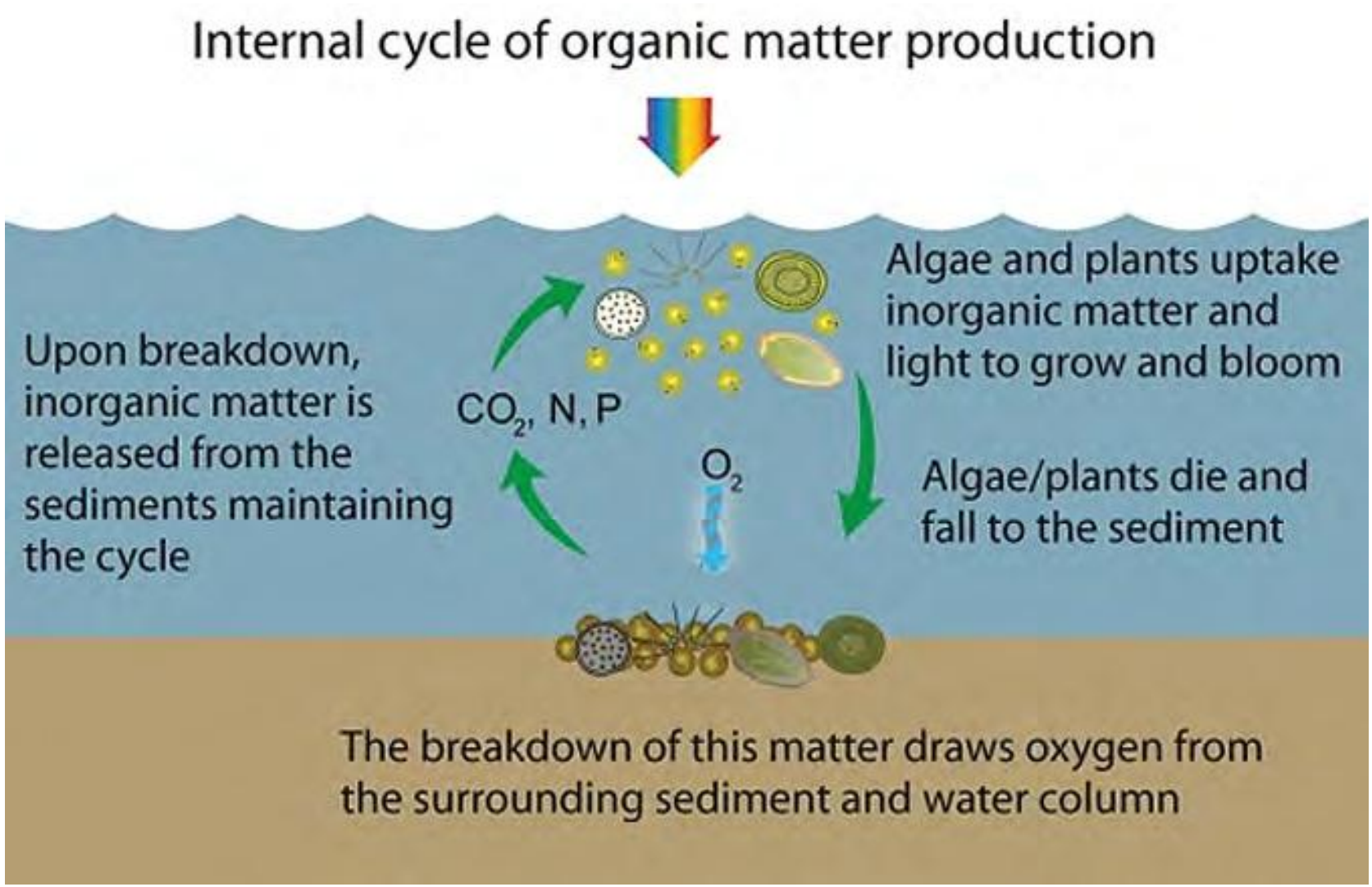
The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20^0C and is often used as an indication of the degree of organic pollution of water.

Question

Describe how BOD levels are used to assess water pollution with reference to organic matter production.

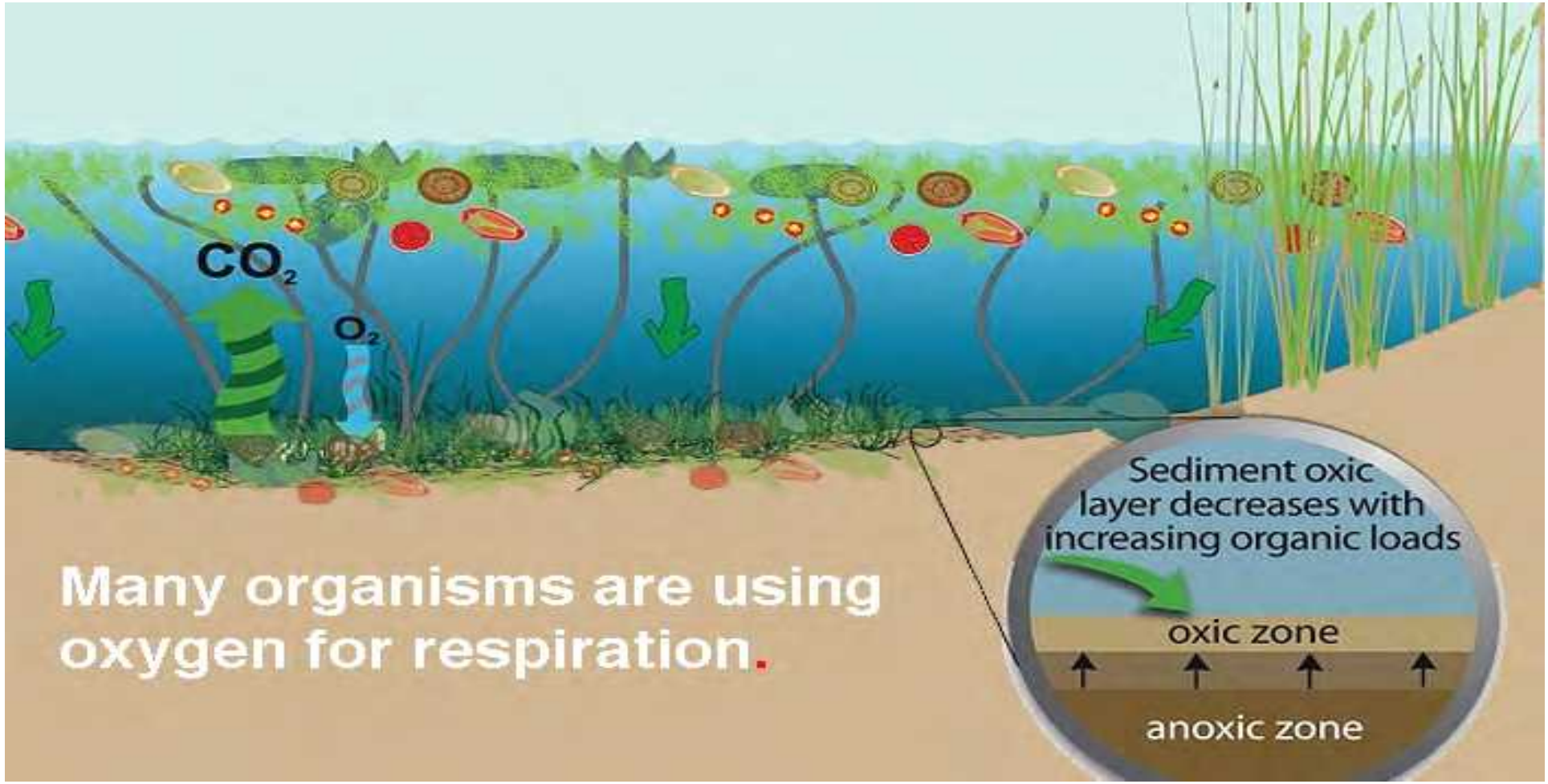
The BOD test (Biological Oxygen Demand) measures the use of organic material in water.

Bob Moffatt



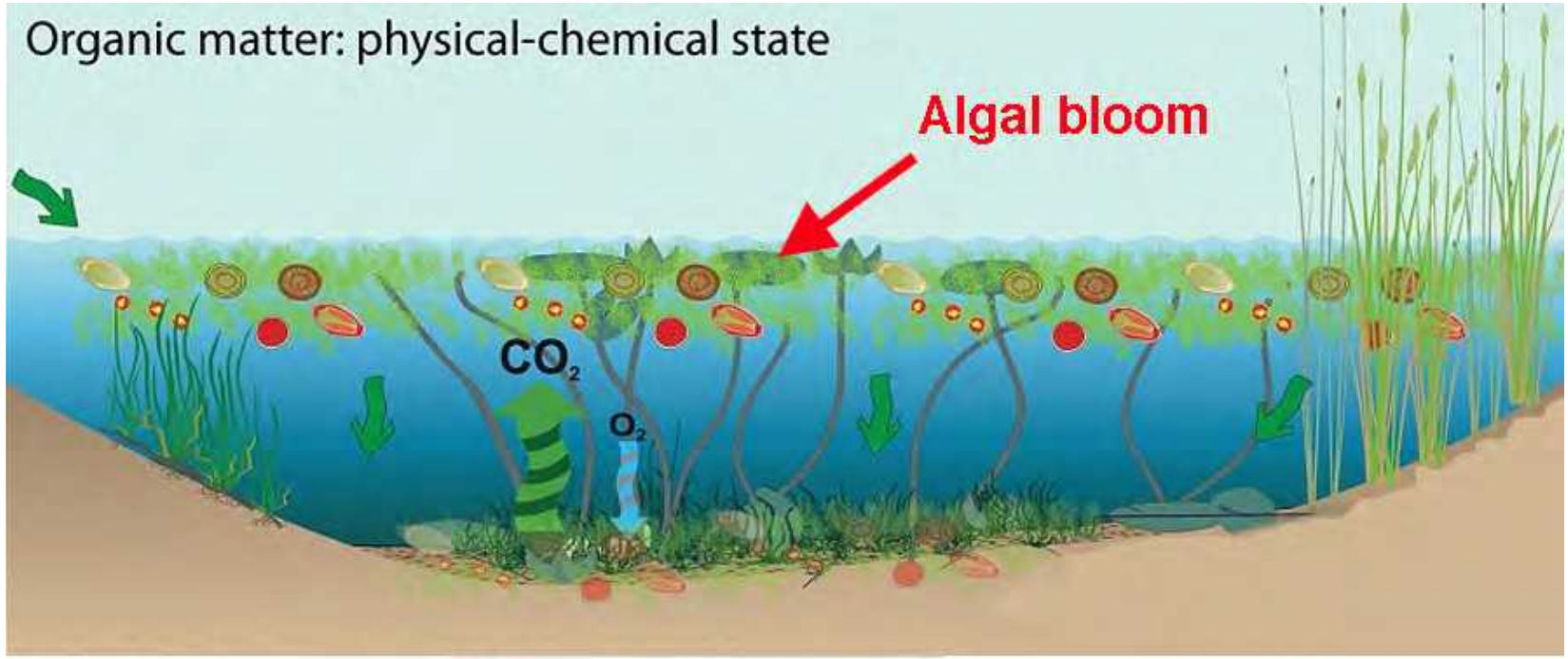
Internal cycle of organic matter production
https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/lacustrine-palustrine-threats/organic-matter/state.html

If the organic matter increases, the oxygen layer in benthic sediment decreases because there are no many organisms using oxygen for respiration.

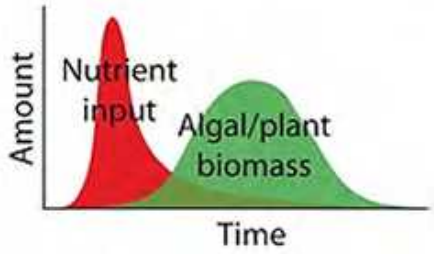


Sediment oxic zone decrease

https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/lacustrine-palustrine-threats/organic-matter/state.html



Algae blooms may follow inflow events which bring increased nutrients



Increased BOD_5

Organic state and BOD

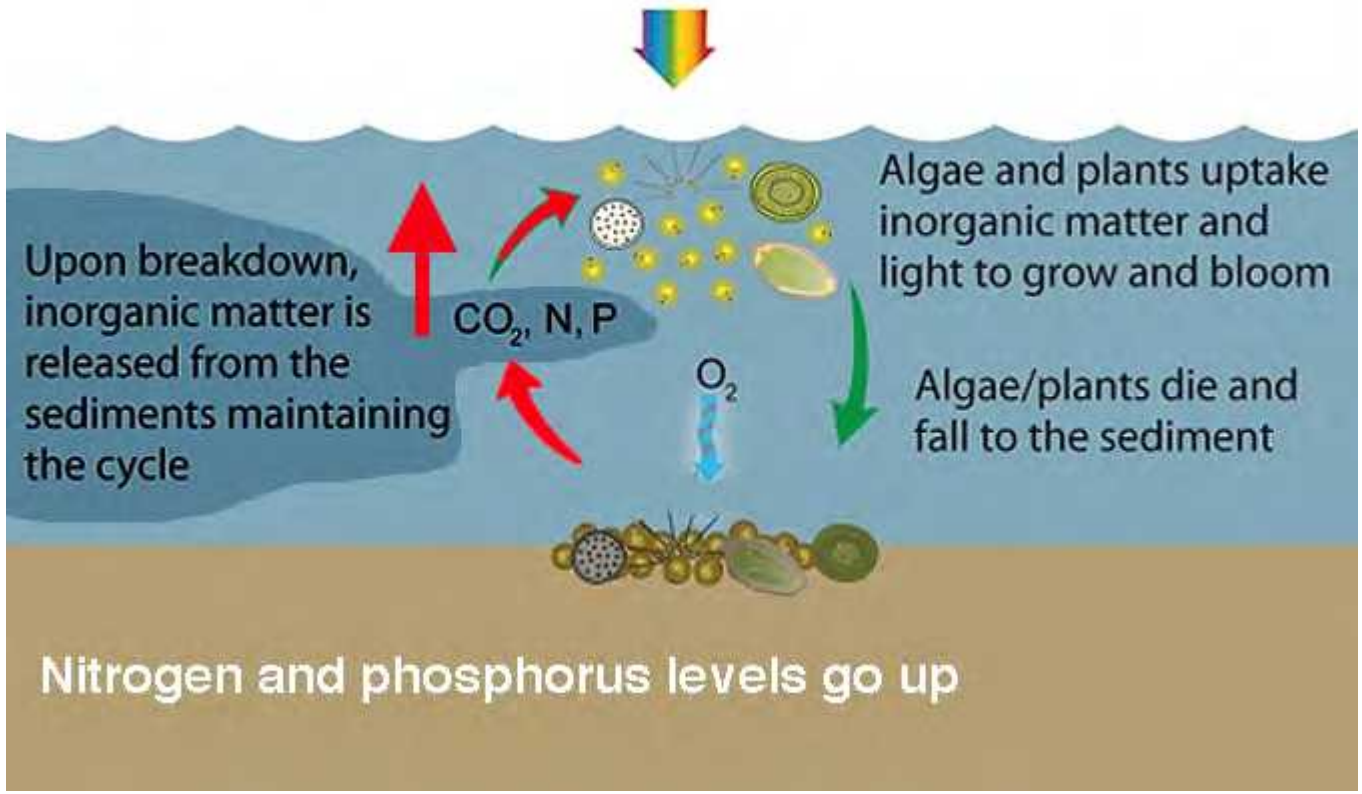
https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/lacustrine-palustrine-threats/organic-matter/state.html

A high BOD indicates there are many organisms using oxygen for respiration. The water quality is very poor, its polluted and contains organic waste.

BOD pollution levels

https://www.mrgscience.com/ess-topic-44-water-pollution.html

High BOD = low DO levels = high pollutant levels and may involve nitrate and phosphate resulting from algal blooms.

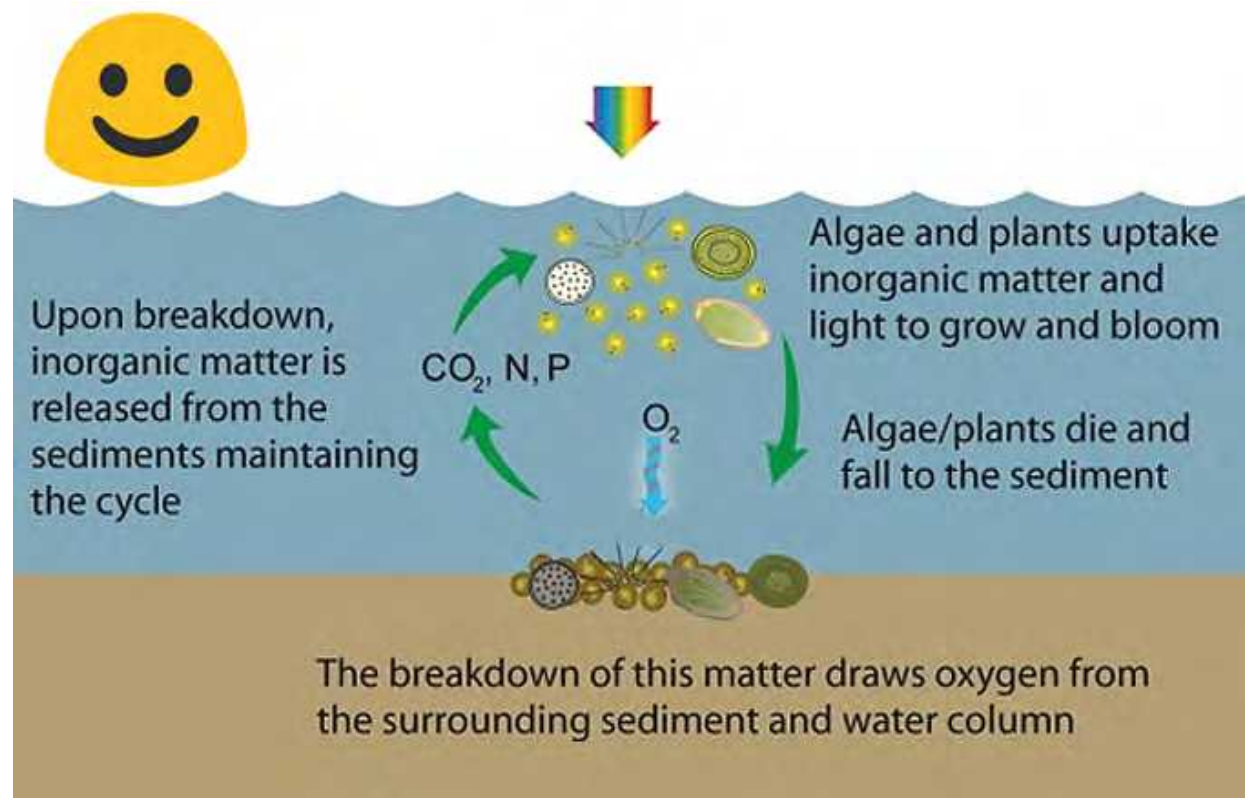


Nitrogen levels go up

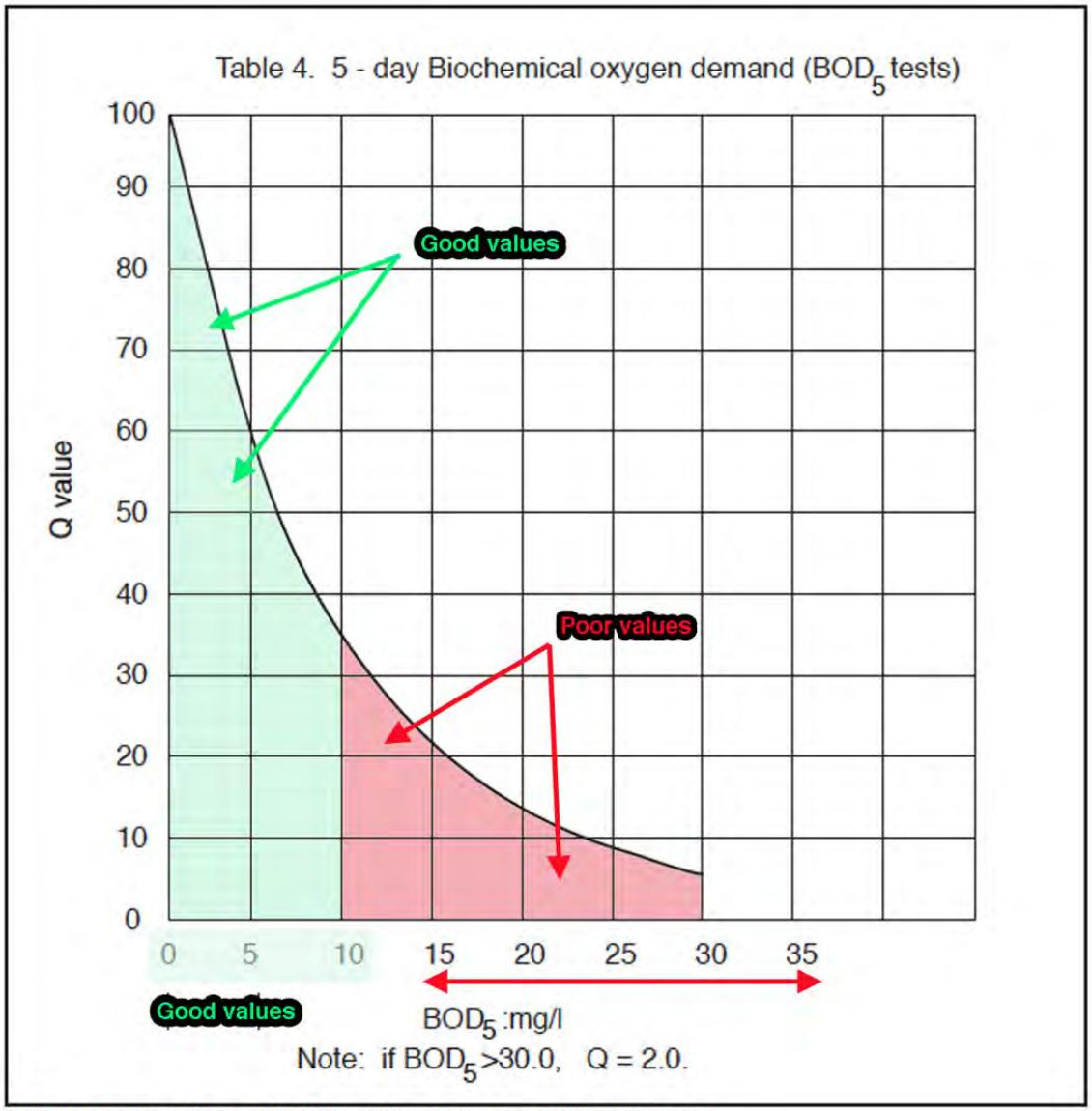
https://www.mrgscience.com/ess-topic-44-water-pollution.html

A low BOD indicates relatively few organisms needing oxygen for respiration.

Low BOD
= high DO levels
= low pollutant levels



Happy Internal cycle of organic matter production
Happy emoji By Google - https://github.com/googlei18n/noto-emoji/blob/bf295c4/svg/emoji_u263a.svg, Apache License 2.0, https://commons.wikimedia.org/w/index.php?curid=62004381
https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/lacustrine-palustrine-threats/organic-matter/state.html



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Question

Describe how BOD levels are used to assess water pollution with reference to organic matter production.


T032 Eutrophication

Syllabus statement

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

Define the process of eutrophication

Define

- give the meaning of a word, phrase, concept or physical quantity;

- state meaning and identify or describe qualities.

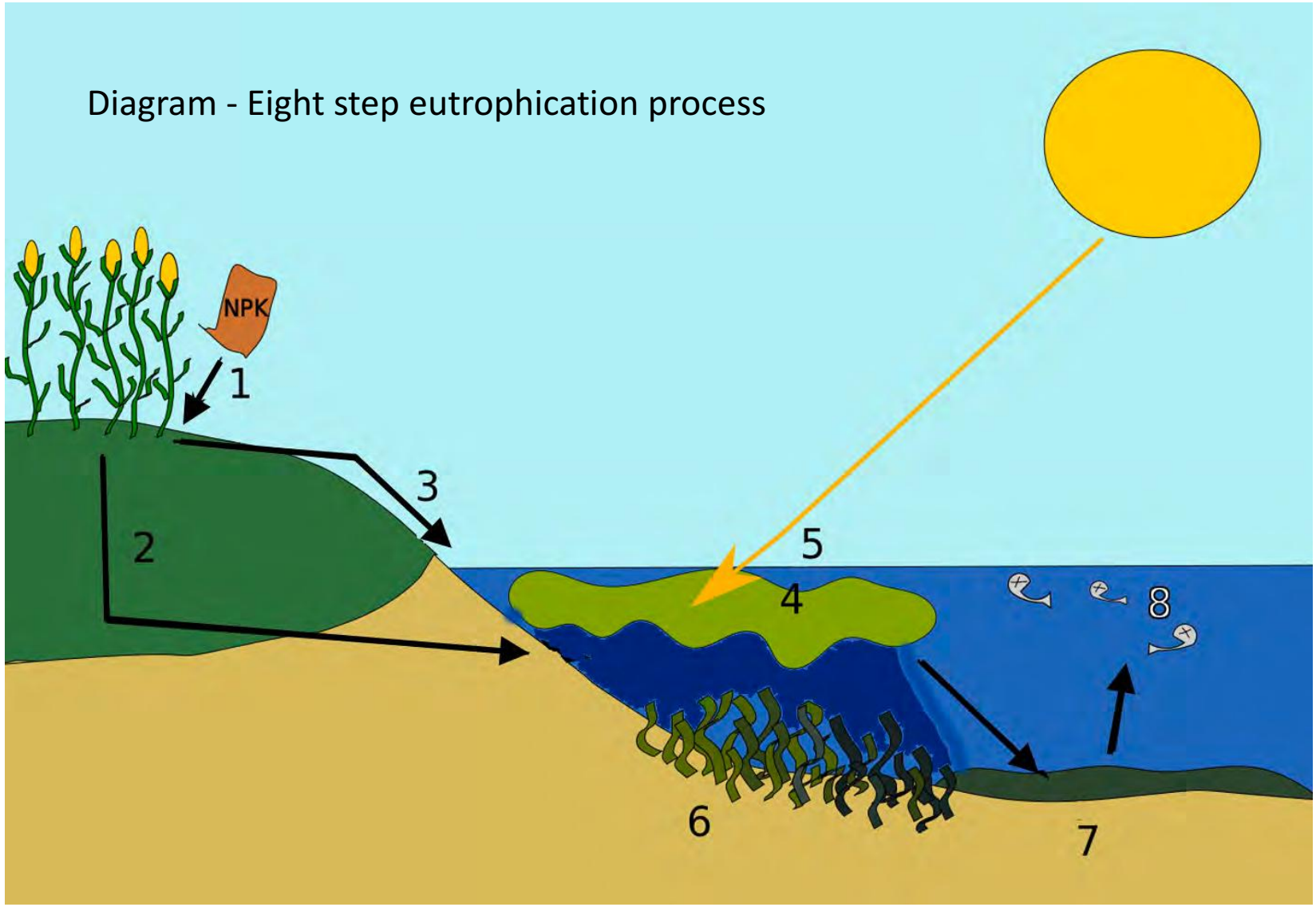
Definition

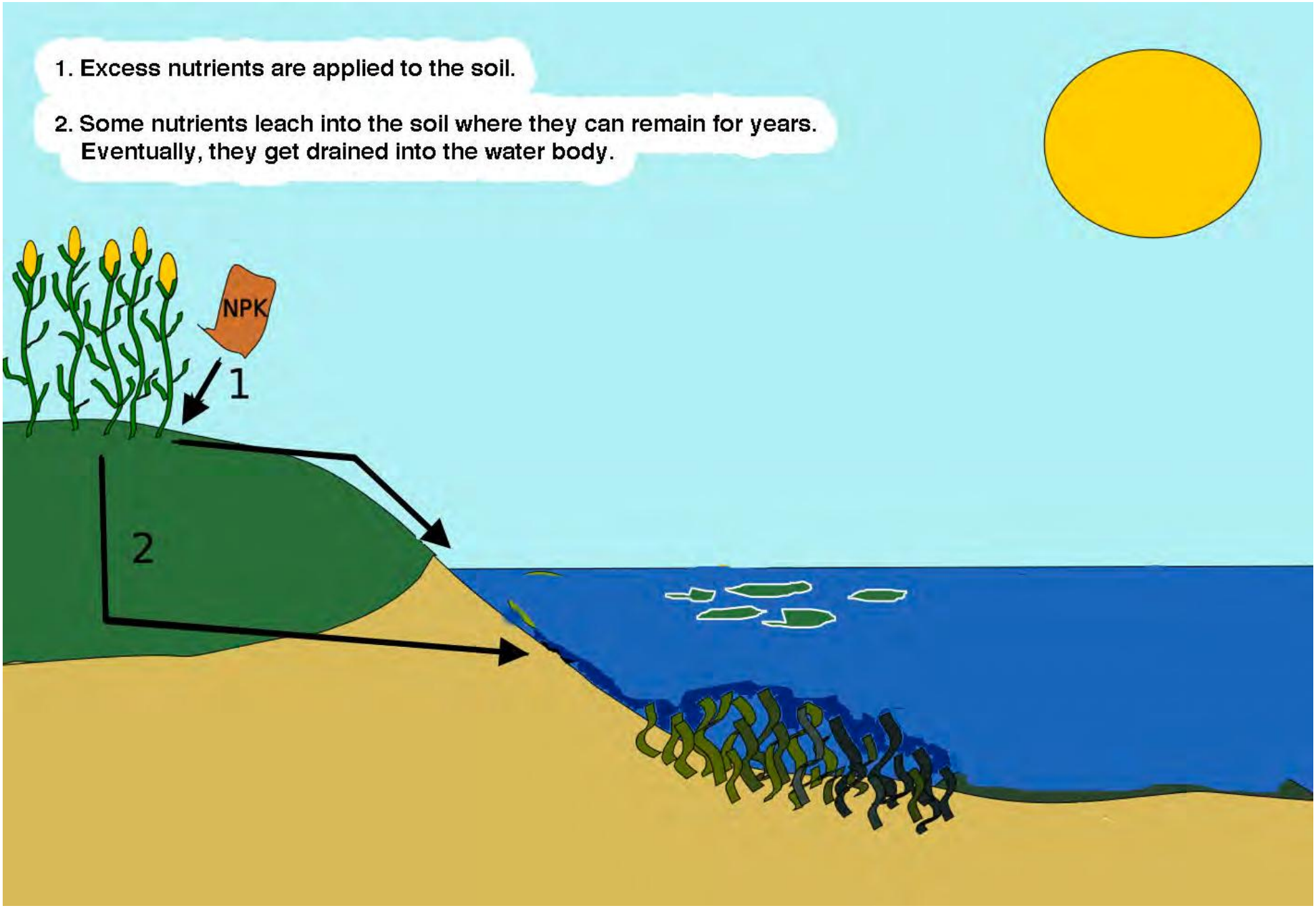
Eutrophication is the natural or artificial enrichment of a body of water, particularly with respect to nitrates and phosphates, that results in depletion of the oxygen content of the water.

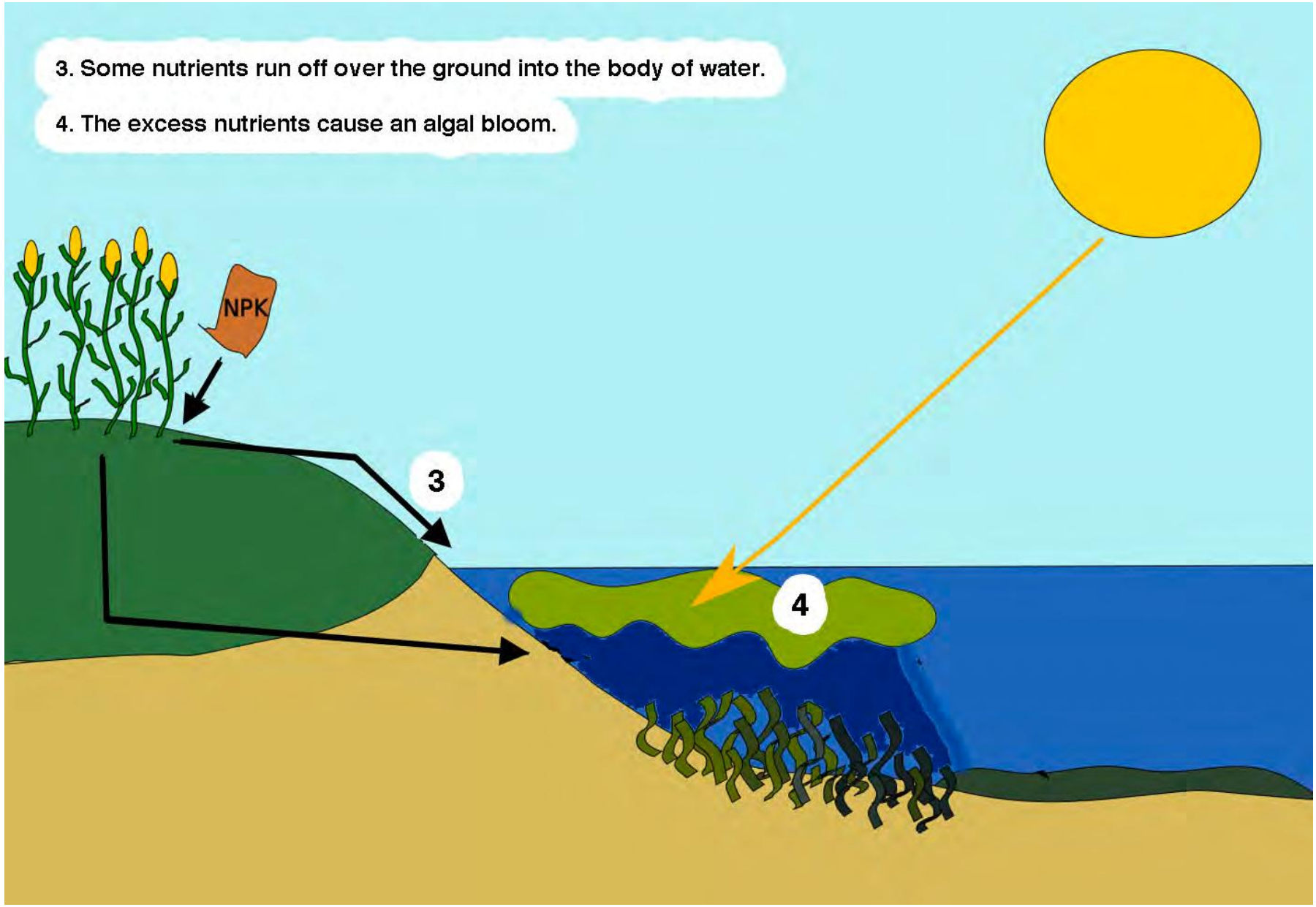
Question

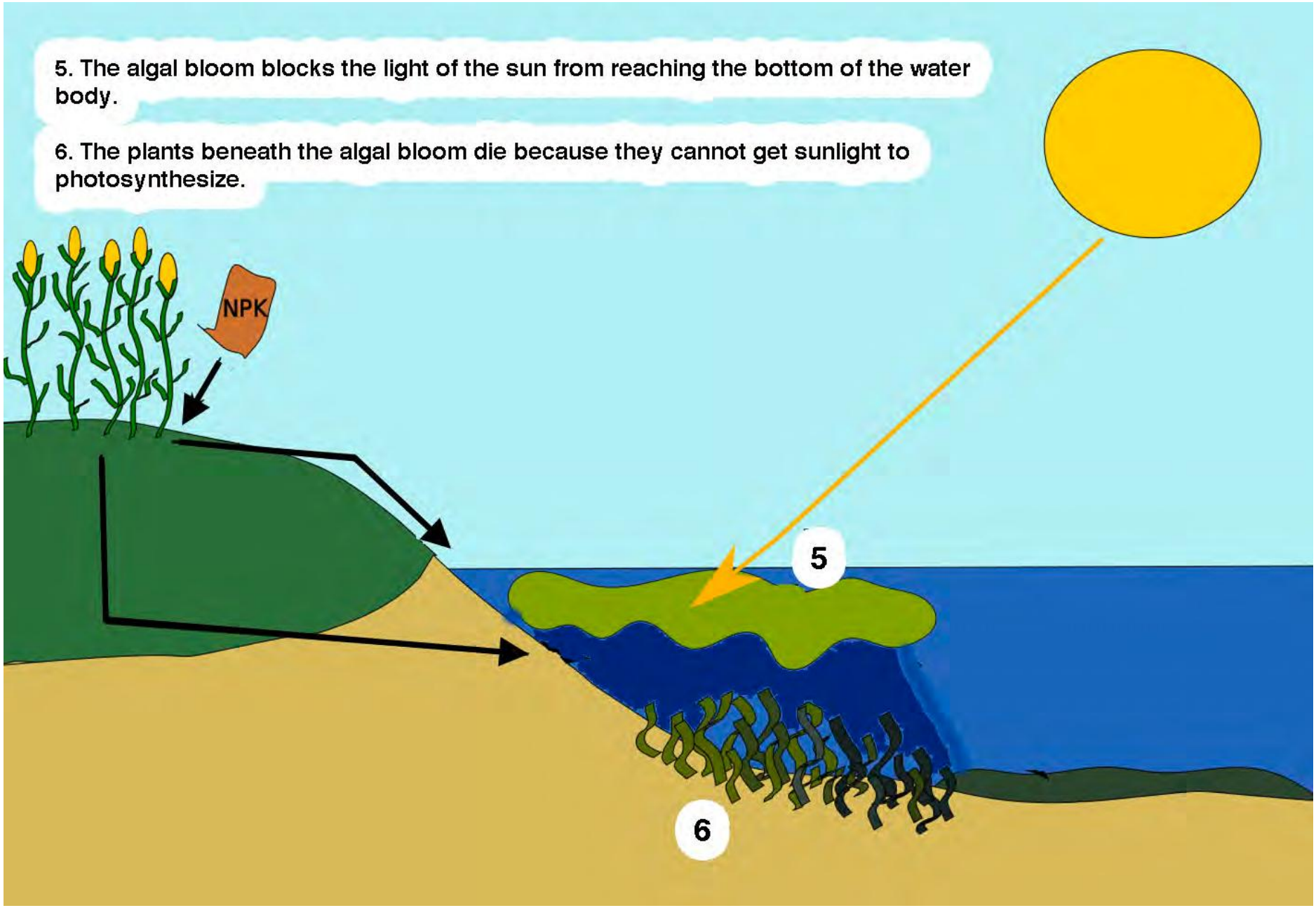
Detail an 8 step process that describes eutrophication. Draw a diagram to illustrate your answer.

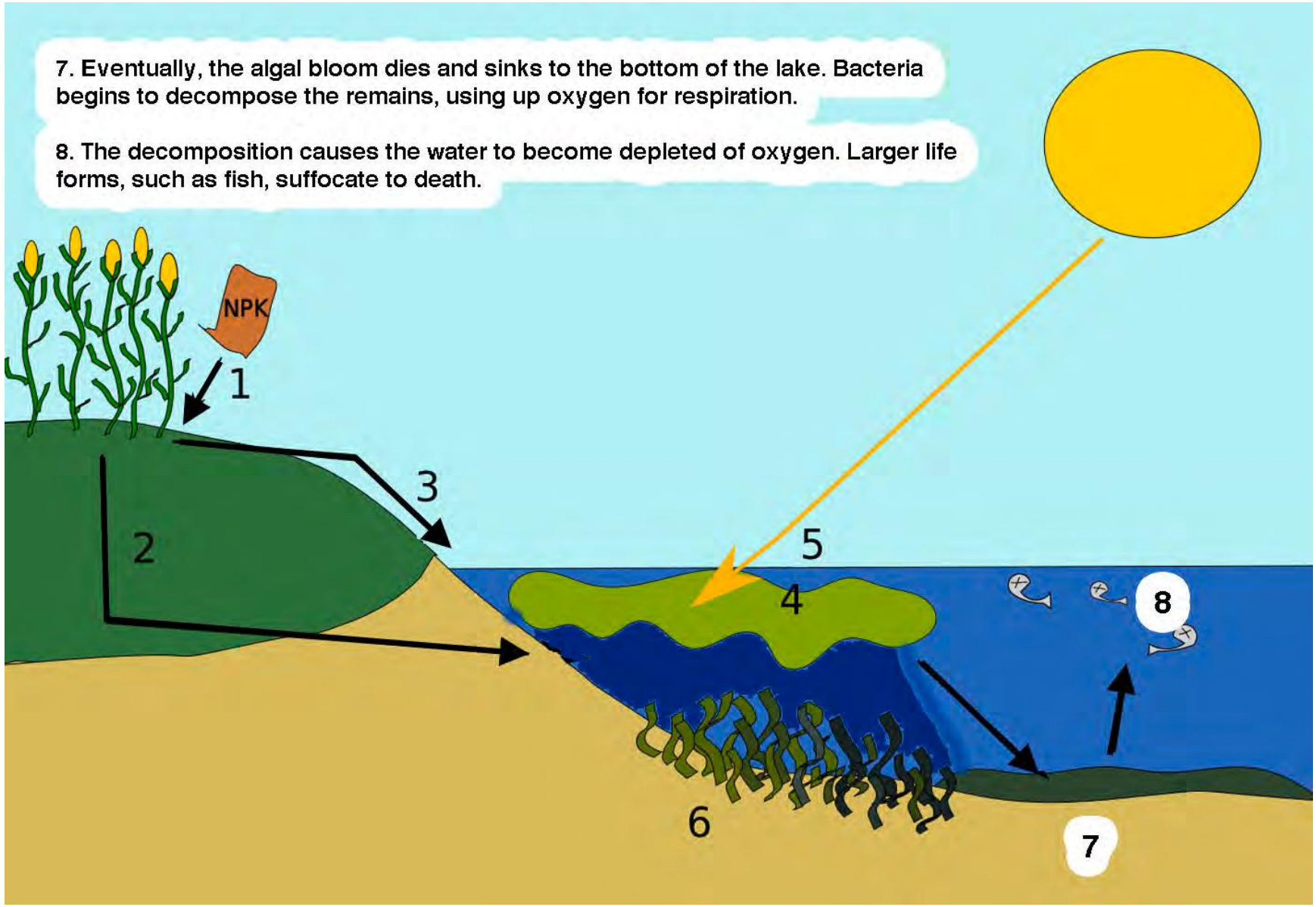
Diagram - Eight step eutrophication process



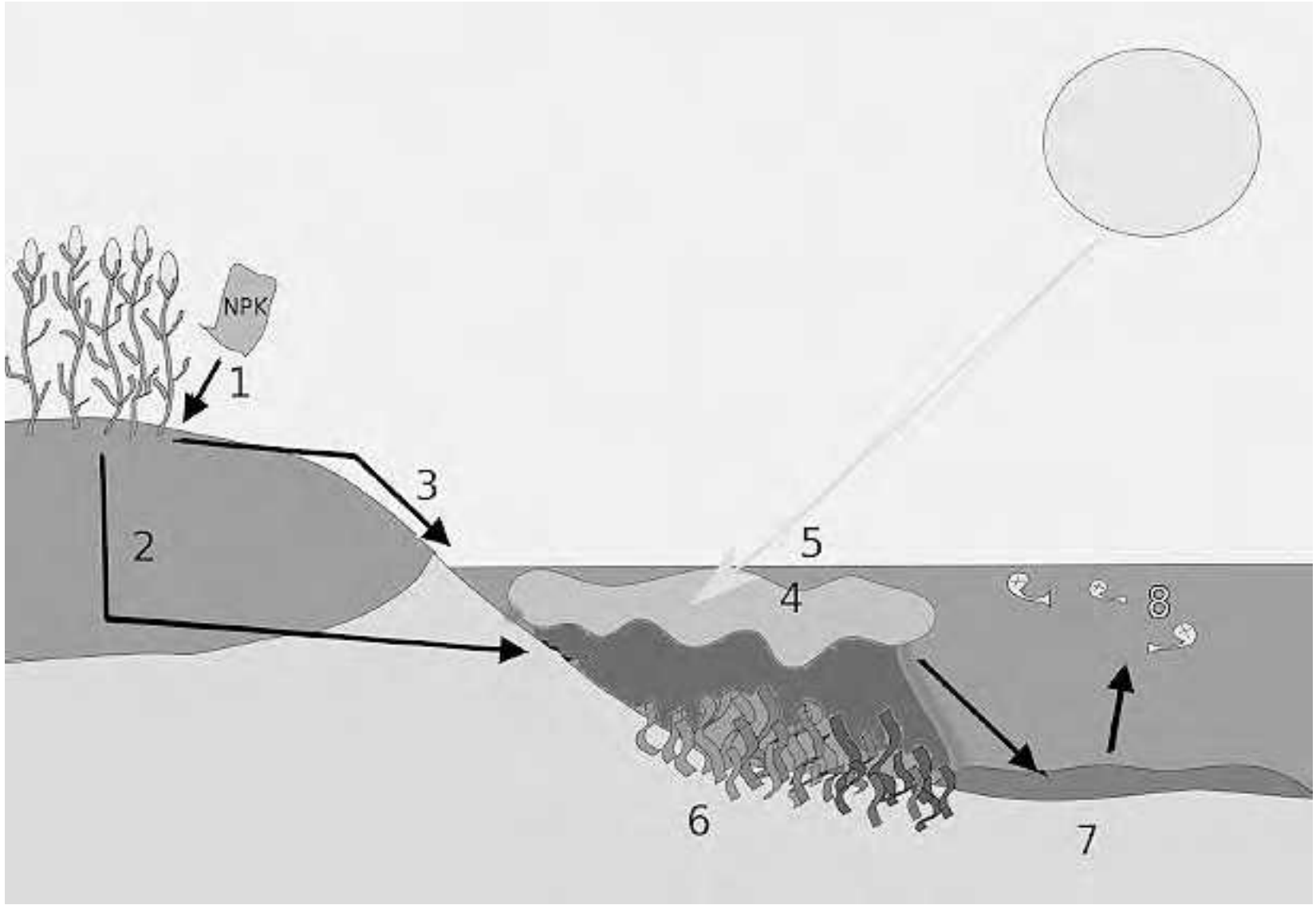

1. Excess nutrients are applied to the soil.
2. Some nutrients leach into the soil where they can remain for years. Eventually, they get drained into the water body.
NPK
1
2


3. Some nutrients run off over the ground into the body of water.
4. The excess nutrients cause an algal bloom.
NPK
3
4


5. The algal bloom blocks the light of the sun from reaching the bottom of the water body.
6. The plants beneath the algal bloom die because they cannot get sunlight to photosynthesize.
NPK
5
6


7. Eventually, the algal bloom dies and sinks to the bottom of the lake. Bacteria begins to decompose the remains, using up oxygen for respiration.
8. The decomposition causes the water to become depleted of oxygen. Larger life forms, such as fish, suffocate to death.
NPK
1
2
3
4
5
6
7
8

Complete the diagram to explain 8 steps in eutrophication.



T033 Pollution practices

Syllabus statement

At the end of this topic you should be able to ... **identify** and **describe** land management practices that contribute to the health of marine ecosystems, including siltation, algal blooms and agricultural practices.

Indentify

- Locate, recognise and name;

- establish or indicate who or what someone or something is;

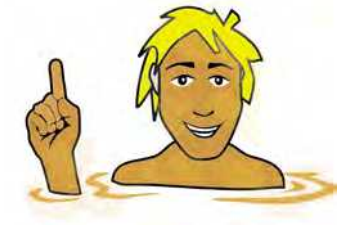
- provide an answer from a number of possibilities; recognise and state a distinguishing factor or feature.

Describe

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

Definition

A healthy ecosystem is one that is sustainable – that is, it has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress. (resilience).



Question

Identify from the list below, how the how the following land management practices hinder the health of marine ecosystems.

A. Siltation
B. Algal blooms
C. Agricultural and urban practices

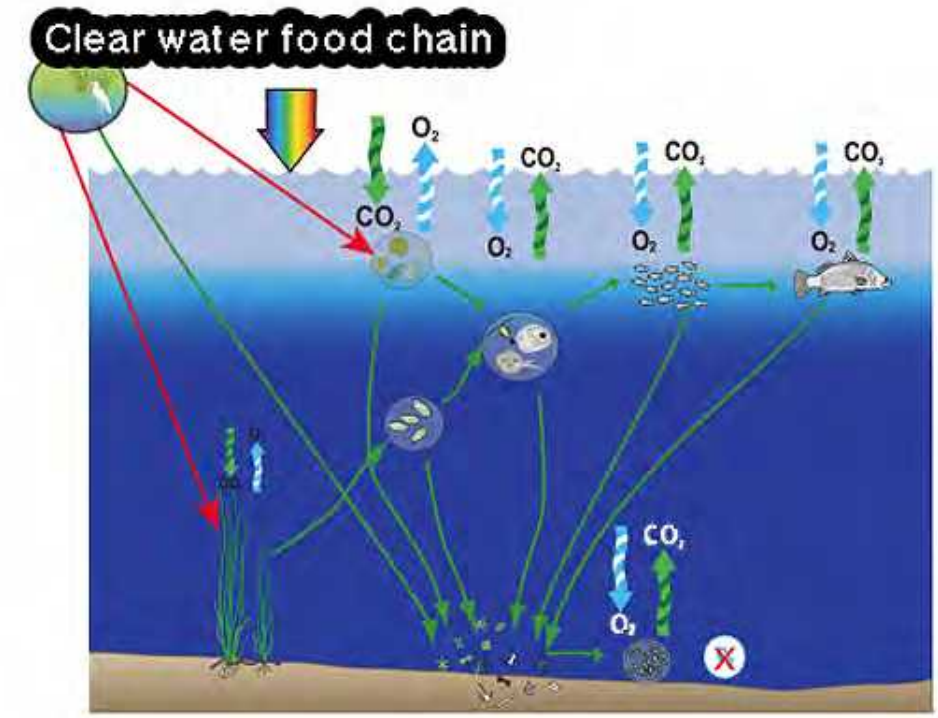
Siltation

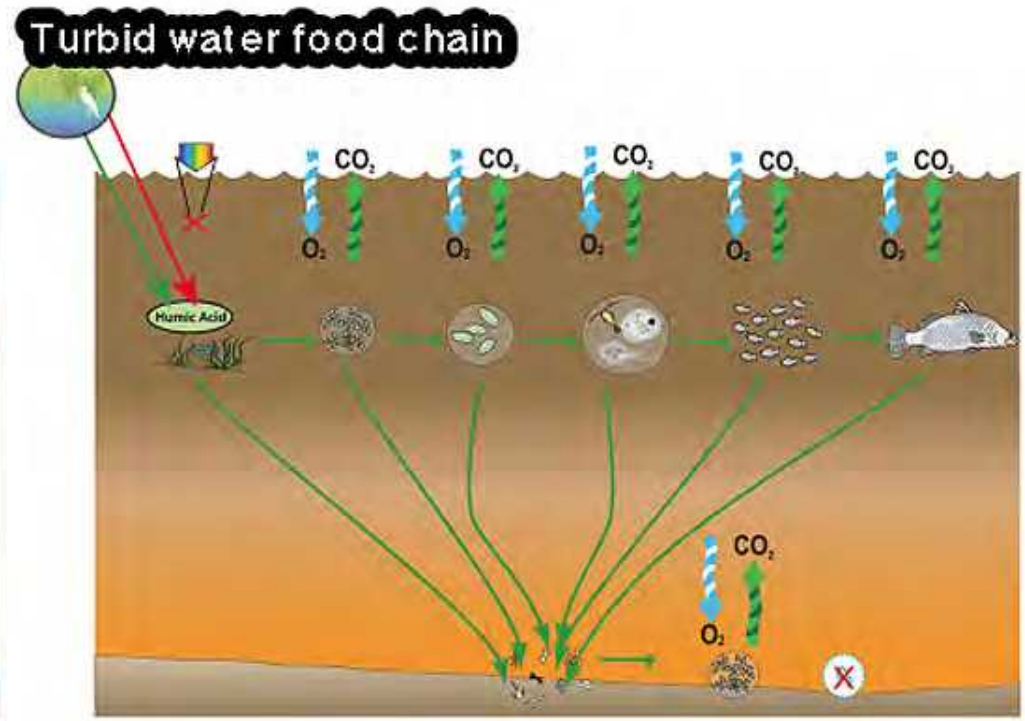
Siltation hinders ecosystem health because it increases the water clarity (turbidity) of coastal and estuarine waters.

Siltation blocked by incoming tide

Photo Geoscience Australia

Water quality can have an impact on food web processes.
a. Clear water allows aquatic photosynthesis
b. Turbid water can provide a source of carbon in the form of particulate matter or coloured dissolved organic matter such as Melaleuca tannins.



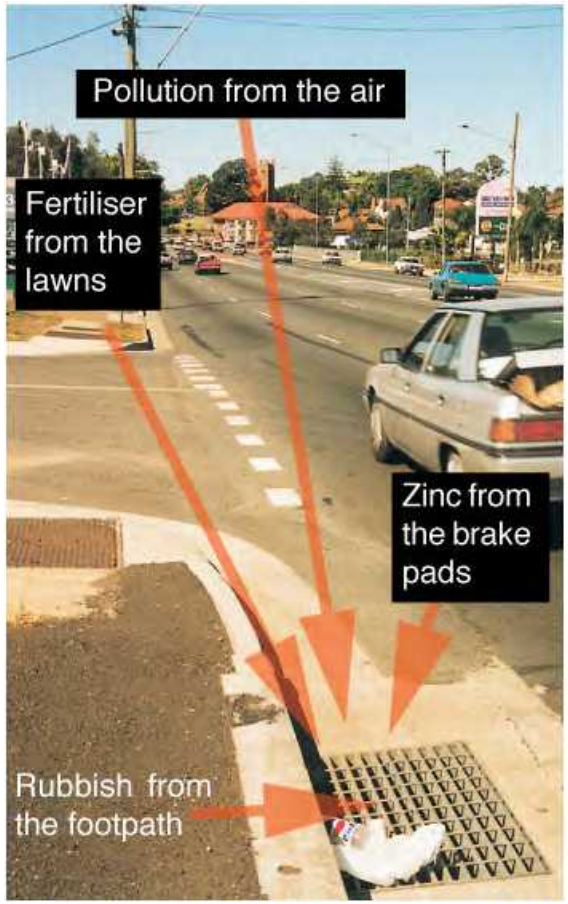


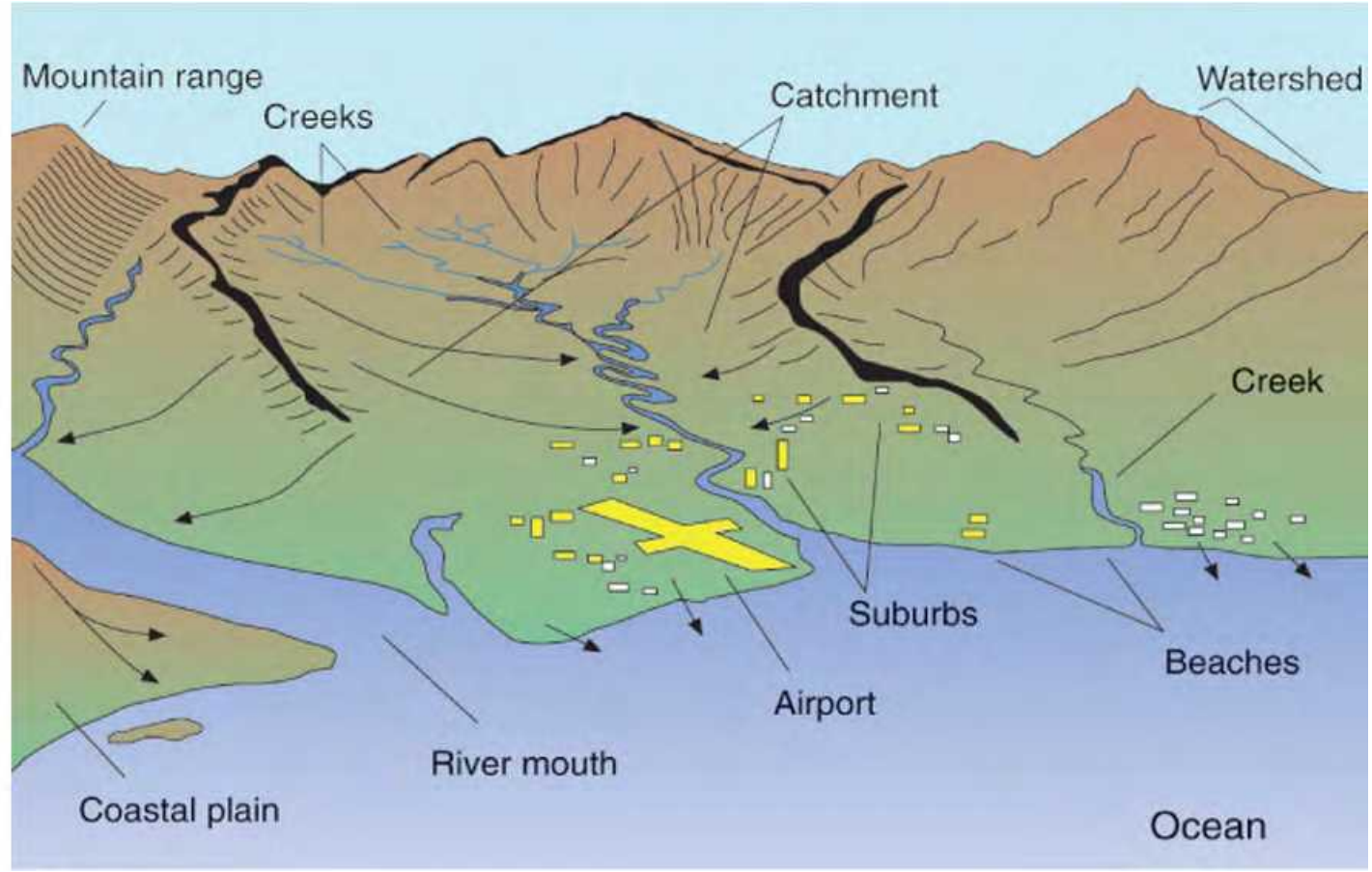
https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/lacustrine-palustrine-threats/organic-matter/state.html

Siltation also covers the filter feeding mechanisms of marine invertebrates.
Too much sediment on the river bed also limits the breeding of certain species of fish, for example, the catfish which builds its nest on gravelly river beds.

Sediment will kill barnacles

Sediment also carries with it a whole range of chemical pollutants including heavy metals with can bioaccumulate in the food chain. Roads, construction sites and hard surfaces make a huge contribution to this sediment load.





Siltation from roads in a catchment

Photo Bob Moffatt

Urban surface water runoff:

By Monterey Bay National Marine Sanctuary, California, USA.Original uploader was Mattisse at English Wikipedia - Transferred from en.wikipedia to Commons. (25 August 2009 (original upload date))Original source: http://montereybay.noaa.gov/resourcepro/urban.html, Public Domain, https://commons.wikimedia.org/w/index.php?curid=45258254

When we clear natural vegetation from land, we increase the amount of soil eroded away by storm water.

Ploughing a field

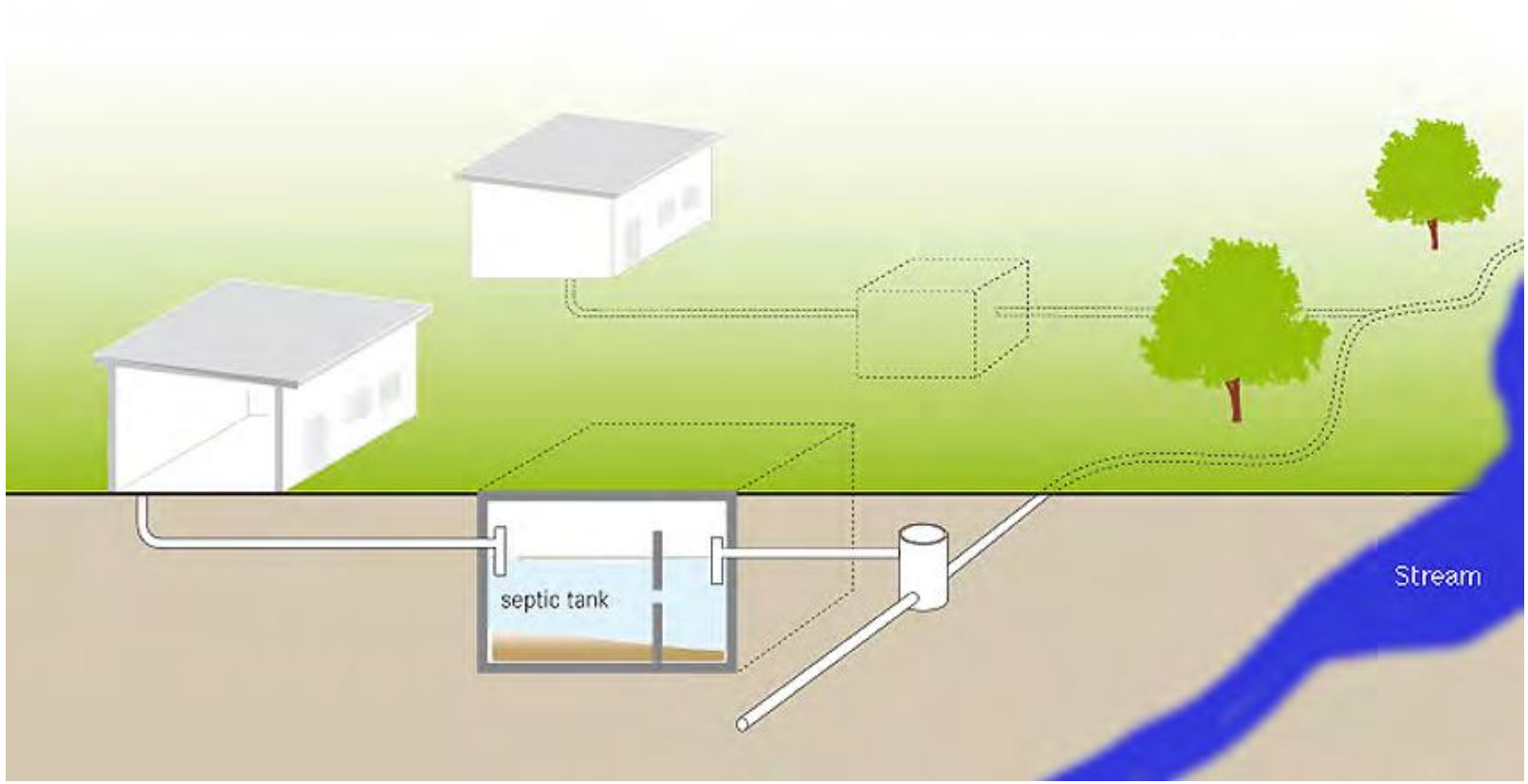
By Joevilliers - Transferred from en.wikipedia.org [1]: 2006-07-11 06:06 . . Joevilliers . . 1632 × 1232 × 8 (436766 bytes), Public Domain, https://commons.wikimedia.org/w/index.php?curid=3936954

Algal blooms

Algal blooms can occur close to cities due to increased nutrient run off from hard surfaces such as streets and roads

Algae on the coast of northern Germany

Faulty sewage mains or septic tanks can also cause algal blooms by introducing large amounts of nitrogen and phosphorus into creeks and rivers.



Septic tank and stream modified

Marinas and canals can stop the natural flushing of estuaries causing water to stagnate promoting algal growth.

Canal estate GC.

Photo Viewfinder

Thermal pollution from power plants and factories can increase water ways promoting algal growth.

Power house and stacks

Photo Bob Moffatt

Dams can also reduce water levels in inland waterways and with increased water temperatures, algal blooms can occur downstream

Wier NSW

By John Hewat from Canberra Australia [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], from Wikimedia Commons
https://upload.wikimedia.org/wikipedia/commons/e/e4/Culverts_under_yass_river_walkway_weir.JPG

Most farmers add extra nutrients to the soil to increase their production.

Water hyacinth in river

Overstocking

Increased numbers of stock close to sheltered waterways and estuaries results in too much solid waste from these animals entering the sea.

Cows in a green field

The increase in solid waste leads to increased faecal coliform levels resulting in seafood consumption bans.

Pollution sign Tasmania

Photo Bob Moffatt

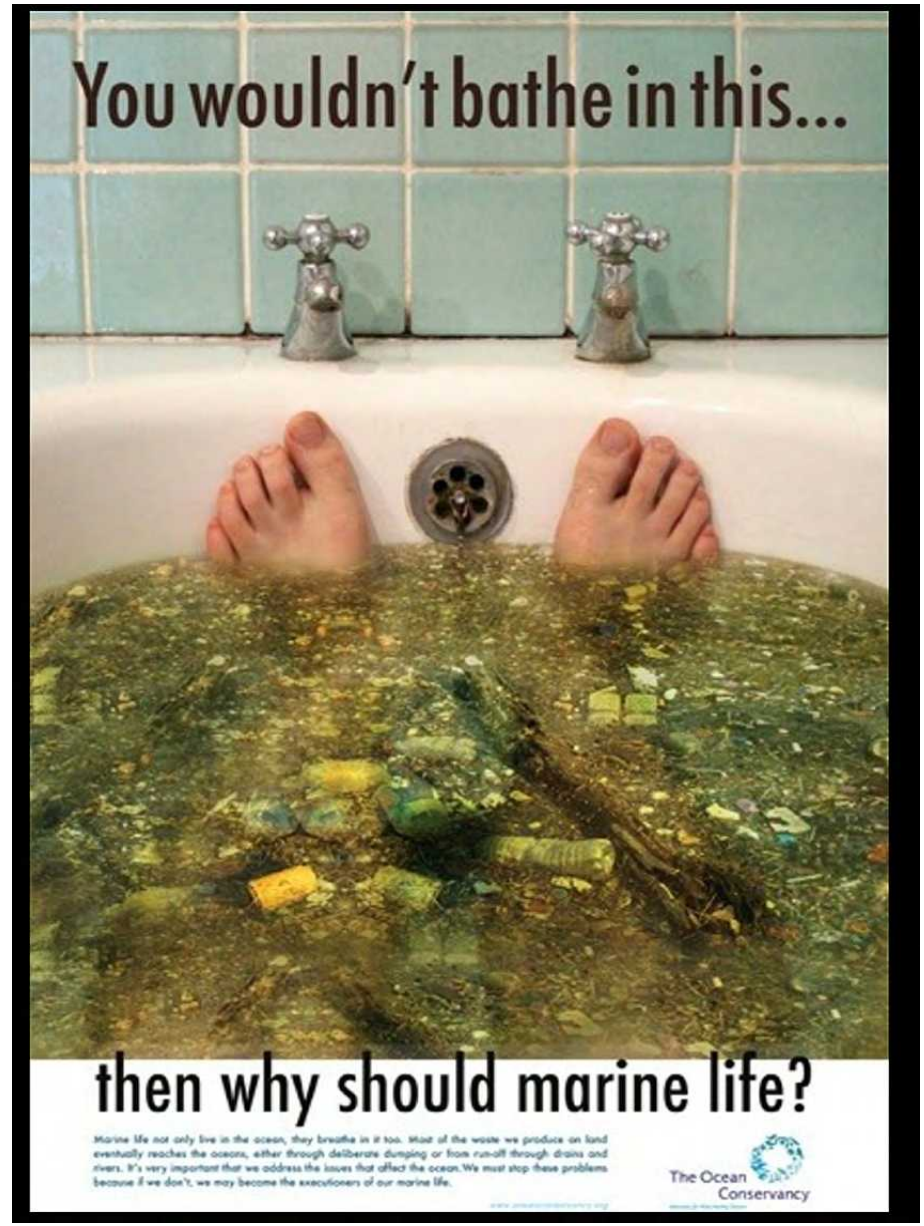
Wastes from cities and towns

Research also indicates that the Great Barrier Reef is at risk of being destroyed by waste produced by the non-point source pollution of coastal cities and towns.

Brisbane

Photo Murray Waite

It is believed that the corals will be smothered by debris and plants, such as algae, which will increase in number as they break down the wastes.



Pollution poster

Credit: The Ocean Conservancy
http://underthevastblueseas.tumblr.com/post/73494817638

For further research

Identify how the control of siltation, nutrient run off and strategies to reduce algae blooms by land management practices contribute to the health of a marine ecosystems.

T034 Measuring pollution levels

Syllabus statement

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

describe and **explain** an indirect method of measuring pollution levels using a biotic index.

Describe

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

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.

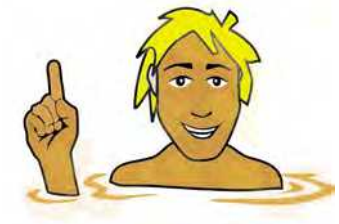
Definition

A Biotic Index is a scale for showing the quality of an environment by indicating the types of organisms present in it.
It is often used to assess the quality of water in rivers. It is measured from 1 to 10 and corresponds to the four basic water quality (Excellent, Good, Fair or Poor).

The concept of the Biotic Index was developed by Cherie Stephens in an effort to provide a simple measurement of stream pollution and its effects on the biology of the stream.

Reference:

https://en.wikipedia.org/wiki/Biotic_index



Question

Use the examples below of to explain how a biotic index can be created and used as an indirect method to measure pollution.

A. Freshwater species
B. Riparian vegetation

Freshwater species

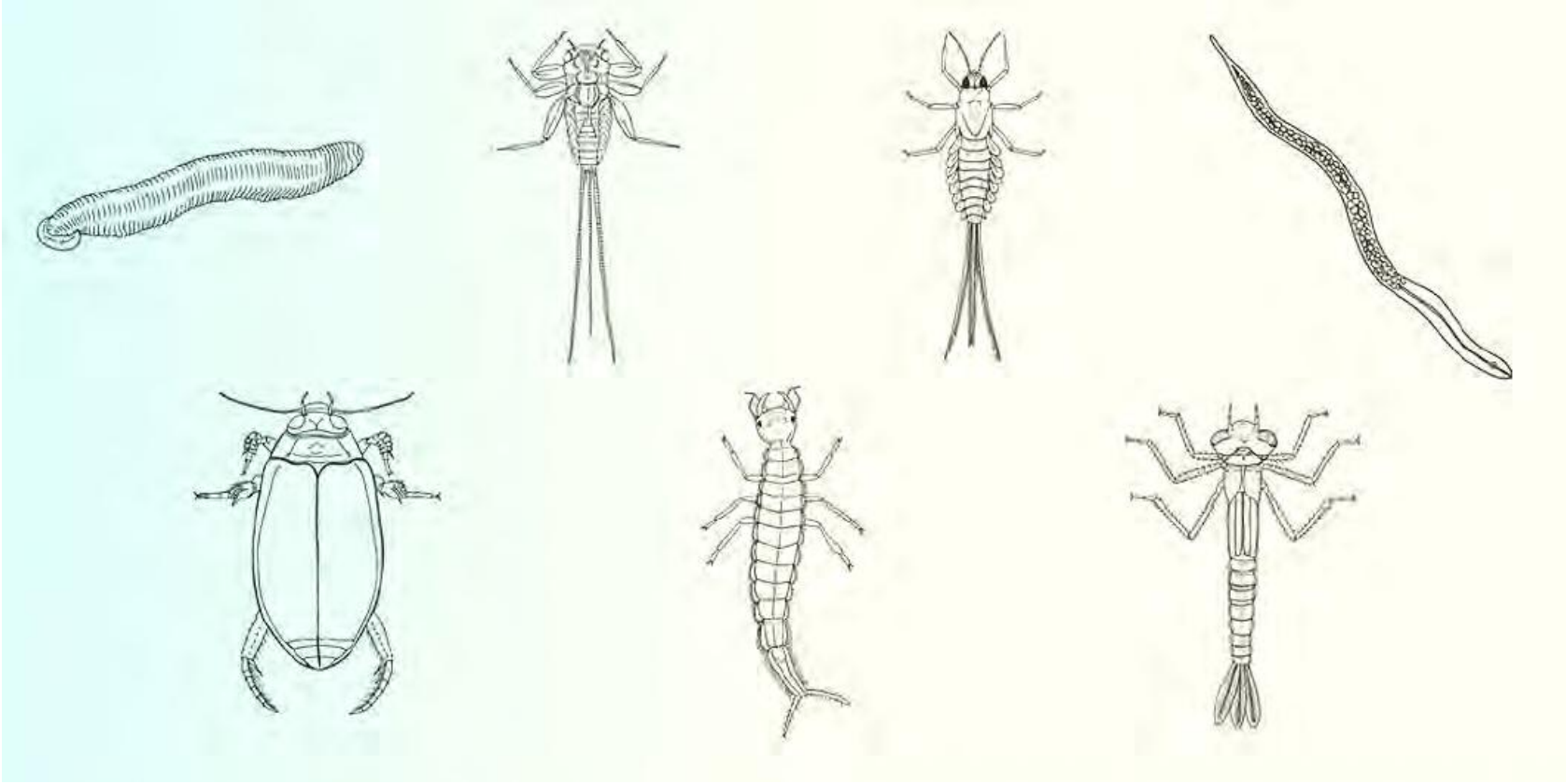
Water invertebrates vary in their ability to withstand pollution levels.

Caddisfly biotic indicator - a macroinvertebrate used as an indicator of water quality

These water invertebrates can be classified into four different groups depending on how sensitive they are to pollution. These groups are very sensitive, sensitive, tolerant and very tolerant.

Stonefly nymph

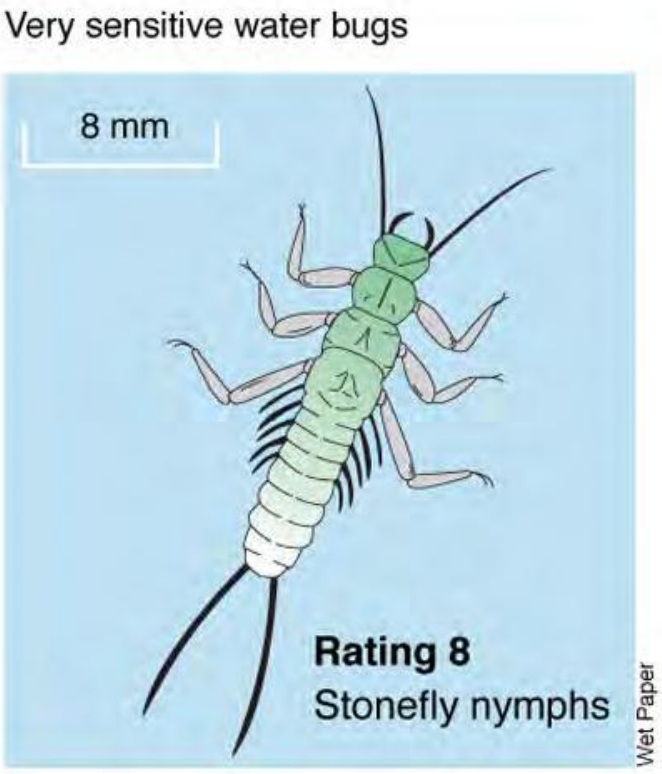
Each water invertebrate is given a rating according to how sensitive it is to pollution. Very sensitive animals are given high numbers and very tolerant animals low numbers.

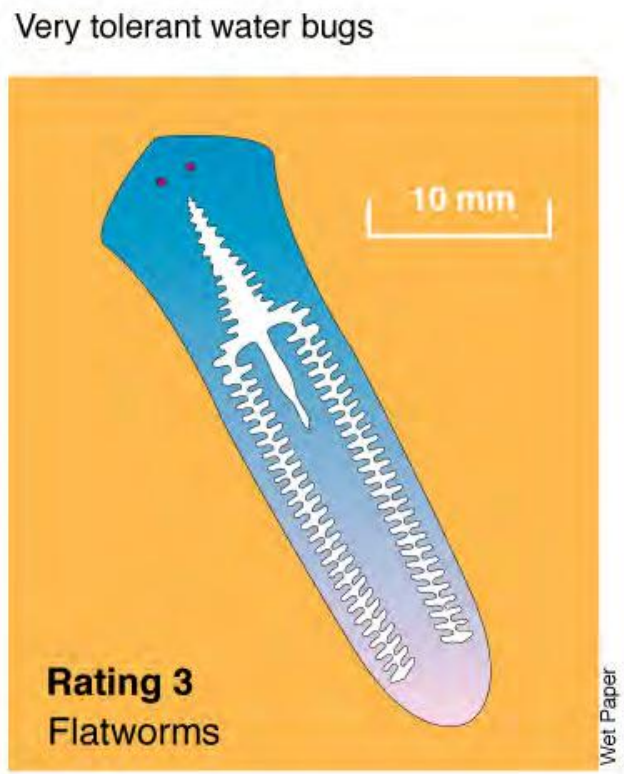


Common bugs used in a biotic index

From NSW waterwatch

Stonefly nymphs are very sensitive. Flatworms belong to the very tolerant group.
So the stonefly bug is given a rating of 8 and the flatworm a rating of 3.





Sensitive and non sensitive bugs

Wet paper

The more sensitive the animals found in a stream, the less polluted the water quality is likely to be.
To calculate the water quality of a stream, add the numbers to get a pollution index.

Very sensitive		Sensitive		Tolerant		Very tolerant	
Yabbies	(7)	Dragon flies	(6)	Leech	(3)	Mosquito	(1)
May flies	(7)	Mussels	(6)	Beetles	(5)	Bloodworm	(1)
		Shrimp	(6)	Snails	(3)		
Totals	(14)	+	(18)	+	(11)	+	(2)

Pollution index = 45

Biotic index

Pollution index	Stream quality rating
20 or less	Poor
21 - 35	Fair
36 - 50	Good
51 or more	Excellent

Stream quality pollution index

Wet paper

The stream is rated according to the index number you get.

If there were lots of very-tolerant-to-pollution animals and no very sensitive- to-pollution animals, then the water quality would be poor.

Scientists from programs called Streamwatch, WaterWatch and from CSIRO have developed other stream pollution level tables.

Extract from a water bug recording table

Bug type			A	B	C	D
Sensitivity rating	**Taxa richness (bug types)**	**Tick if present**	**Sensitivity rating**	**Number of bugs**	**Weight factor**	**Column A X Column C**
Very sensitive	Stonefly nymph	✓	10	3	2	20
Sensitive	Water mite	✓	6	20	4	24
Tolerant	Whirligig beetle & larva	✓	4	11	4	16
	Freshwater yabby/crayfish	✓	4	2	1	4
	Damselfly nymph	✓	3	5	2	6
	Freshwater shrimp	✓	3	30	5	15
Very tolerant	Water boatman	✓	2	16	4	8
	Freshwater worm	✓	2	15	4	8
	Mosquito larva & pupa	✓	1	12	4	4
	Freshwater snail	✓	1	33	5	5
	TOTALS	10		147	35	110

Stream bug table
NSW WaterWatch

Riparian vegetation

A riparian zone or riparian area is the interface between land and a river or stream.

Creek with good riparian vegetation

Plant habitats and communities along the river margins and banks are called riparian vegetation, characterized by hydrophilic (water-loving) plants.

Riparian estuarine zone

Photo Bob Moffatt

Riparian zones are important in ecology, environmental management, and civil engineering because of their role in soil conservation, their habitat biodiversity, and the influence they have on fauna and aquatic ecosystems, including grasslands, woodlands, wetlands, or even non-vegetative areas.

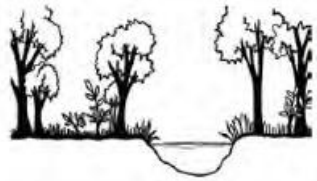
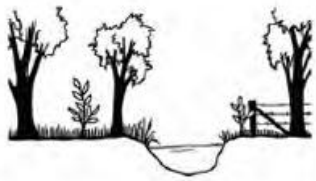
Estuarine riparian zone
Bob Moffatt

Riparian vegetation assessment can be also be used to measure levels of pollution.

8.4 Rapid observations at the site: riparian condition

Site name: .....

Date: .....

Appearance of my site Tick the box that most looks like your site	**Stream condition** Tick the boxes for the site that looks most like your site
1 	**Good** ☐ Native vegetation along the entire stretch ☐ Distinct tree, shrub and grass layers of native vegetation ☐ Area protected from human use, e.g. fences keep out stock, no pollution evident
2 	**Average/moderate** ☐ Vegetation patchy ☐ Distinct vegetation layers not visible ☐ Many weeds ☐ Some bank erosion ☐ Some human use of the area evident, e.g. drains or stock access
3 	**Poor** ☐ Little native vegetation ☐ Exotic tree species present ☐ Some trees have dead limbs or look unhealthy ☐ Weeds ☐ Human use obvious, e.g. stock access, drains, vegetation removal
4 	**Very poor** ☐ Erosion across a wide area ☐ Little riparian vegetation or absent ☐ Bank erosion evident ☐ Many changes caused by human use, e.g. pollution, stock access, drains

FIELD RECORDING SHEET

Riparian assessment rapid

NSW WaterWatch

These results can be used to determine an overall biotic index.

T035 Bio-indicator examples

Syllabus statement

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

.. **recall** a bio-indicator with an example.

Recall

- remember;

- present remembered ideas, facts or experiences;

- bring something back into thought, attention or into one’s mind.

Definition

Bioindicators are living organisms such as plants, planktons, animals, and microbes, which are utilized to screen the health of the natural ecosystem in the environment.

They are used for assessing environmental health and biogeographic changes taking place in the environment.

Health

Each organic entity inside a biological system provides an indication regarding the health of its surroundings such as plankton responding rapidly to changes taking place in the surrounding environment and serving as an important biomarker for assessing the quality of water as well as an indicator of water pollution.

Even the health of aquatic flora is best reflected by plankton, which acts as an early warning signal.

Reference

https://www.tandfonline.com/doi/full/10.1080/21553769.2016.1162753
Ref: https://en.wikipedia.org/wiki/Indicator_species

Question

Use one of the examples below to describe how the a bio-indicator can be used to determine the level of water pollution

a. Marine bivalves such as mussels
b. Sentinel fish species such as mudskippers
c. Seagrass

Marine bivalves (mussels)

In Croatia mussels were analysed for common aquatic pollutants such as organochlorines, DDTs and polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs)and heavy metals.

Mediterranean mussel (Mytilus galloprovincialis) shell

The concentrations gave a level of how much pollution was entering the Adriatic Sea.

Adriatic Sea map

By No machine-readable author provided. NormanEinstein assumed (based on copyright claims). - No machine-readable source provided. Own work assumed (based on copyright claims)., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=157083

Mudskipper

Mudskippers are a very sensitive bioindicator of the contaminants found in mangrove forests.

Contaminants can be obtained in their tissues by the ingestion of contaminated sediments or food items.

Mudskippers

Atlantic mudskippers (Periophthalmus barbarus) photographed on the shore near Tenda-Ba in The Gambia.
By Bjørn Christian Tørrissen - own photo. See more travel photos by the uploader at http://www.pvv.org/~bct/waf/, CC BY-SA 4.0
https://commons.wikimedia.org/w/index.php?curid=4385752

It is also thought that they can gain pollutants by diffusion across any respiratory surfaces and through any parts of the body that are in direct contact with contaminated substrate. Levels can then be compared with recommended guidelines to indicate pollution level.

APPENDIX 3

CANADIAN GUIDELINES FOR CHEMICAL CONTAMINANTS AND TOXINS IN FISH AND FISH PRODUCTS

Table of levels of contaminants permitted in fish and fish products

Contaminants	Product Type	Action Level [1]
Mercury	All fish products (except swordfish, shark, fresh and frozen tuna, escolar, orange roughy and marlin)	0.5 ppm
Mercury	Swordfish, shark, fresh and frozen tuna, escolar, orange roughy and marlin	1.0 ppm
Arsenic	Fish protein concentrate	3.5 ppm
Lead	Fish protein concentrate	0.5 ppm
Fluoride	Fish protein concentrate	150 ppm
2,3,7,8 TCDD (Dioxin)	All fish products	20 ppt ***under review***

Contaminants	Product Type	Action Level [1]
DDT and metabolites (DDD and DDE)	All fish products	5.0 ppm
PCB	All fish products	2.0 ppm ***under review***
Piperonyl butoxide	Dried Cod	1.0 ppm
Other agricultural chemicals or their derivatives	All fish products	0.1 ppm

[1] Based on contaminants level of edible weight

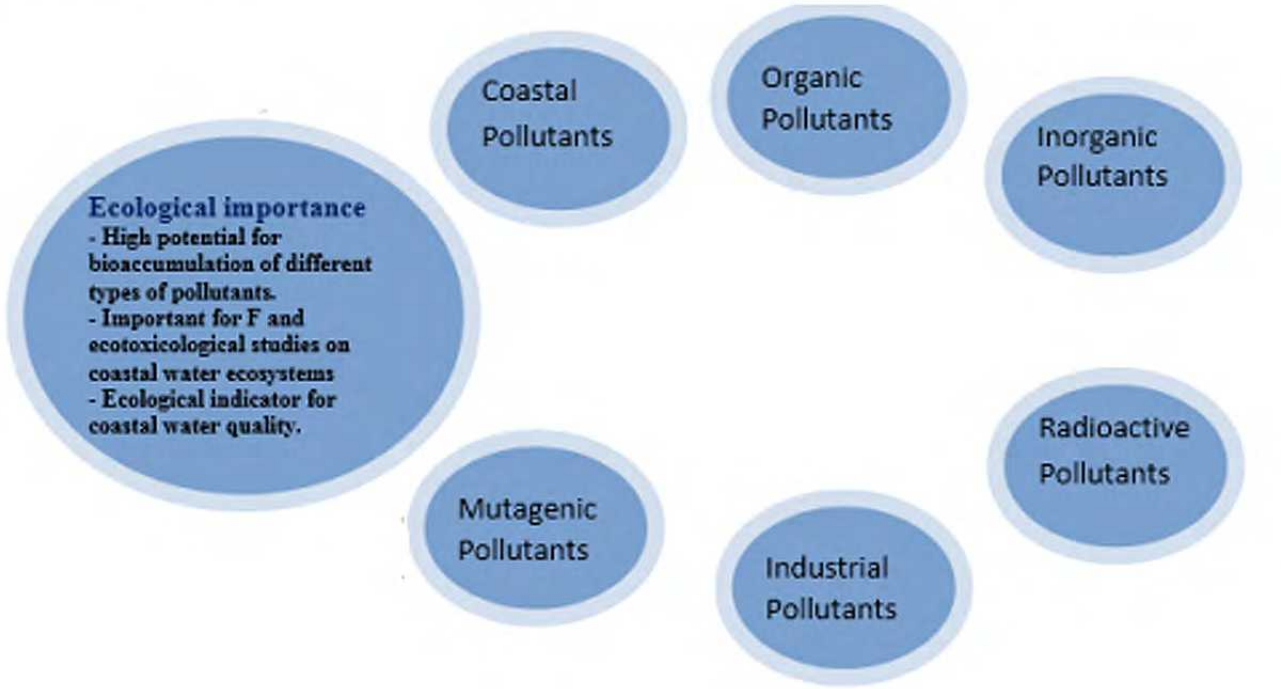
http://www.inspection.gc.ca/DAM/DAM-food-aliments/STAGING/text-texte/fish_man_standardsmethods_appendix3_1406403090196_eng.pdf

Acceptable levels of heavy metals in fish

http://www.inspection.gc.ca/DAM/DAM-food-aliments/STAGING/text-texte/fish_man_standardsmethods_appendix3_1406403090196_eng.pdf

As this species has no commercial value, it is not likely to be affected by local fisheries, therefore distribution will be predominantly determined by environmental factors. Due to this, their distribution can also be regarded as an indicator of issues in the mangrove environment.

Fig 3: A summary on mudskipper and its importance as a biological indicator



Mudskipper bio indicator chart

REF: A biological indicator for environmental monitoring and assessment of coastal waters by Abid A Ansari, Subrata Trivedi, Shalini Saggu, Hasibur Rehman
http://www.entomoljournal.com/vol2Issue6/pdf/48.1.pdf

Seagrass (Zostera spp)

Seagrasses form extensive beds or meadows, which can be either monospecific (made up of a single species) or in mixed beds where more than one species coexist.

Seagrass bed

Seagrass beds are highly diverse and productive ecosystems, and can harbor hundreds of associated species from all phyla.

White spotted puffer in seagrass

By Janderk (Photographed by Jan Derk) [Public domain], via Wikimedia Commons
https://upload.wikimedia.org/wikipedia/commons/7/79/White-spotted_puffer.jpg

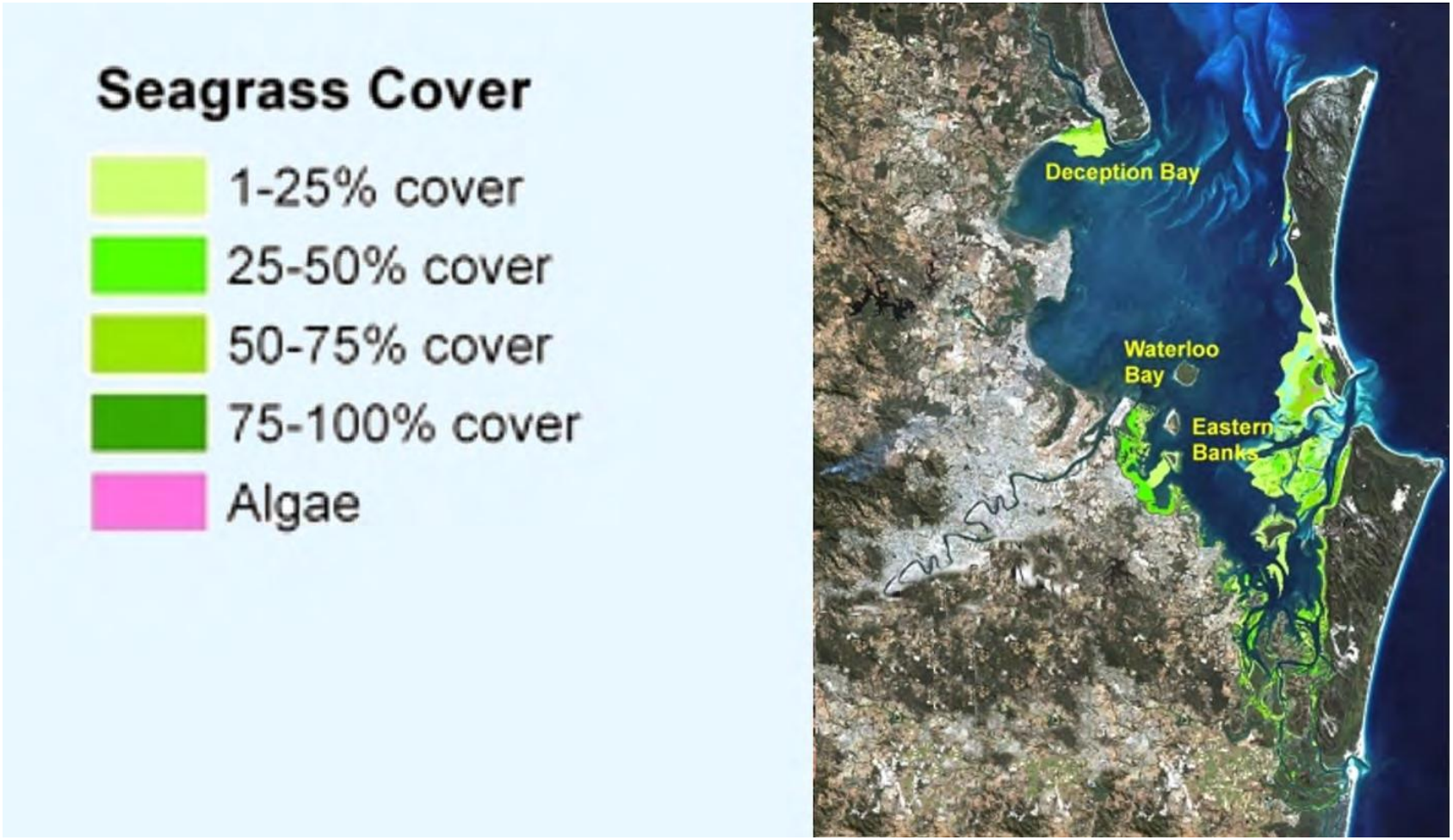
Seagrass is a highly important link in the food chain, with hundreds of species feeding on seagrasses worldwide, including green turtles, dugongs, manatees, fish, geese, swans, sea urchins and crabs.

Zostera Eel Grass

Seagrass beds

Illustration Qld Fisheries

The loss of seagrass beds can be used as a bioindicator.



Seagrass percent cover Moreton Bay

Geoscience Australia

Question

Use one of the examples below to describe how the a bio-indicator can be used to determine the level of water pollution.

a. Marine bivalves such as mussels
b. Sentinel fish species such as mudskippers
c. Seagrass

T036 Water quality testing experiments

Syllabus statement

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

Conduct water quality tests on a water sample.

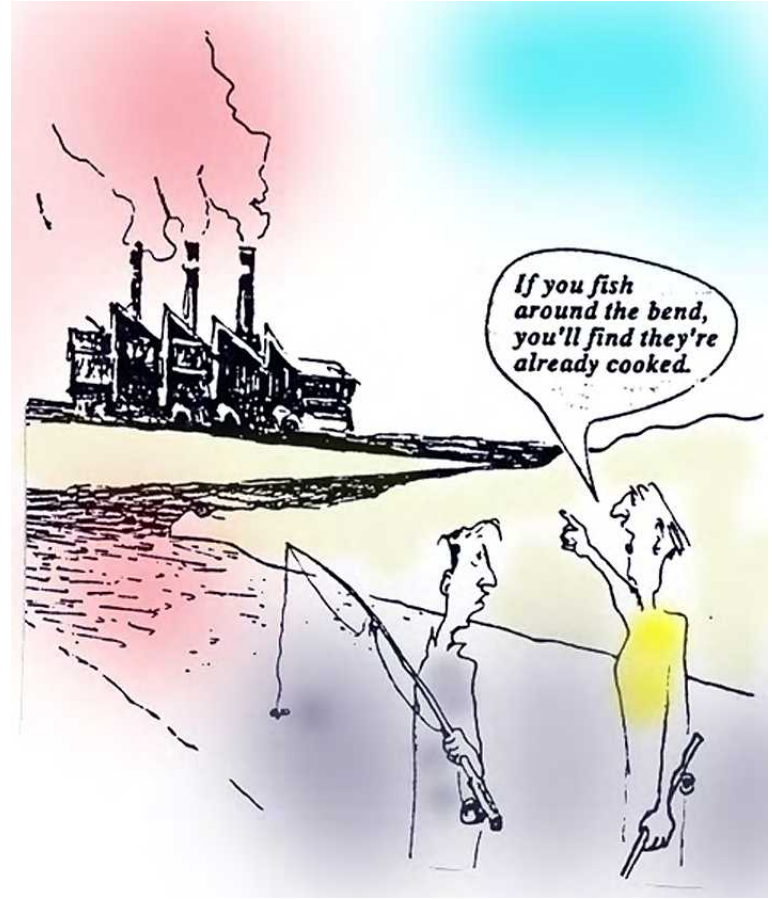
Conduct

- direct in action or course; manage;
- organise;
- carry out.

Long ago when industries were allowed to do what they liked, many young people joined forces to change the law to stop people polluting our seas and waterways with chemical and biological wastes.

These community groups used water pollution tables and indexes, to create headlines and force governments into action.

The Q tables presented here are an historic record for how these indexes were used.



They were our environmental fore bearers

- we owe them a lot and we should not forget what they have done.

A climate change rally in Melbourne on 5 July 2008

By Peter Campbell - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=4325910

Question

Use a selection of water test kits supplied to conduct the following tests on water sample collected during your field investigations to complete a Q table of water pollution ursine the following parameters. Comment on the historic nature of these tests.

Dissolved oxygen

Faecal coliform

pH

BOD

Temperature change

Phosphorus

Nitrate

Turbidity

Total dissolved solids

Dissolved oxygen

Hatch DO kit instructions
Credit https://www.hach.com/dissolved-oxygen-test-kit-model-ox-2p/product?id=7640219538#

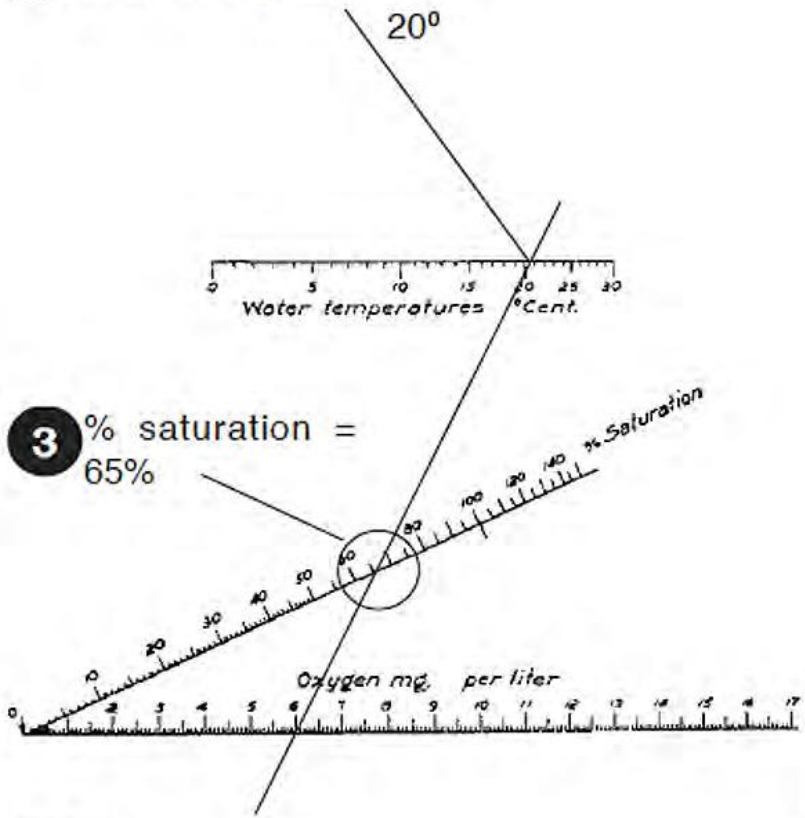

BOD Worksheet Manager
File Edit Read Hach
Save
Mark Status
Approve
Worksheet # WS-080805-0002
New
5 days later, transfer your final readings from the LBOD meter and the BOD Manager calculates your Final BODs and applies Standard Methods Criteria to the bottles.
Analyst
Seed Correction [mg/l] per ml of seed added
Seed 0.606
Notes
Sample Name
Bottle #
Sample Volume (ml)
Seed Volume (ml)
Initial DO (mg/l)
Final DO (mg/l)
Dil %
O2 Depl. (mg/l)
Seed Factor (mg/l)
BOD (mg/l)
1 Dilblank 300.00 0.00 8.00 7.94 0.06
2 300.00 0.00 8.00 8.01 -0.01
3 GGA 10.00 0.00 8.50 2.70 3.33 5.80 0.00 174.00 174
4 12.00 0.00 8.60 2.10 4.00 6.50 0.00 162.50
5 Seed 8.00 0.00 8.00 3.00 2.67 5.00 0.00 187.50 182
6 10.00 0.00 8.00 1.80 3.33 6.20 0.00 186.00
7 12.00 0.00 8.00 1.14 4.00 6.86 0.00 171.50
8 Influent 10.00 0.00 8.00 3.10 3.33 4.90 0.00 147.00 147
9 12.00 0.00 8.00 0.88 4.00 7.12 0.00 178.00
10 Effluent 100.00 1.00 8.00 5.00 33.33 3.00 0.61 7.18 7
11 150.00 1.00 8.00 4.00 50.00 4.00 0.61 6.79
12 200.00 1.00 8.00 3.00 66.67 5.00 0.61 6.59
Normal (0)
SUPER [Pending Save]
HQ440d multi
5.56
24.4 °C
HACH

How to calculate % saturation

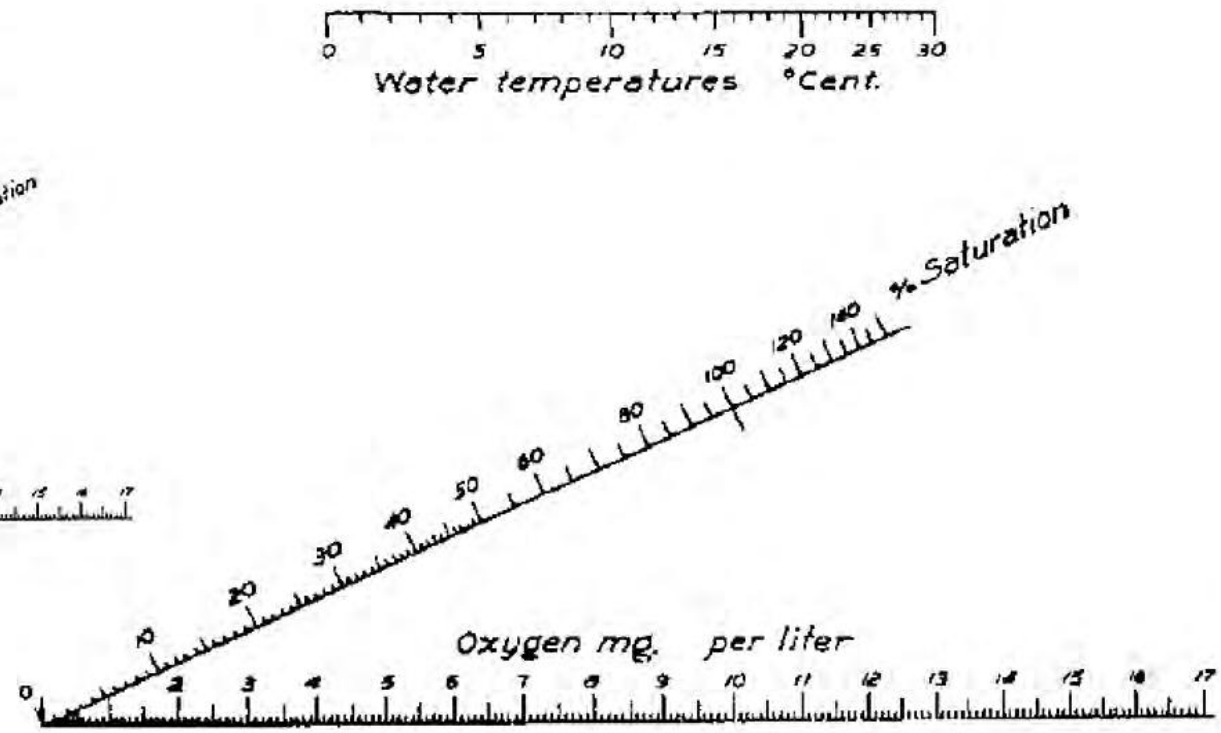
1 Water temperature = 20°

2 Dissolved oxygen 6 mgl/L

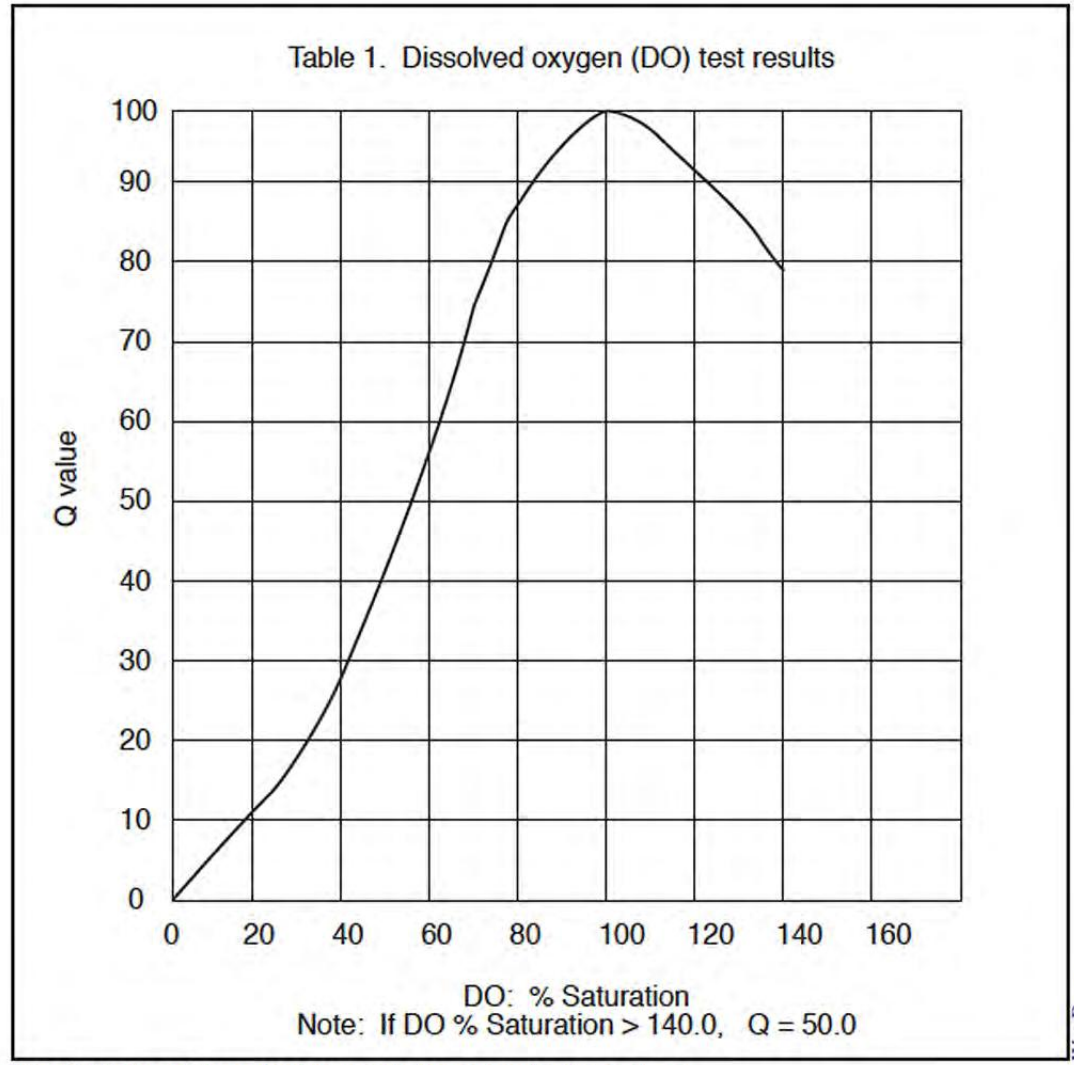
3 % saturation = 65%



Percent saturation calibration graph

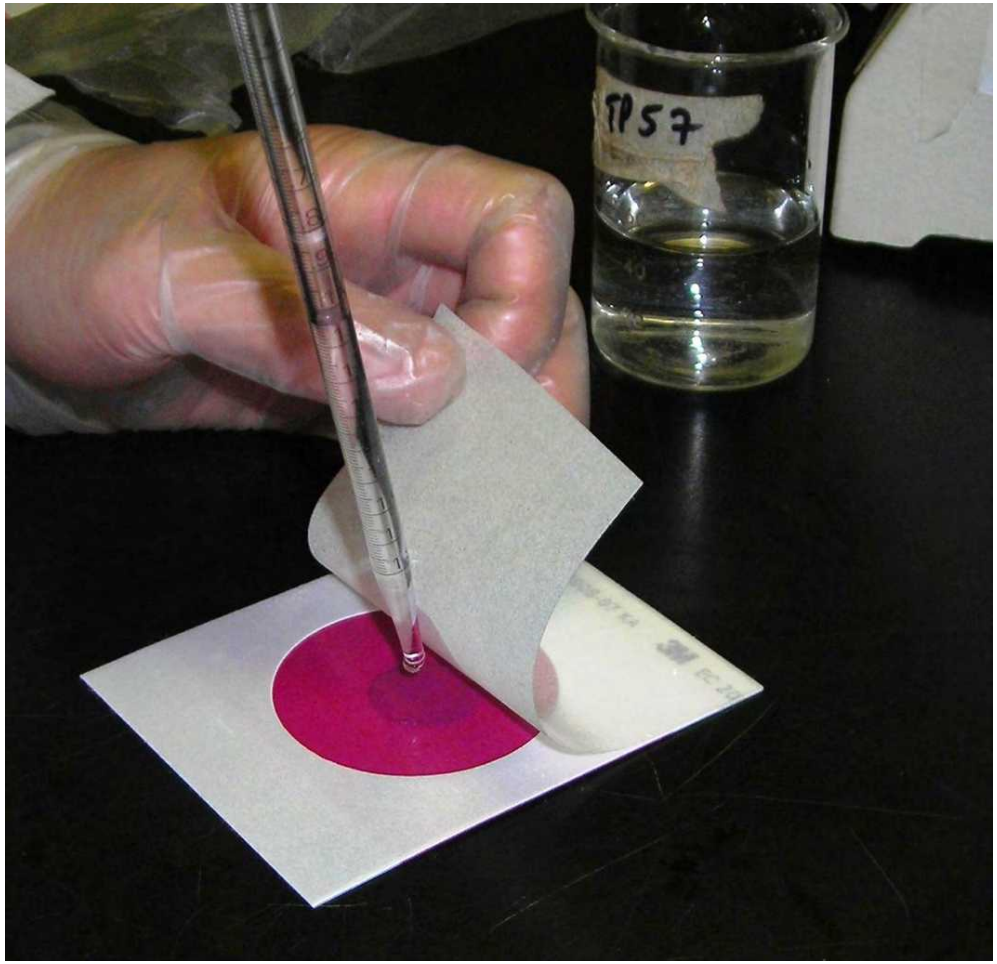


A low Q value meant the water was polluted.

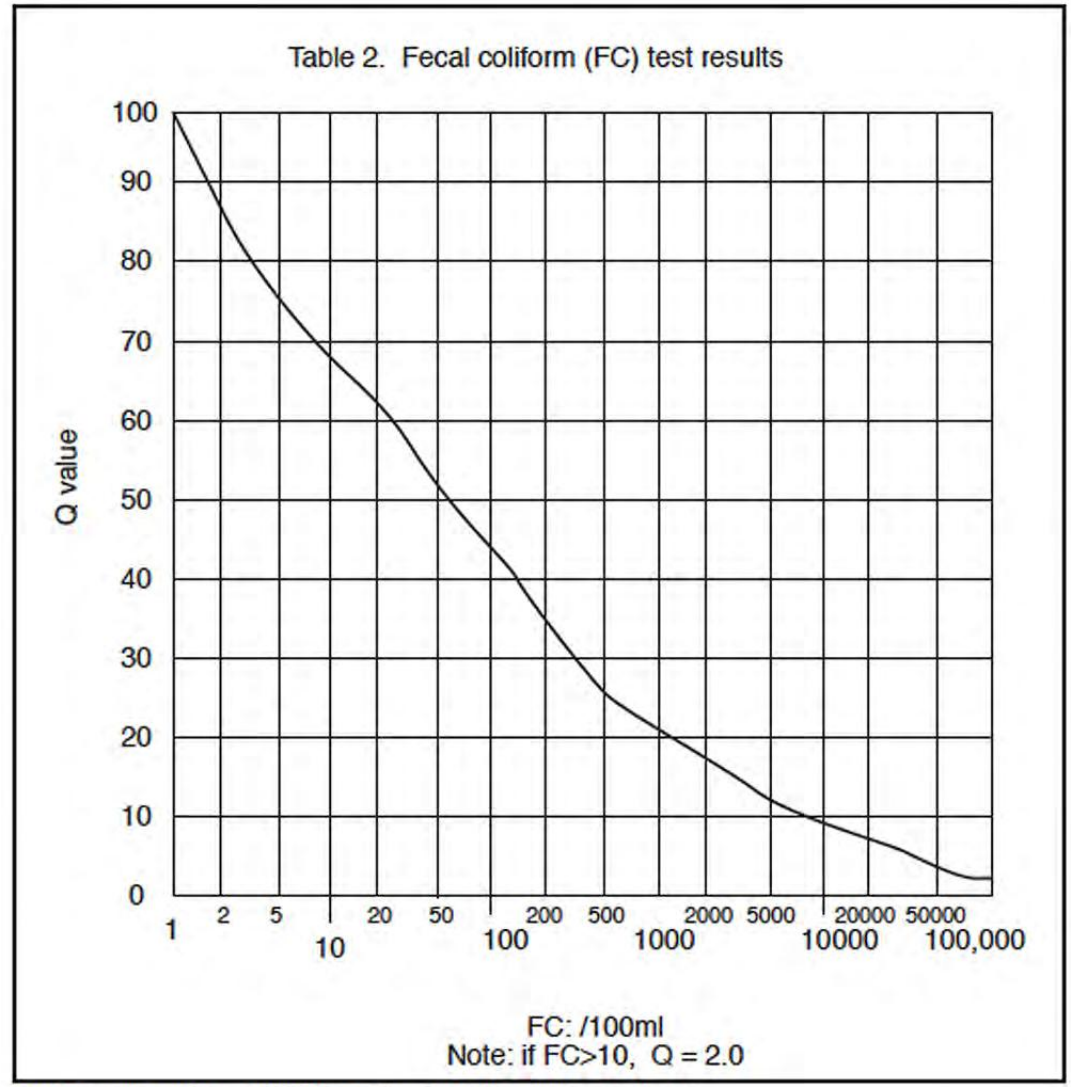


After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

Faecal coliform



A low Q value meant the water was polluted.

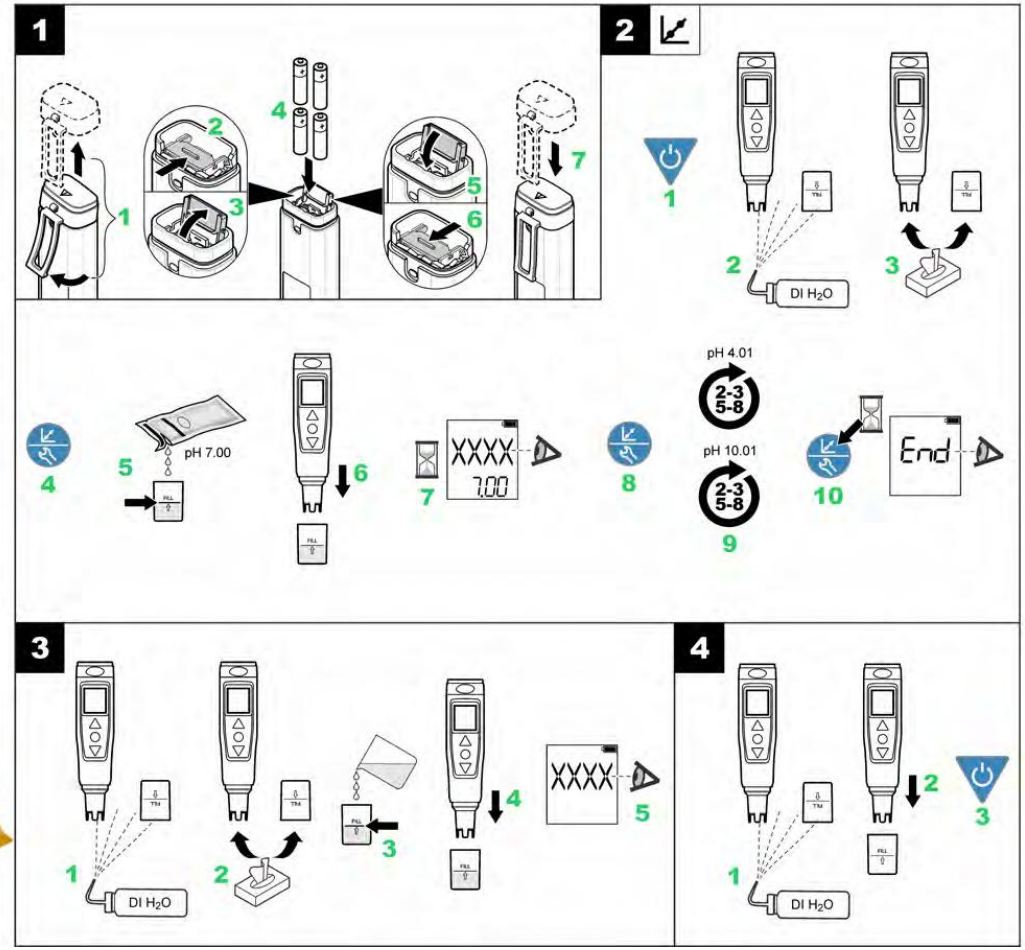


After Mitchell and Stapp (1988) Page 67. Reproduced with permission.

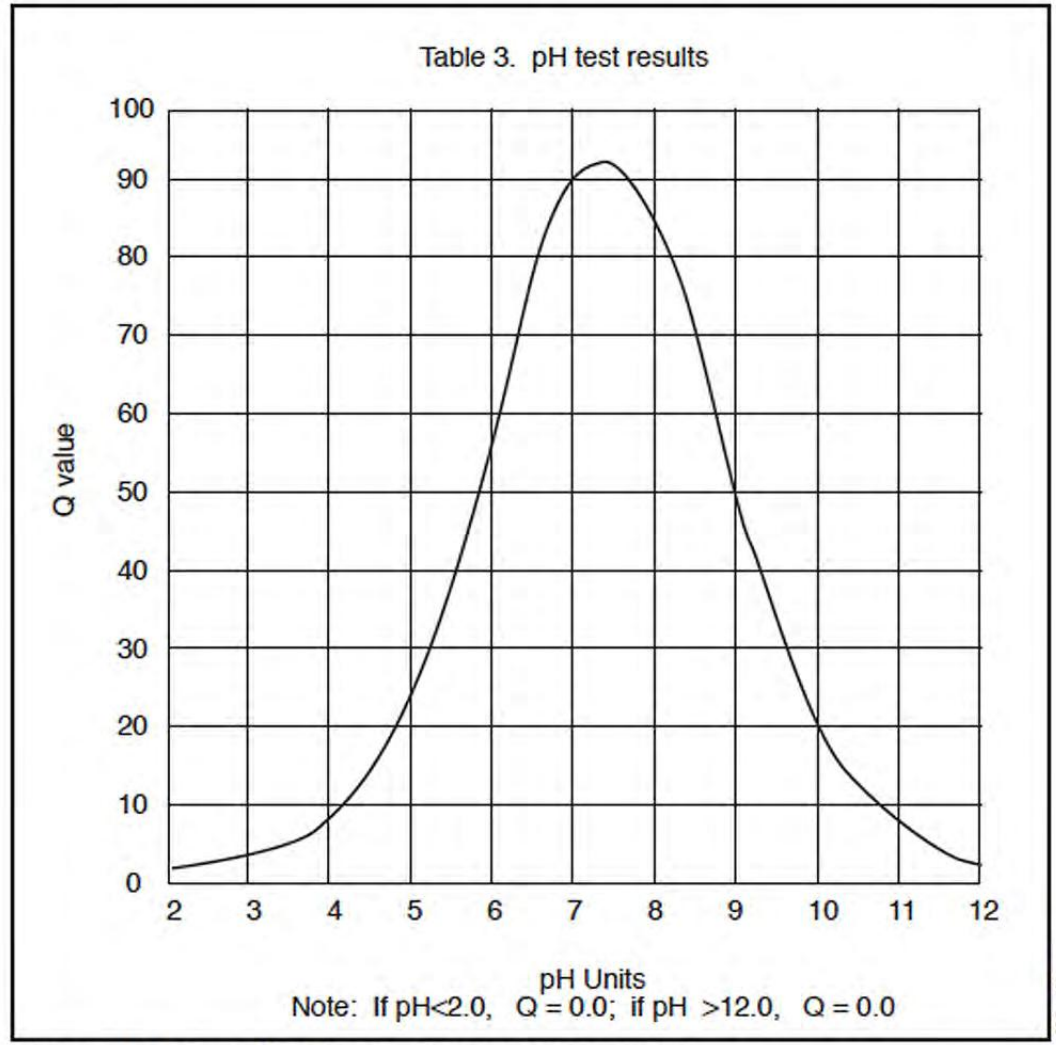
pH

pH

POCKET PRO AND POCKET PRO+ TESTERS



A low Q value meant the water was polluted.



After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

BOD

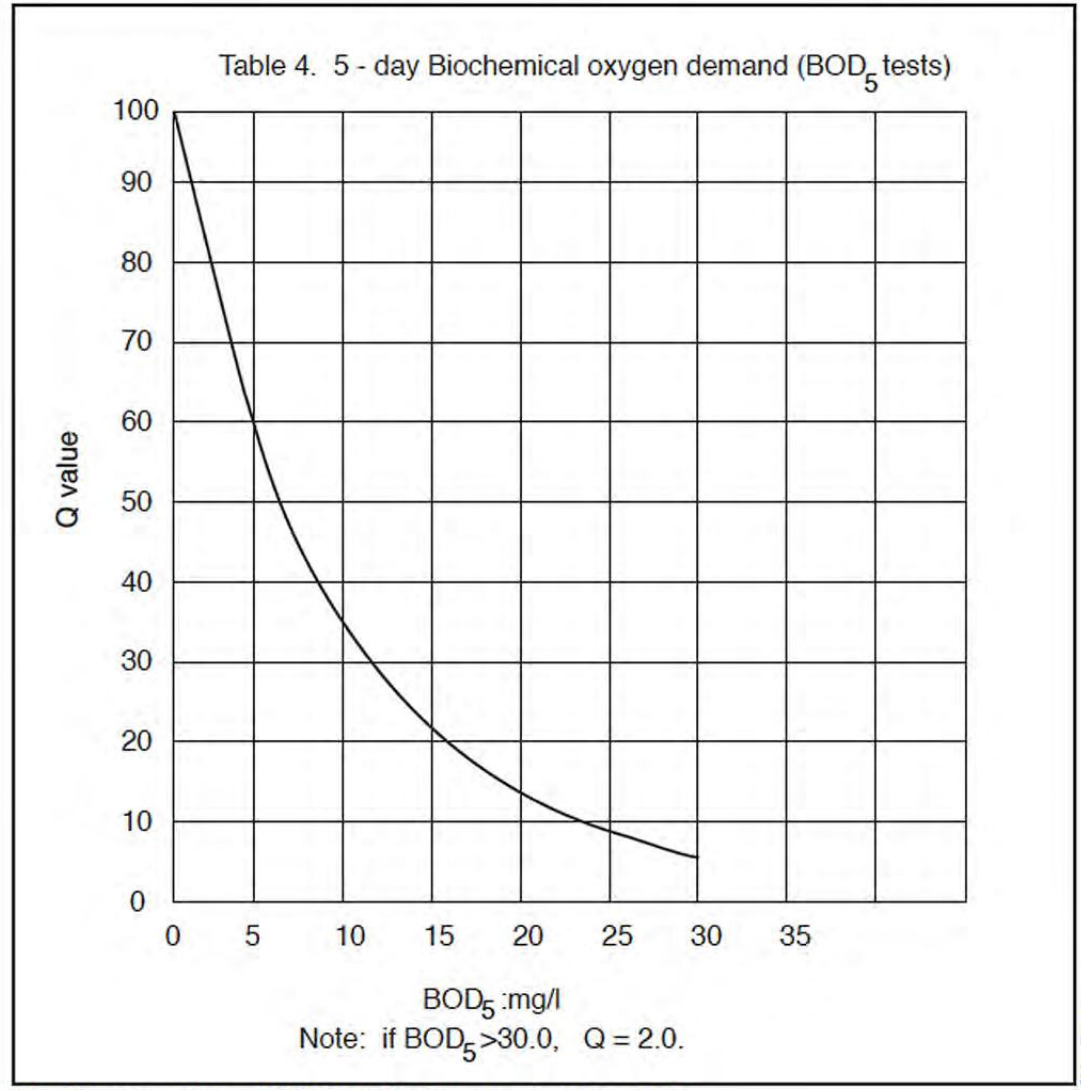
25mg/L

5 days

5mg/L

0 days

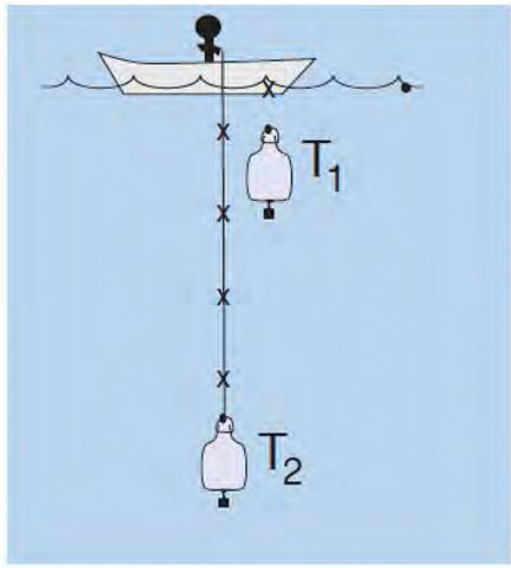
A low Q value meant
the water was polluted.

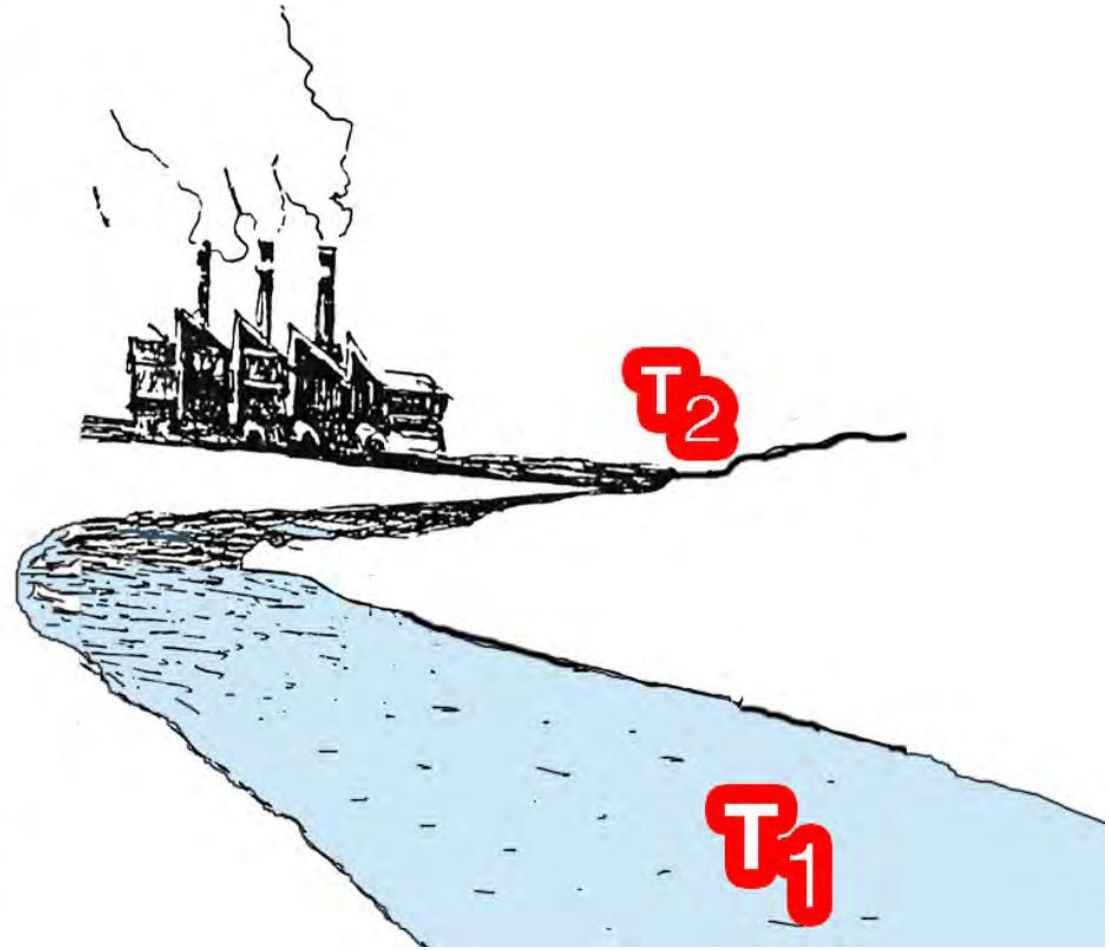


After Mitchell and Stapp (1988) Page 66. Reproduced with permission.

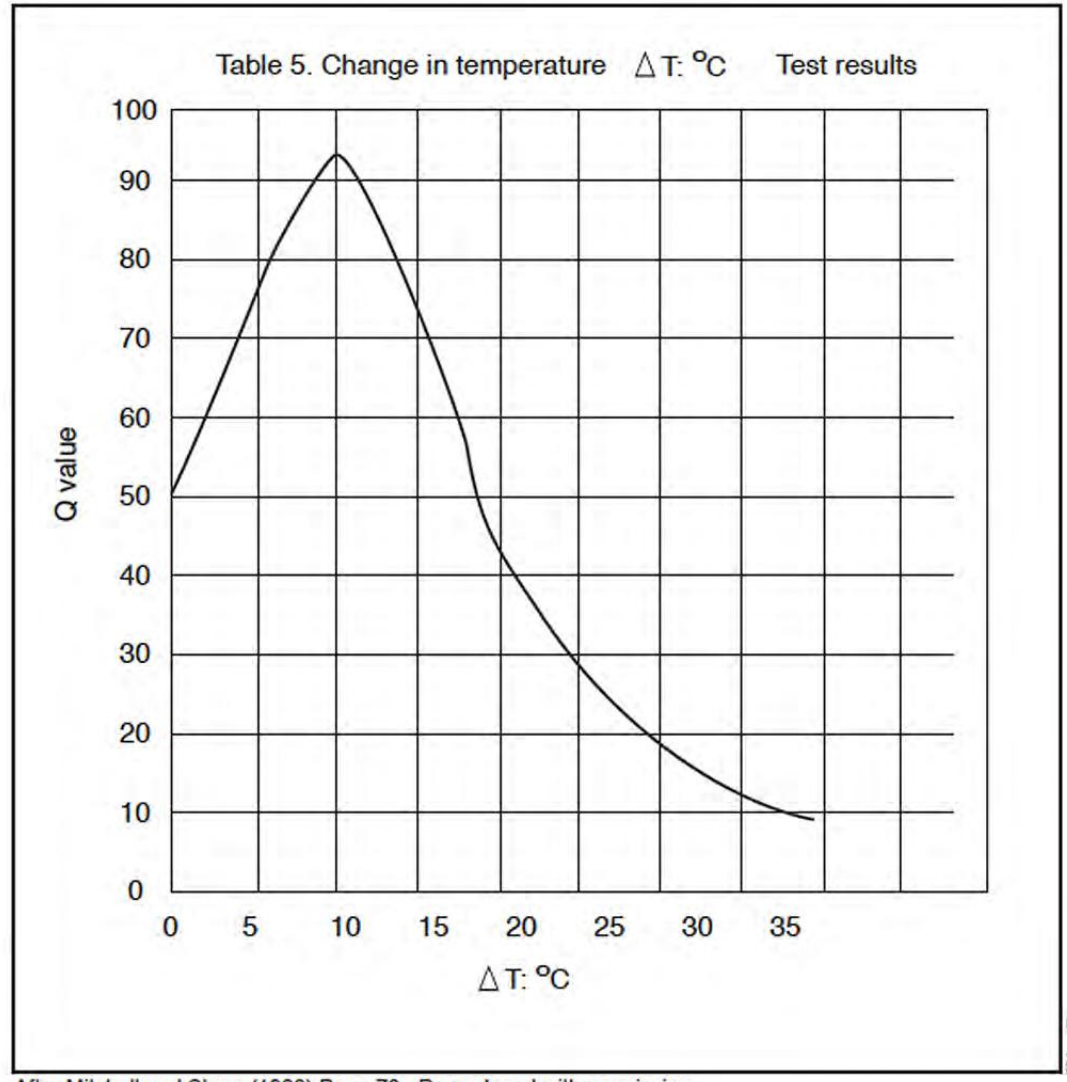
Temperature change

$$T_1 - T_2 = \Delta T$$





A low Q value meant
the water was polluted.



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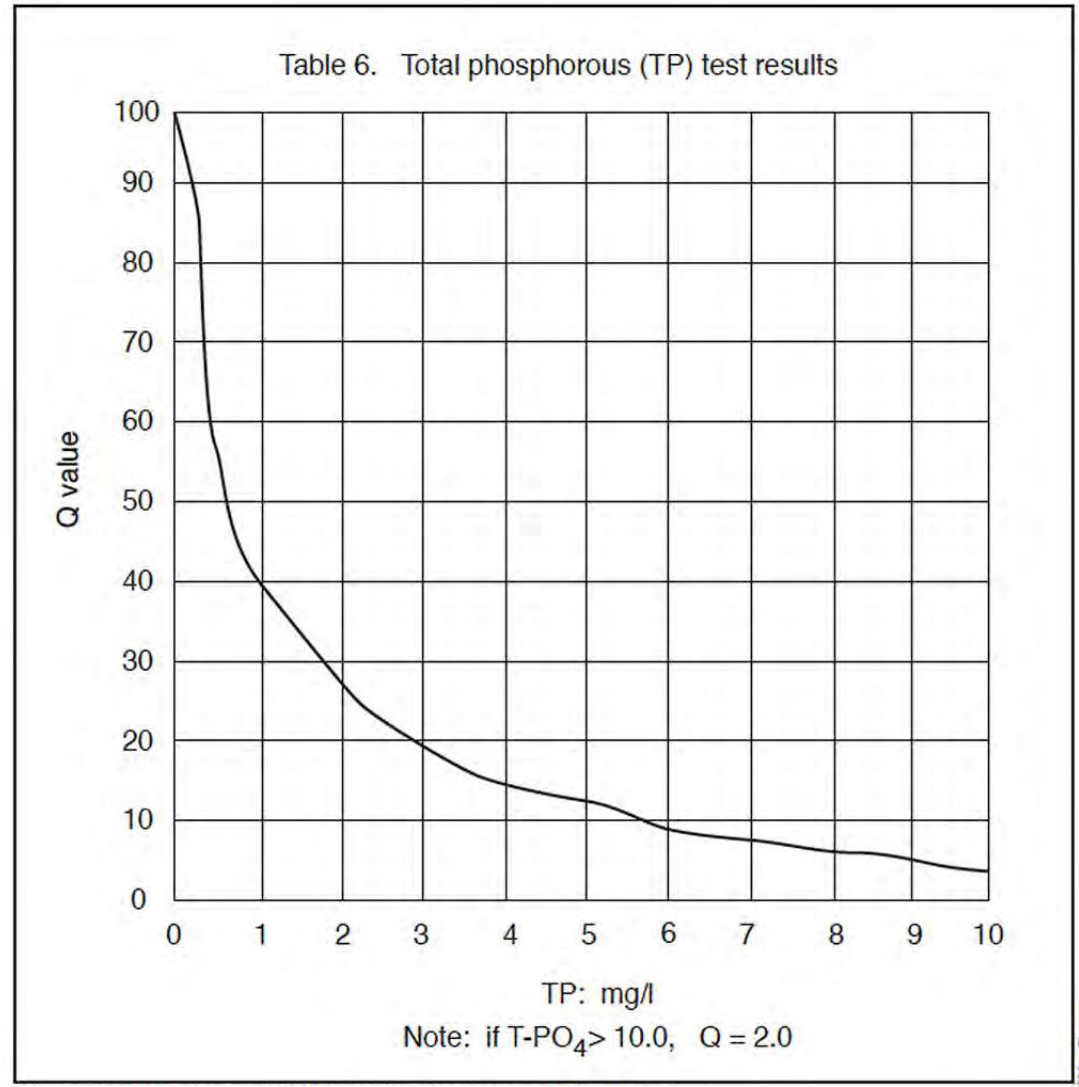
Phosphate

A low Q value meant the water was polluted.

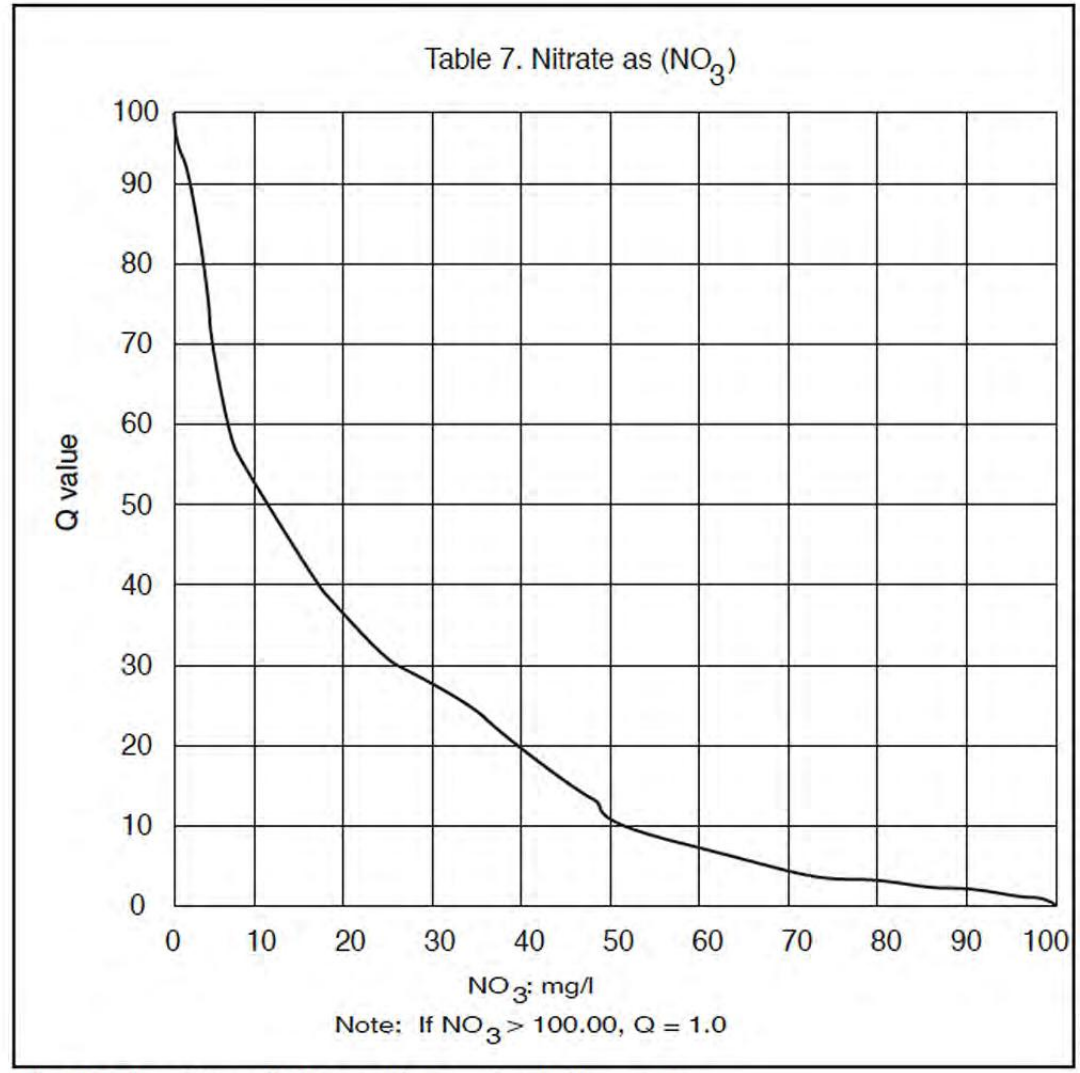


After Mitchell and Stapp (1988) Page 71. Reproduced with permission.

Nitrate


NITRATE
NITRATE TEST KIT
AQUASONIC
TEST KIT
AQUASONIC
AUSTRALIAN MADE

A low Q value meant the water was polluted.



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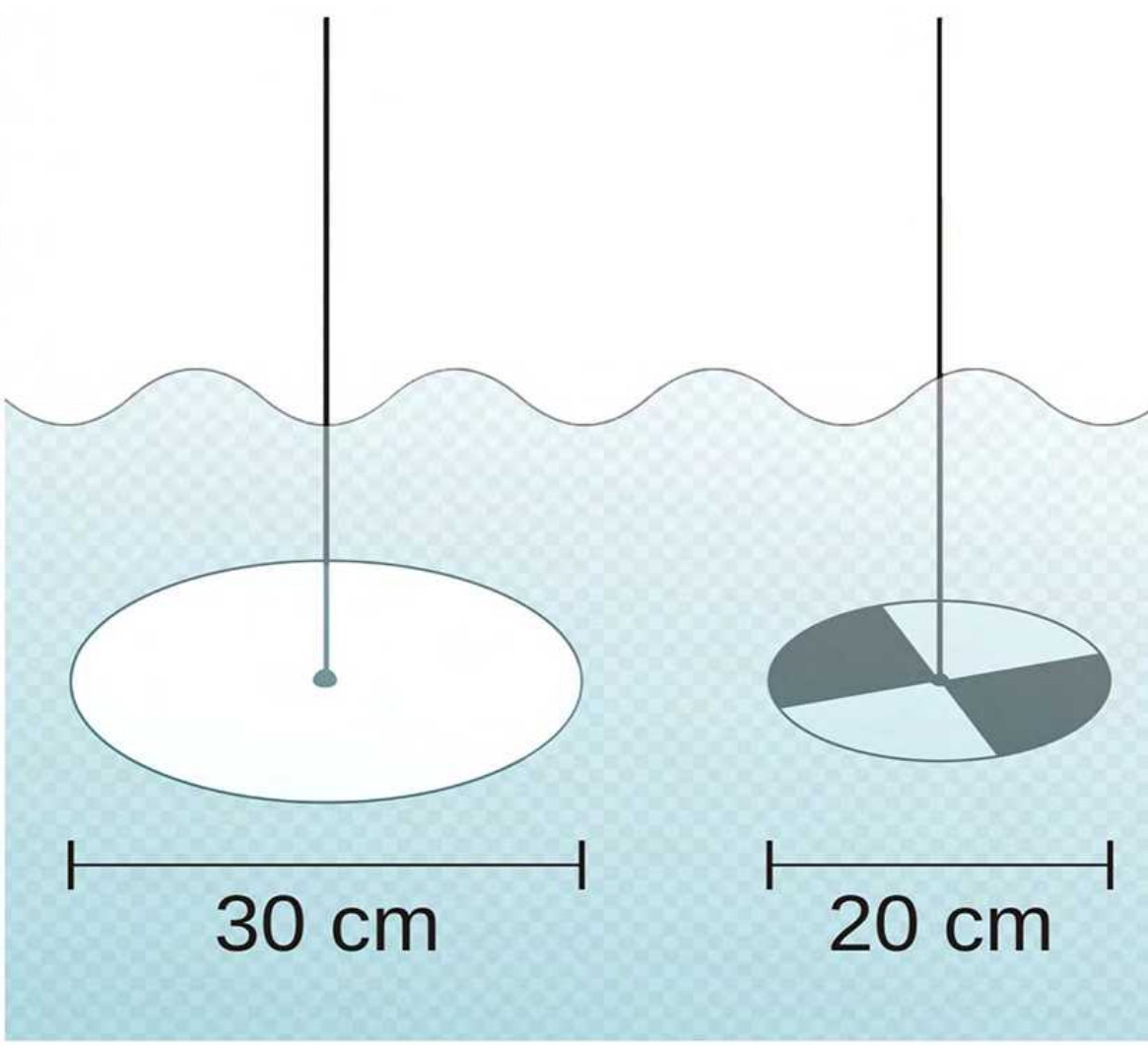
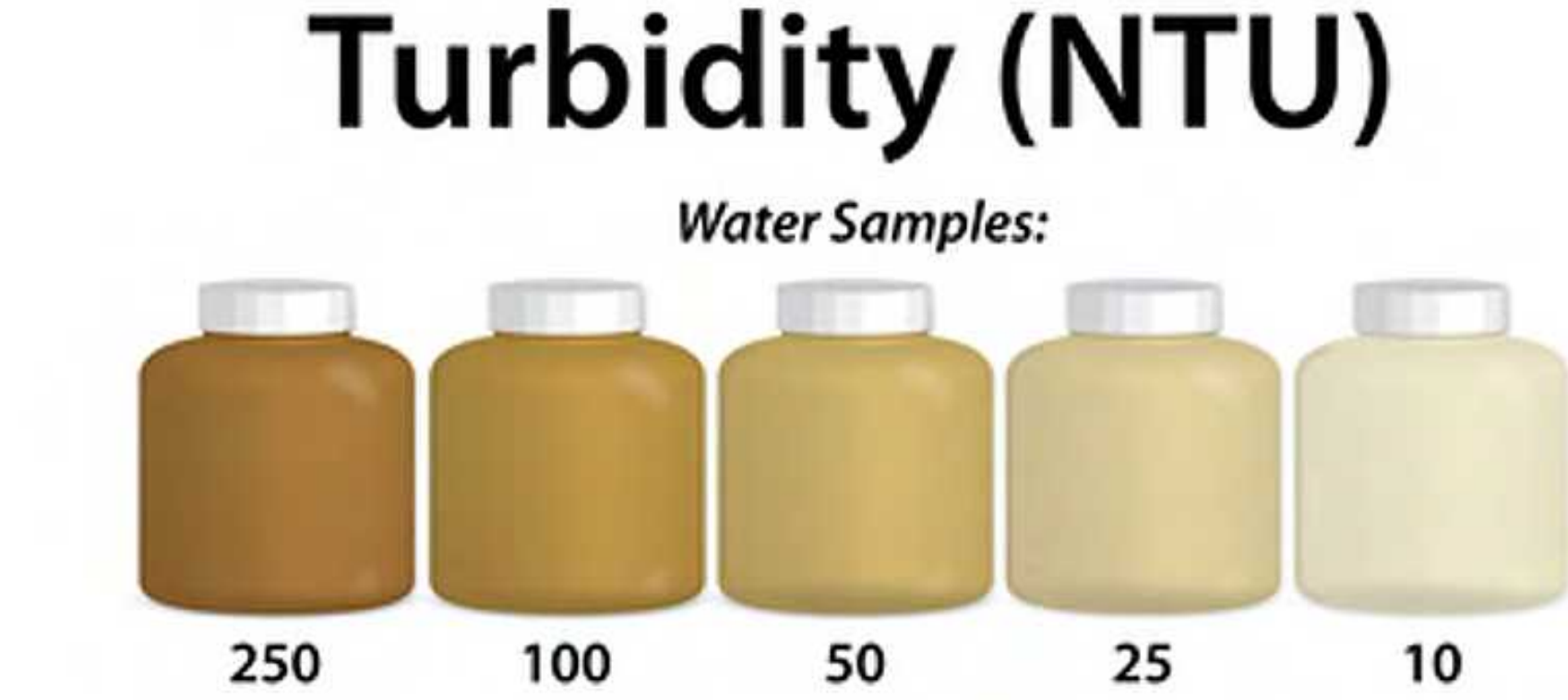
Turbidity




100
150
200
300
400
500

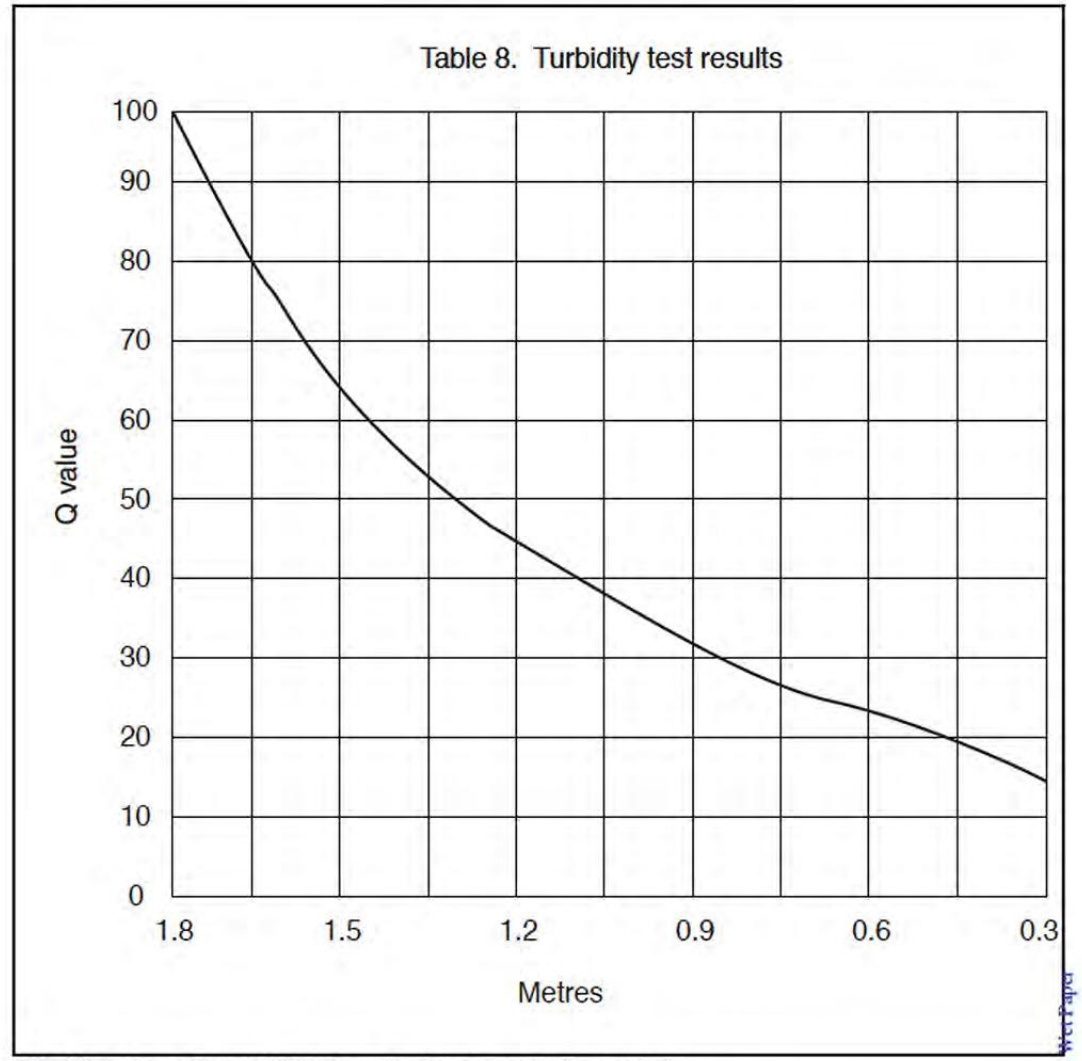

BALLINA MARINE DISCOVERY AND RESOURCE CENTRE



Turbidity NTU samples
From https://www.mrgscience.com/ess-topic-44-water-pollution.html

A low Q value meant the water was polluted.

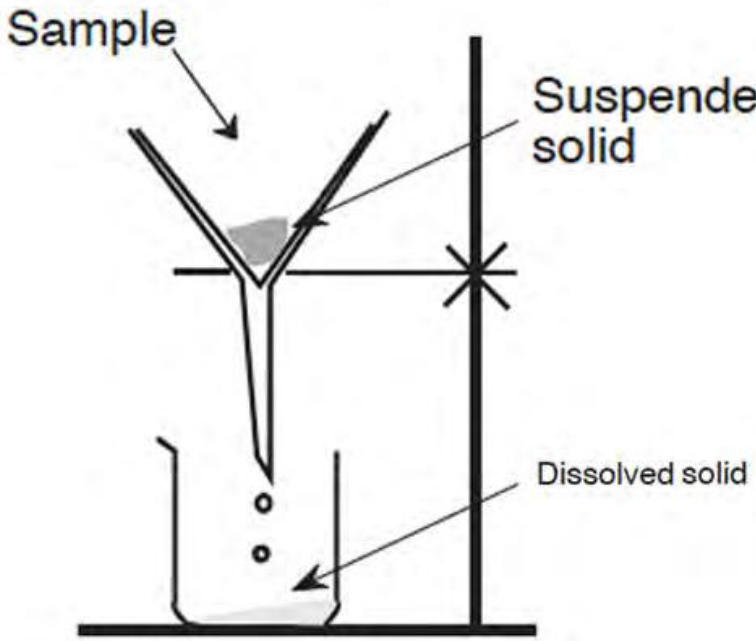
If using a turbidity tube (measures in NTU) the unit of measurement needs to be modified.



After Mitchell and Stapp (1988) Page 73. Reproduced with permission.

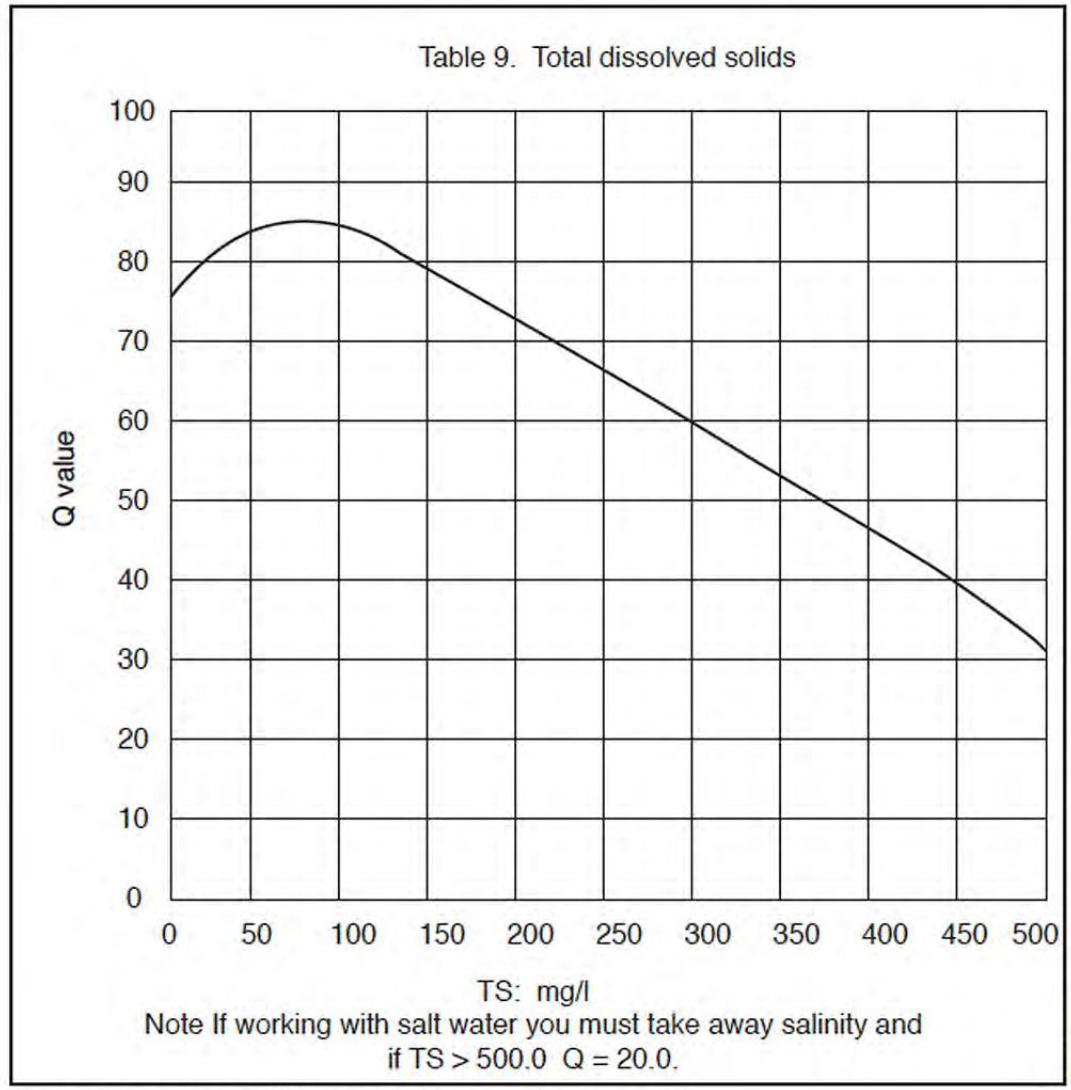
Total dissolved solids

Total solids are the suspended solids plus the dissolved solids minus the salinity



Suspended solid + Dissolved solid − Salinity = Total solids

A low Q value meant the water was polluted.



After Mitchell and Stapp (1988) Page 74. Reproduced with permission.

Collate data into a table and calculate the overall index.

Date _____ Time _____

Location _____

Weather conditions _____

Variable	Results (Column A)	Column B (From Q table)	Factor (Column C)	Column D
1. Dissolved oxygen	%		0.17	
2. Faecal coliform	colonies /100ml		0.16	
3. pH	units		0.11	
4. B.O.D.	p.p.m.		0.11	
5. Temperature	$\Delta^{\circ}C$		0.10	
6. Total Phosphorous	mg/l		0.10	
7. Nitrates	mg/l		0.10	
8. Turbidity	cm		0.08	
9. Total solids (-salinity)	mg/l		0.07	
Overall water quality index				

After Mitchell and Stapp 1988

Water quality tests and pollution

WQI values and their significance are summarised below:

- 90 - 100 excellent
- 70 - 90 good
- 50 - 70 medium
- 25 - 50 bad
- 0 - 25 very bad

Example

Variable	Results (Column A)	Column B (From Q tables)	Factor (Column C)	Column D
1. **Dissolved oxygen**	**130%**	**91**	**0.17**	15.47
2. Faecal coliform	colonies 130/100ml	41	0.16	6.56
3. pH	8.8 units	58	0.11	6.38
4. B.O.D.	6.5 p.p.m.	48	0.11	4.28
5. Temperature	+0.5 Δ°C	90	0.10	9.00
6. Total Phosphorous	0.3 mg/l	82	0.10	8.20
7. Nitrates	0.62 mg/l	98	0.10	9.80
8. Turbidity	90 cm	30	0.08	2.40
9. Total solids (-salinity)	**430 mg/l**	42	0.07	2.94
	Overall water quality index			**65.03**

Water quality measurement table After Mitchell and Stapp (Reproduced with permission)

There are also other interpretations on how to assess water quality.

The methods just described were historic involving pollution of water ways.

Community groups and activist groups formed to convince governments to legislate anti pollution laws.

To a large degree this has been a success and many of the activists from the time now have jobs in government agencies to monitor the pollution.

Modern methods look at catchment volumes of nitrogen and phosphorus as well as heavy metal pollution in harbours caused by new industries.

Levels of fire fighting pollution's from airports is a recent example.

Where will the next round of jobs come from?

One of them may be yours.

“If you know where you came from you know where you are going”.

Community/Land Manager Waterwatch Guide

A guide for community monitoring of water quality and waterway health

waterwatch NEW SOUTH WALES
Communities Caring for Catchments

NSW GOVERNMENT
Environment, Climate Change & Water

Australian Government