SEREAD

Oceans Rising?

A TEACHING UNIT FOR 13 –16 YEAR OLD CHILDREN

CONTENTS:

THIS WORKSHOP AND THE SEREAD PROGRAMME ARE SPONSORED BY:

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- National Oceanic and Atmospheric Administration. U.S.A.
- South Pacific Applied Geoscience Commission
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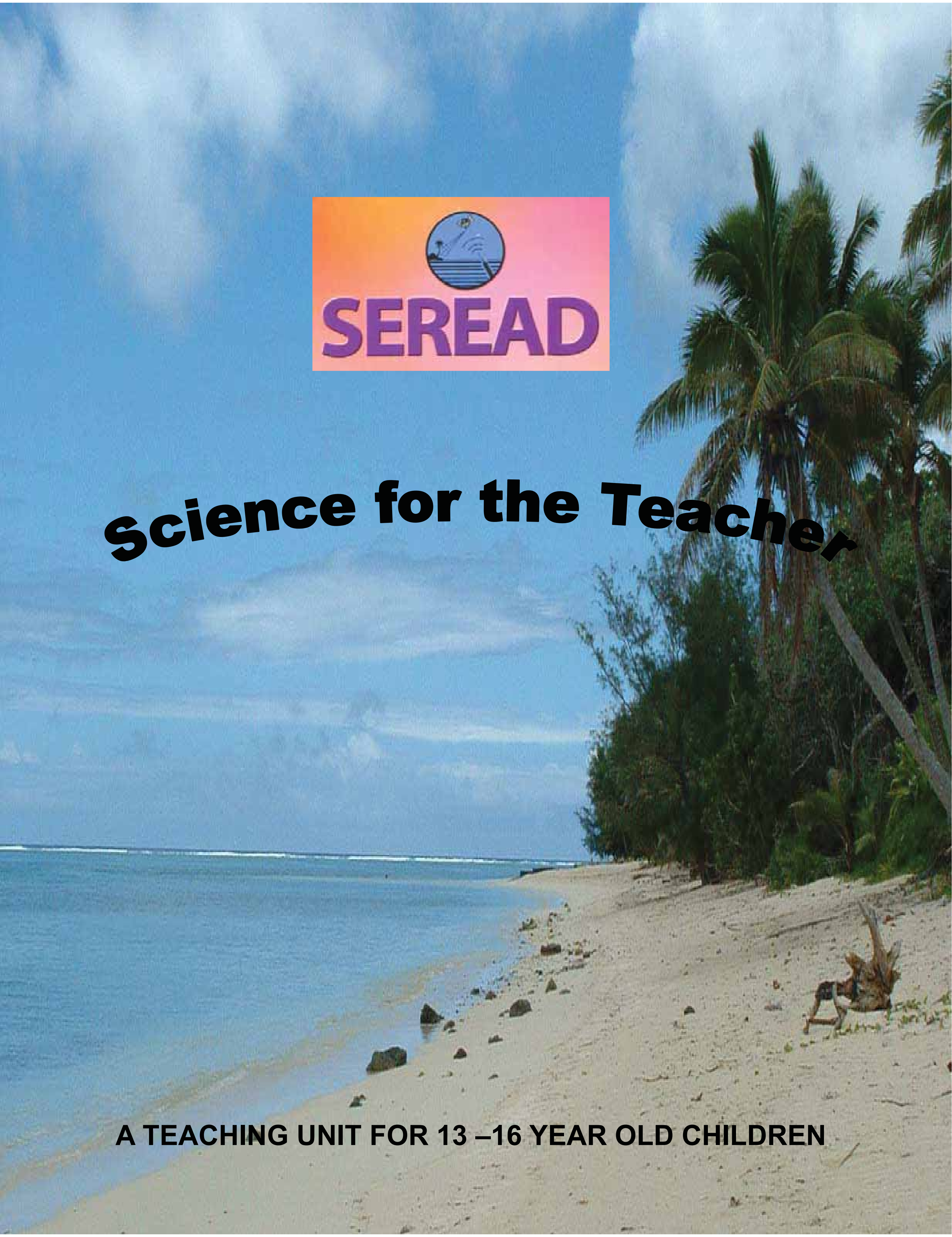


SEREAD

Science for the Teacher

A TEACHING UNIT FOR 13 –16 YEAR OLD CHILDREN

WELCOME TO SEREAD

What is SEREAD?
SEREAD is an educational programme linked to current teaching programmes in Pacific Island schools.
SEREAD stands for Scientific Educational Resources and Experience Associated with the Deployment of Argo. The Argo Project is a series of ocean floats that move up and down vertically through the water and the information they provide is used to help understand the changes taking place in today's climate.

The goal of SEREAD

The goal is to help generate awareness, discussion and an understanding of the ocean's role in the climate system. Climate changes can take place over months or years. The key to understanding change involves the role of the water and energy cycles in the tropical marine climate of the Pacific Islands.

SEREAD's objectives are to:

- Provide teaching resources that complement current teaching curriculum and demonstrate the value of scientific knowledge through realistic and locally relevant applications.
- Teach students about the fundamental measurements that are used to describe and measure changes in climate.
- Help teachers and students to understand how scientists use data.
- Provide opportunities for interaction between scientists and teachers.

In this Workshop the topics will be:

Argo floats: What they are, how they work and the information they provide.
Understanding climate change and the Island Climate Updates.
Introducing the Teaching Programmes.
Unit Studies for Lower Secondary Teaching.

Goals of the SEREAD the workshop:

To provide teachers with practical classroom materials and resources that they can take away with them for use in their classrooms.
Develop teacher's knowledge of climate change and the role of the ocean.

WHAT CAUSES THE SEA LEVEL TO CHANGE?

Water is a fluid. You can squeeze it. You can make it flow from one point to another. Put it in a container and it will adopt the shape of its container. Since water can be so easily influenced, maybe we can picture the oceans as one very large bowl of water.

Using this idea we will try to see the influence of change on our planet caused by the forces associated with gravitational pull and the expansion heat energy causes on the ocean.

Some of these changes will take place over both long and short periods in time.

Some changes are noticeable and occur as a regular event, other changes are more irregular and can be the result of weather. Some are not so noticeable and take place over long periods of time.

REGULAR EVENTS

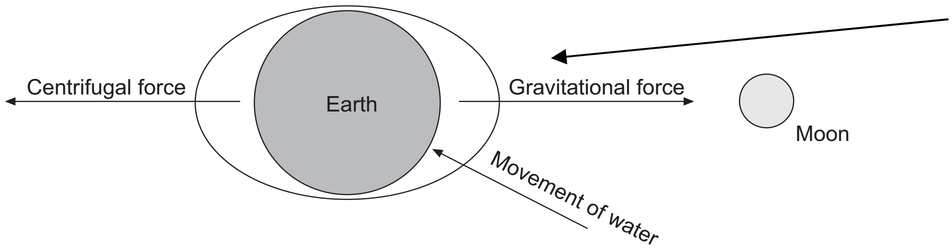
To start with perhaps the most regular of change we are all aware of are the tides.

THE TIDAL WAVE, OR AS IT MORE COMMONLY KNOWN, TIDES.

Tides are a wave, one that happens to have a very long wavelength. What we see is the result of the interaction of the moon and sun's gravitational forces on this planet. Fluid materials like water are the most responsive to these forces and that is why we see the water levels respond to the attraction of the sun and moon. Isaac Newton was one of the first people to attempt an explanation of tides in terms of gravitational forces, way back in the 17th century.

Why is the tidal movement like a wave?

The moon orbits the earth and as a result of its orbit there is a bulge of water resulting from the attraction of its gravitational field towards it. There is also a bulge of water in the opposite direction to the gravitational force as a result of the rotation of the moon and earth system. This bulge is created by the centrifugal force of the rotating system. (It’s the same force that keeps the water in the bucket when you spin it around over your head! Try it!!!)



The centrifugal force balances the gravitational force resulting in equilibrium and the two tidal bulges.

This water, in effect, is being dragged around the earth as the moon rotates on a regular time basis. Each moon orbit takes roughly 24 hours. So in effect we have a wave that is travelling slowly around the earth. The time between each wave, called its period, is a little over 12 hours. If the island is big enough there is always somewhere where there is a high tide. Rather like a Mexican wave going round a sports stadium.

DIAGRAM SHOWING THE EFFECT OF GRAVITIATIONAL FORCE AND CENTRIFUGAL FORCE ON THE EARTH’S OCEANS

You may notice that successive high tides do not coincide exactly by 12 hours. In fact the difference is usually about 12 and a half hours. The reason for this is the lunar day is actually 24 hours 50 minutes.

Why does this happen? The Moon revolves about the Earth every 27.3 days, and in the same direction as the Earth spins upon its axis. This provides a lunar day of slightly longer than 24 hours, i.e. 24 hours 50 minutes.

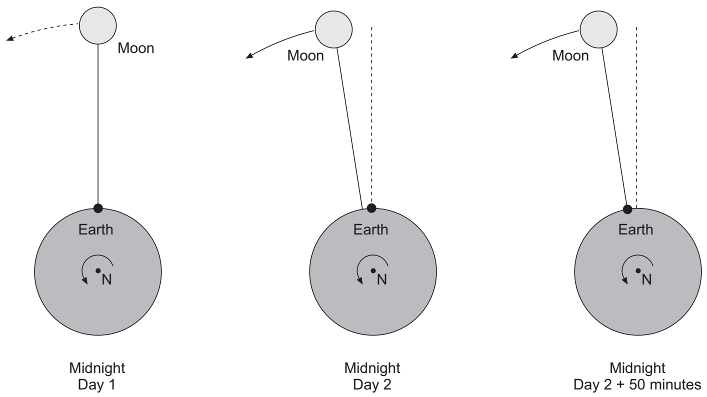


DIAGRAM SHOWING THE ROTATION OF MOON RELATIVE TO EARTH OVER THE 24 HOUR DAY

Other variations in tide height level are caused by the Sun's gravitational force and the Moon's declination, (tilt angle).

The Sun's Gravitation Force has a considerable effect on the tides. Although further away, the Sun is certainly more massive in size. It can therefore play its part in influencing the sea level. Since the earth rotates over a 24 hour period, the sun produces two daily tides 12 hours apart.

When the moon is in conjunction (in line) with or opposing the sun, the gravitational forces of the sun and moon combine to increase the size of the tidal bulge. These large tides are known as Spring tides.

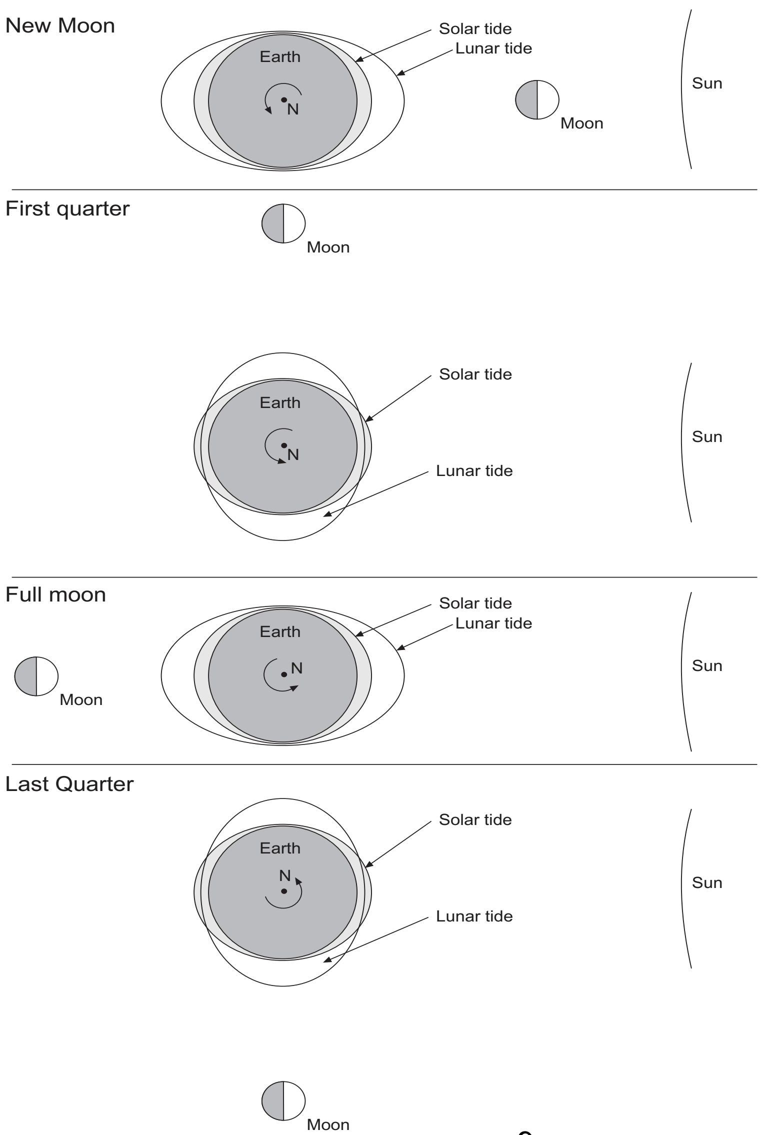


DIAGRAM SHOWING THE SPRING – NEAP TIDE CYCLE RELATION TO PHASES OF THE MOON.

When the Moon is out of phase with the Sun, the tidal heights are smaller. The gravitational forces of the sun and moon work to oppose each other. These tides are called Neap tides.

Everything so far has assumed that moon orbits around Earth's equator. This is not true. In fact the Moon orbits Earth at an offset angle of 23^0. This is called the angle of declination. The effect is that we see the Moon rise and set in a succession of different paths over the month rather like the Sun does over the year. We also see that the tidal bulge is offset and tide heights will change.

This provides the reason for the differences in tide heights over the day.

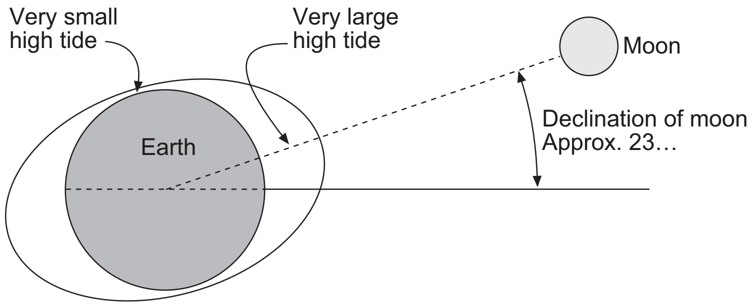


DIAGRAM SHOWING HOW THE MOON'S DECLINATION ALTERS TIDE HEIGHT.

There are other natural factors that influence sea level.

Apogee and Perigee:
The moon's orbit, besides being offset, is not circular but an ellipse. This means we have an increased gravitational force when the Moon is closest to the Earth, the perigee. in its orbit, as compared to when it is the furthest distance away. This is called the apogee. The difference in distance amounts to a 40% difference in gravitational force between the two positions, and successive perigees occur every 27.3 days.

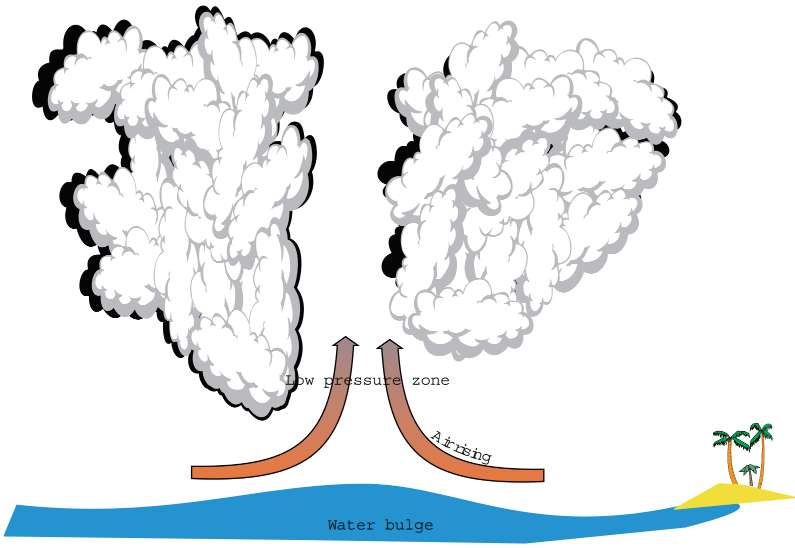
So when the moon is closer its gravitational effect on the earth is that bit larger. Since the oceans are the most easily influenced by the gravitational force, the tide heights will alter with the increase and decrease of this distance.

IRREGULAR AND SHORT TERM EVENTS

Storm Surge:

Weather can affect sea level and produce tides that are out of the ordinary. If a deep low-pressure zone such as a Tropical Cyclone is passing over, at the same time as a high tide, it can severely increase the height of the tide. Once again this is due to water's fluid behaviour and the ocean effectively expands (occupies more space) under less air pressure.

DIAGRAM SHOWING THE OCEAN WATER BULGING UNDER A LOW PRESSURE ZONE.



Combine this with the effect of storm driven waves and the result are islands being swamped far inland by seawater, as was seen in Niue 2004

Tsunami:

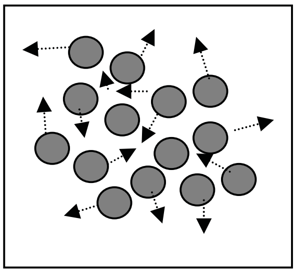
These are waves, which can travel at high speeds and carry a deal of energy. They are caused by seismic activity like earthquakes and volcanoes on the sea floor.

Movement caused by earthquakes in the earth's crust under the sea floor creates seismic "energy waves". This energy is carried as a wave by water over very long distances. As the wave approaches land, the sea gets shallower and the effect is to create an increase in the height of the travelling wave, and a subsequent surge.

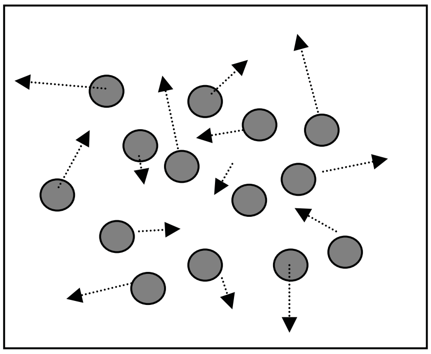
LONG TERM EVENTS: HOW DOES HEAT EFFECT THE OCEANS?

The Greenhouse effect or global warming is not just having an effect on our atmospheric conditions e.g. air temperature and weather, but also ocean temperature. Just as the sun's energy is absorbed by the atmosphere, so it is also by the oceans. Water warms up more slowly than the air, the reason being water's much higher heat capacity or ability to store more heat energy. This means that global warming is going to be seen over the long term in the oceans.

The question is then, how is this heat energy held in the ocean? Heat energy is transformed into kinetic energy of water molecules, that is movement. The more heat energy that is transformed into kinetic energy the faster the water molecules will move around. Therefore, the heat energy is held internally by the water molecules. This is what we measure as temperature.



Particles moving around at a low temperature



The same particles moving around at higher temperatures. Notice they also occupy more space.

Besides the observed increase in temperature, the increased movement of the water molecules means that they need more space to move around in. This we see as expansion.

The next question is, how much heat energy can the oceans hold and what changes are taking place as a result?

Heated water expands. If there was to be a one degree temperature rise spread throughout the whole ocean to its full depth, this would correspond to sea levels rising approximately 80cm. Just think, could that happen? What would it mean?

We need to develop a picture to see what is going on, and work out what changes are going on in sea levels. Satellites provide one part of the story. The satellites look down from above and measure the surface temperature of the ocean, and sea level changes through the year. This helps establish a pattern that relates to the seasons.

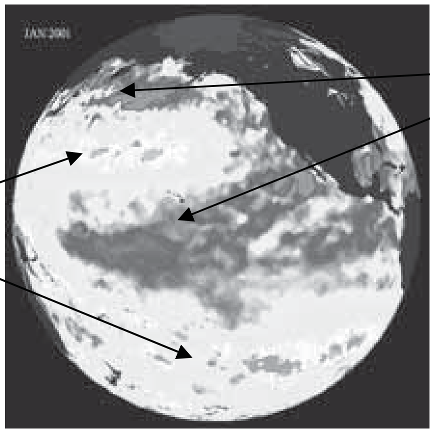
The type of information obtained by satellite is shown on the next page. They can be found on associated N.A.S.A web sites. By continuous monitoring over a period of time it is possible to assess what long term changes are taking place in surface ocean temperature.

The problem is that satellites may show what happens on the surface, but what happens beneath?

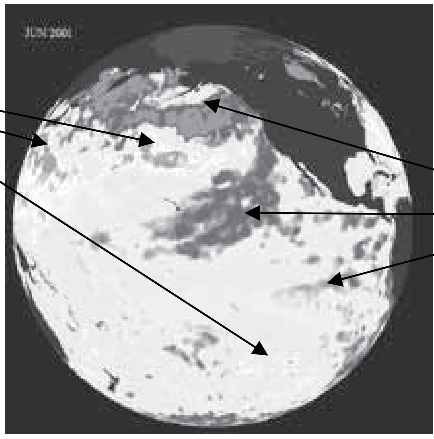
Knowing what happens below the surface is important if we are to understand how the heat energy is distributed and the changes in sea levels that will result.

THESE PICTURES ARE TAKEN FROM SATELLITE PHOTOS WHICH SHOW SURFACE TEMPERATURES ACROSS THE PACIFIC DURING THE YEAR 2001

JAN 2001

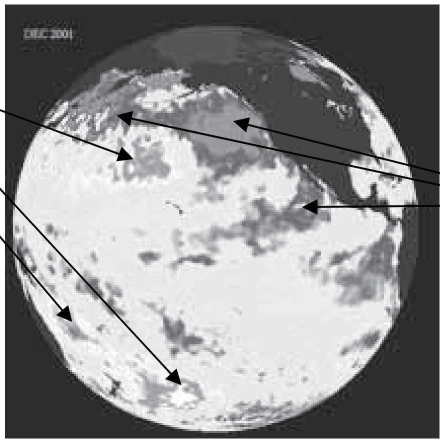


July 2001



You can see how the bands of cool and warmer water change through the year. These bands correspond to the seasons.

December 2001



One of the most effective means of measuring ocean temperature below the surface is by using the Argo floats. They aim to tell us what is going on from deep water to the surface.

Question: Does water temperature remain constant to the bottom, gradually get colder or are there layers?

The answer depends naturally on ocean depth, but there are characteristics that firstly indicate a decline in temperature with depth with some evidence of layering.

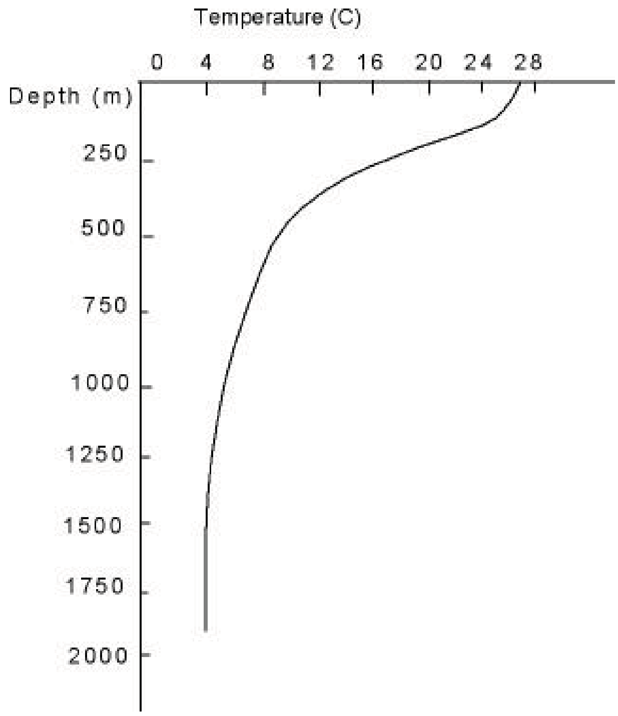


DIAGRAM SHOWING A TYPICAL TEMPERATURE PROFILE FROM AN ARGO FLOAT

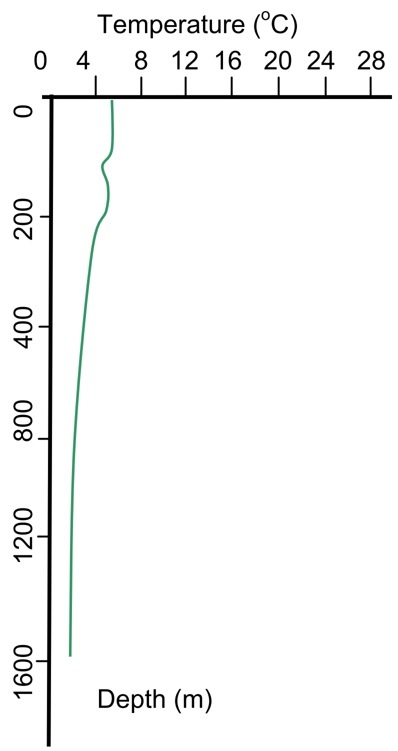
This is known as a thermocline.

The part showing the temperature change (above roughly 300m) is known as the mixed layer.

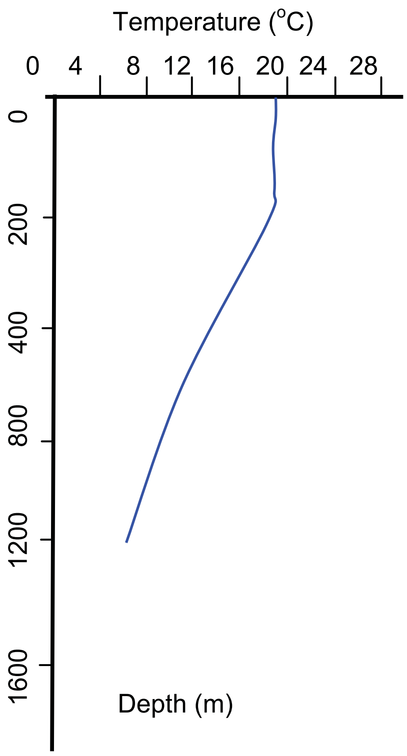
The main method of distributing the heat energy in the ocean comes through the action of wind. The turbulence created by the wind carries the heat energy deeper. But below 1000m the profiles are fairly constant and cold with temperatures in the range of 0 to 5°C.

Different locations have different characteristics.

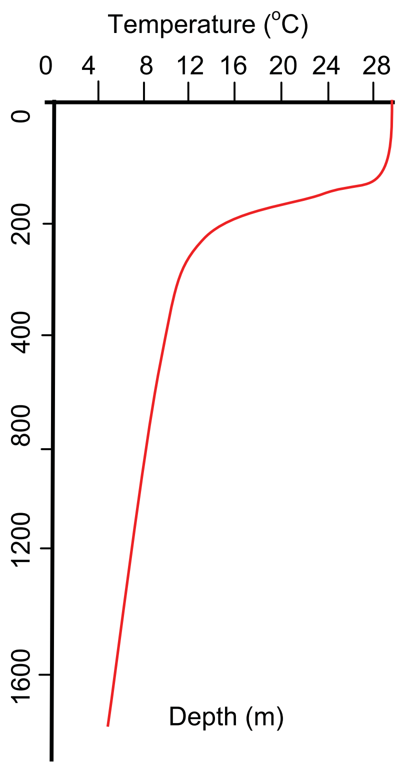
These profiles show thermoclines for equatorial, mid and polar regions.
(The longitudes were in the region of 170 – 180°E)



Profile from latitude around 60°S in the Southern Ocean.



Profile from a latitude around 35°S in the region of the Kermadec Trench

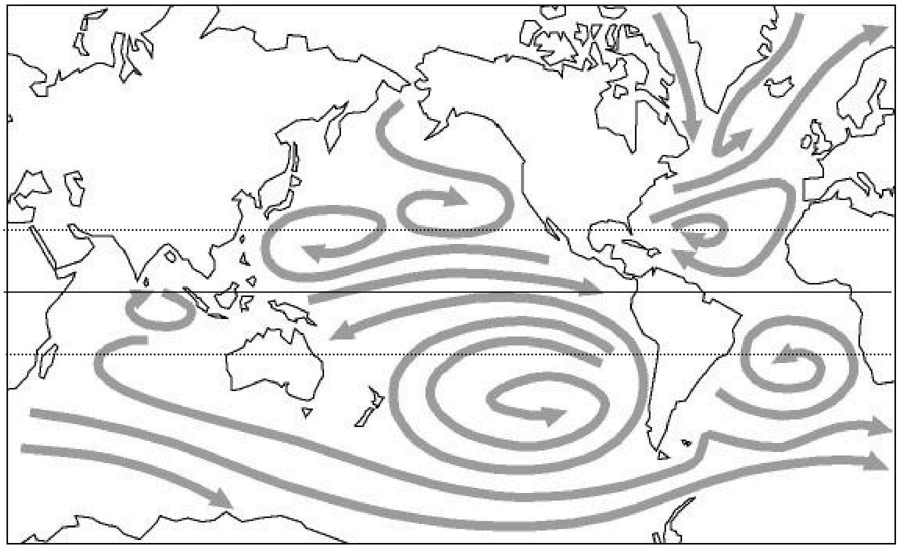


Profile from a latitude close to the equator in the region of theTokelau Islands

Ocean currents can also be seasonal. Mid latitudes in particular will show variations due to the seasons such as summer heating, winter cooling. Wind speeds and directions will have their effect on the temperature levels in the upper layers, and the extent to which the heat is distributed to the lower layers.

DIAGRAM SHOWING SOME OF THE MAIN SURFACE CURRENTS THAT ARE IN PART WIND DRIVEN.

This gives an indication of the direction heat energy will be carried



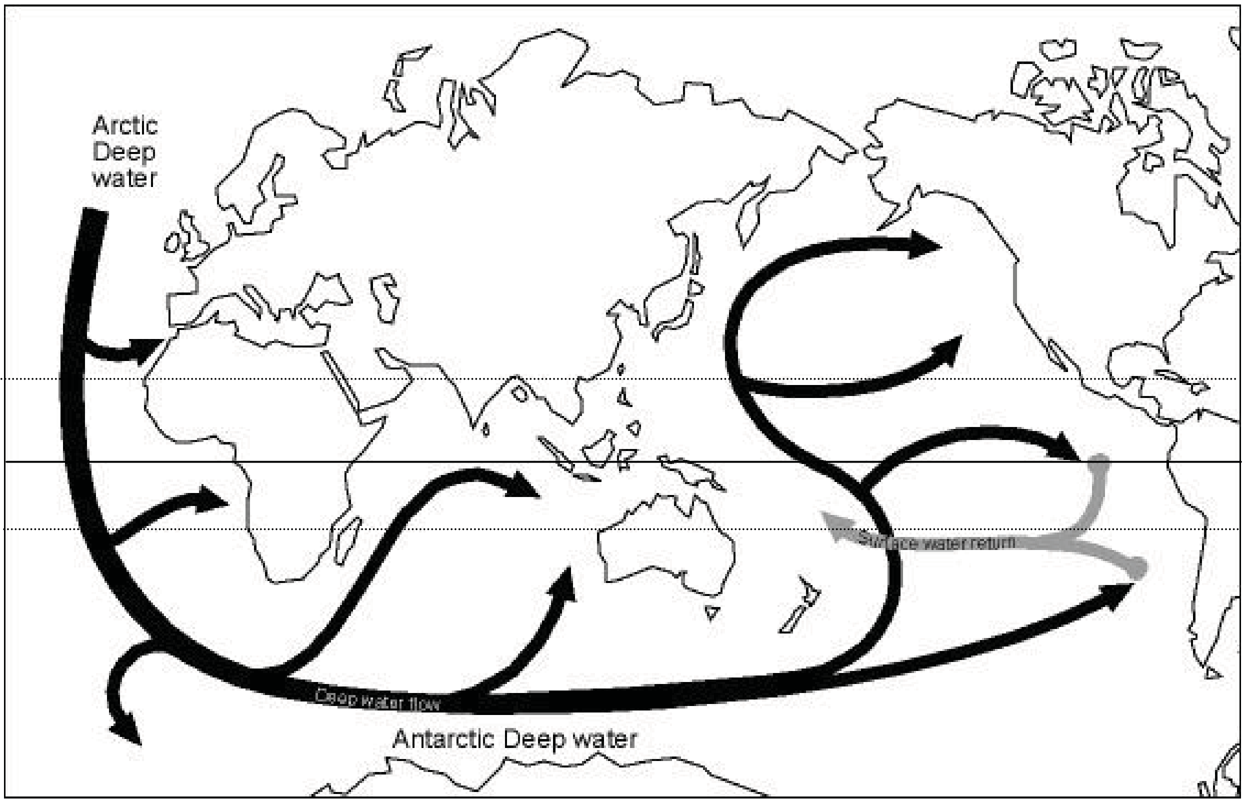
Very low temperatures are maintained at depths throughout Earth's oceans. It is the cold water sinking in the Polar Regions that causes this.

The question is why does this happen?

Cold water is denser and sinks. As it sinks it moves slowly along the ocean floor towards the equator, driving the deep ocean currents. These deep ocean currents will eventually reach the surface as they follow the sea bed. The movement up to the surface is called upwelling.

There is one such current that has a major effect on the climate in the Pacific. This upwelling exists off the coast of South America.

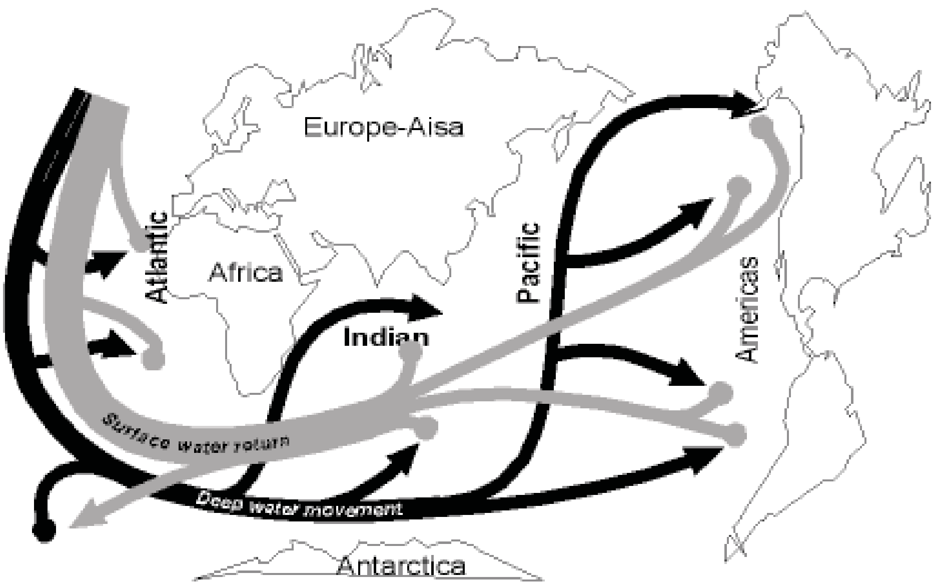
THIS MAP SHOWS THE MAIN DEEP OCEAN CURRENTS THAT AFFECT THE PACIFIC WITH THE EQUATORIAL SURFACE CURRENT AND THE UPWELLING OFF THE WEST COAST OF SOUTH AMERICA



These ocean currents move very large masses of water, and can be identified by their temperature and salinity profiles. This is in part what ARGO does and helps to provide information about where these currents are, where they are rising and mixing with upper water layers.

The average temperature profiles do not seem to change particularly from year to year for particular locations, indicating that the temperature distribution around Earth's oceans should be pretty stable. It is the continuous motion and interaction of the ocean currents through the different depths that is responsible for this stability.

THIS IS A REPRESENTATION OF THE DEEP WATER CURRENT S AND THE RETURNING SURFACE CURRENTS THAT TRAVEL THE WORLD'S OCEANS.



You can imagine this as a giant conveyor belt that drives the oceans, the heat the water carries and consequently our weather.

What is known, is that climate changes result not only from changes in the surface temperatures but also in the changes in temperature of the waters below the surface, what is known as the thermocline. The thermocline shows these changes below the surface.

It is important to remember that the top 3 metres of ocean carries as much heat energy as there is in the whole of the atmosphere. That means that the ocean has a tremendous capacity to store heat and given the nature of the ocean currents, carry this heat energy from one location to another.

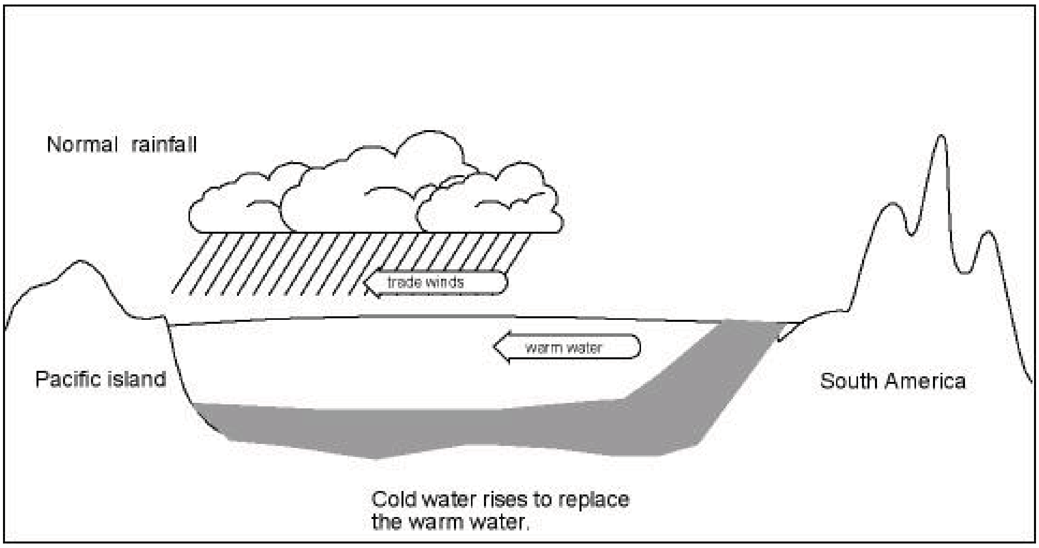
SO WHAT IS AN EL NINO EVENT?

Briefly, El Nino occurs when the normal ocean currents are disturbed. It affects the weather worldwide, as although the sea temperature may only change a few degrees, this takes place over a large area resulting in big changes to weather patterns.

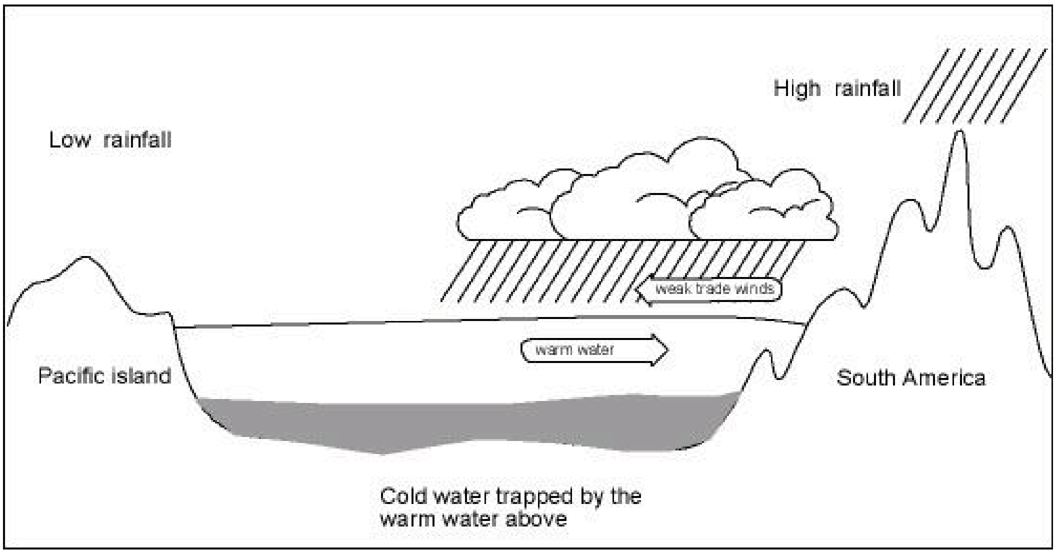
It happens when the easterly trade winds than run along the Equator weaken. Normally these winds blow from east to west, but they can for some reason weaken or even change direction and blow from west to east.
This slows the spreading of warm surface water across the equatorial Pacific and prevents the upwelling of cold water along the western coast of South America. In effect a 'pile of warm water' that would normally be in the Western Pacific ends up building up along the coast of South America.

The result; a cooler western Pacific with droughts in Australia and warmer, wetter weather on the west coast of South America with severe storms and floods .

Under normal conditions what we would see is:

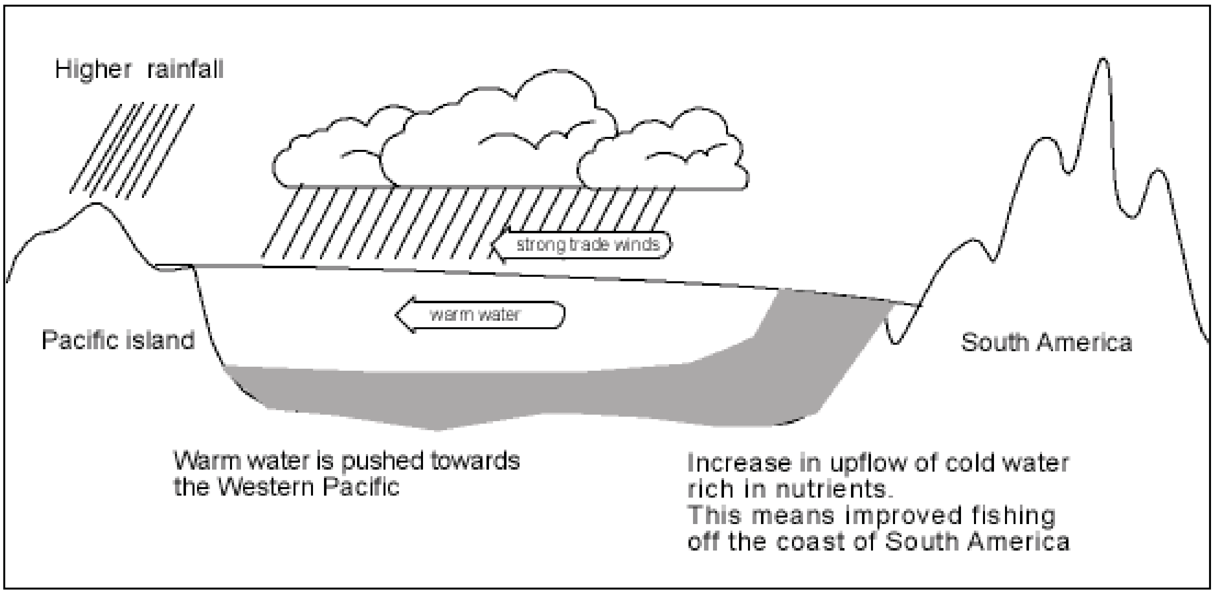


Under El Nino, what happens is this:



The event more commonly know as a La Nina is the opposite of an El Nino. The trade winds are stronger and blow more warm water into the Western Pacific. This results in more cyclones and bad weather for the Pacific Islands and New Zealand, along with an increase in the mean height of sea levels on their shores.

For the fisherman of South America this means bumper fishing!



Salinity measurements also predict the oncoming of an El Nino event. What has been noticed is that before an El Nino event, salinity levels in the waters of the Western Pacific are low six months before the event occurs. This is followed by increased salinity 12 months later in warmer waters close to the equator. It is thought that the sinking of cold, salty water around the equator allows the warmer less salty surface water to spread eastward and helps to create the changing weather pattern.

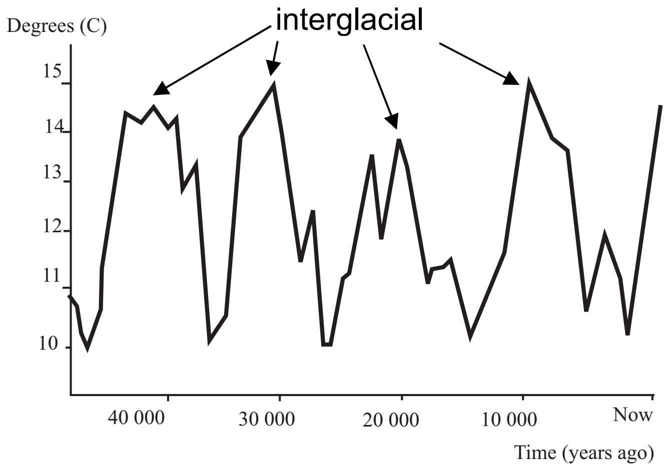
There is still more left unexplained!

THE IMPACT OF CLIMATE CHANGE.

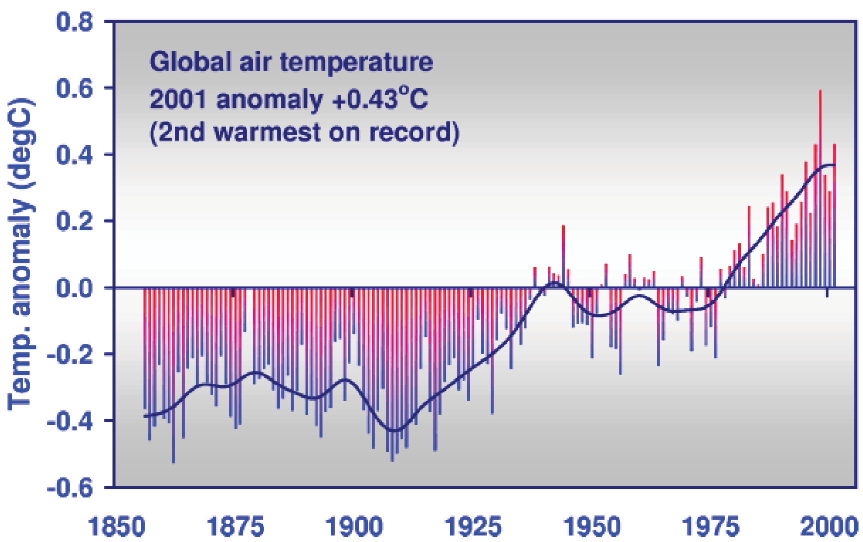
Measurements indicate the planet is getting warmer. It has happened in the past, but these temperature variations were more than likely part of the natural cycles related to volcanic activity or ice ages.

Comparison of the graphs below show that global warming may be nothing new but the reasons behind it in recent times do differ.

THIS GRAPH SHOWS THE AVERAGE TEMPERATURE VARIATIONS OVER THE LAST FORTY THOUSAND YEARS



THIS GRAPH SHOWS TEMPERATURE TRENDS WITHIN RECENT TIMES



Current indications show that there will a rapid increase in temperature due to things we are doing, taking the average temperature two degrees higher on current trends by the end of this century. This is only a guess, some say it will be only half a degree, others as much as six degrees. One thing is known it will go up!

This temperature increase will mean an increase in stored energy in the atmosphere and oceans. This will mean not only weather changes but also sea level changes due to the subsequent expansion.

One thing is for sure, it will impact on the way we live. Some of the effects we might well experience are:

- underground water supplies may become contaminated,
- disasters such as severe storms, flooding and drought may become more common,
- coral reefs will become damaged more frequently by the severe storms,
- increased sea level heights will damage the life on inside the coral reef,
- warmer waters inside the reef will create conditions that cause increase in algae growth,
- diseases once associated with only tropical regions may become more widespread,
- agriculture will change as plants no longer grow in altered climates with warmer soils
- many plants and animals will be under stress as habitats change.
- water stored on land in natural lakes, reservoirs, rivers will evaporate faster.

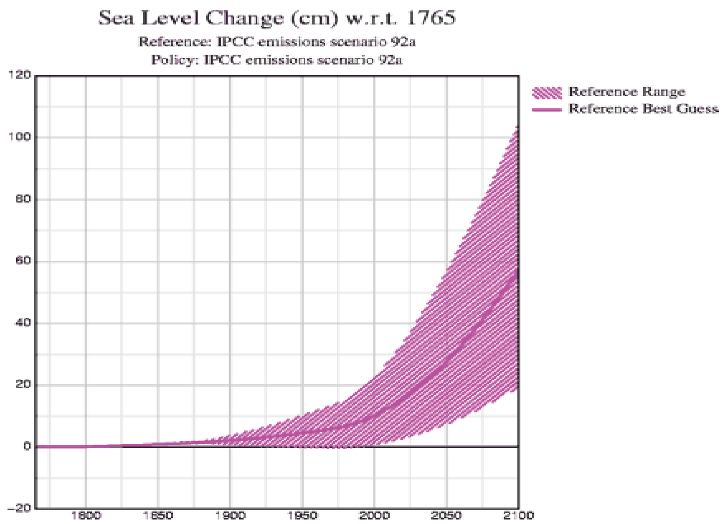
What the scientists think could happen.

One in ten year weather events such as El Nino patterns, or even one in one hundred year events will become more frequent. Weather extremes will become common place.

Important coastal regions, coral atolls and fertile estuaries will be under direct threat from rising sea levels. The sea level increase will come about predominately from increased expansion of the water mass of the oceans, Sea levels already change with seasonal temperature changes and in response to natural climatic events such as El Nino. But with a permanent temperature increase, the ice on the land mass will melt and that will increase the body of water in the oceans.

The idea that the floating ice cap and icebergs will effect the volume of water in the ocean is not correct. This is because they already occupy the same amount of space as they would if they were liquid water.

THIS GRAPH GIVES AN IDEA OF THE PREDICTED SEA LEVEL CHANGES



All of these changes need to be considered as they impact on our environment.

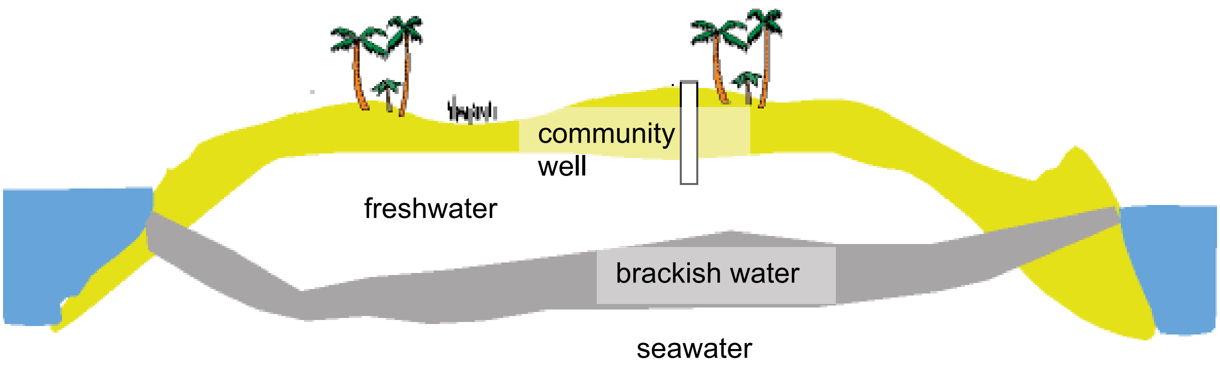
The question is what will the impact be and how will things be altered?

For the Pacific Islands, coral reefs in particular are under threat. As sea levels rise so the water over the coral reefs becomes deeper and the plant algae die through being unable to cope with less light and higher temperatures. The relationship between the algae and animal life that make up the coral reefs is no longer in balance. Already noticeable effects such as coral bleaching have been seen to be on the increase.

All this is on top of the effects of sedimentation being washed out to sea through Man’s activities including deforestation, and pollution (eg sewage). The result will see the coral reefs crumble and the coastline become unprotected from the wave action.

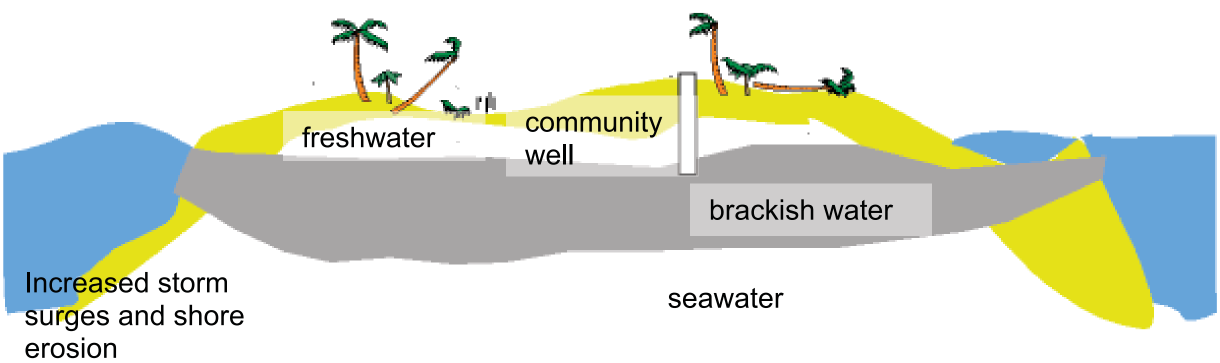
There is the hidden effect that comes from underneath the land.

The land that makes up the island's landmass is usually porous. That means freshwater can filter through them. This is a natural way for water to be stored. The layer of freshwater stored this way is called an aquifer. Communities use this aquifer to provide for freshwater, often in the form of wells.



Since the rock is porous, seawater can also seep into the rock strata. Seawater is more dense, and combined with the effect of sea level, the saltwater sits deep in the rock. Where the two layers of water meet, the water becomes brackish.

As sea levels rise, there is a likelihood of the freshwater layer becoming thinner. The saltwater will be naturally higher in the rocks. This contaminates the well with brackish water, damages the soil and reduces food crop production. What could make matters worse, is a decline in rainfall, even droughts.



SOME BACKGROUND SCIENCE: WHAT IS SEA WATER?

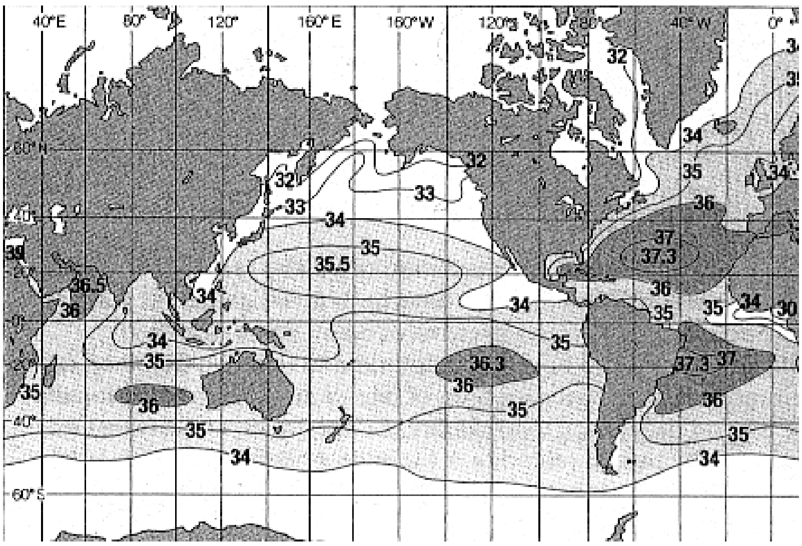
Most people would distinguish between seawater and fresh water by the fact that one of them tastes salty. That's true but there is more to it than that!

There are many materials dissolved in Seawater. Most of these materials are ions, which have originated from salts. The non-metal ions involved are chloride, sulfate; bicarbonate; bromide; fluoride and borate, whilst the metal ions generally found are sodium; magnesium; calcium; potassium and strontium. These are all soluble ions. Other materials such as silicon, aluminium and iron are there but only in very small quantities since they are not very soluble.

The average concentration of these dissolved salts is about 3.5% by weight. That's 3.5g of salts per 100 grams of water (or 35g per litre of water). The actual amount can vary depending on the where in the ocean, or if close to shore or estuary.

Out in the ocean the driving force for salinity depends on the balance between evaporation, precipitation (rain), on the surface and the amount of mixing that has taken place between the upper and lower layers of ocean.

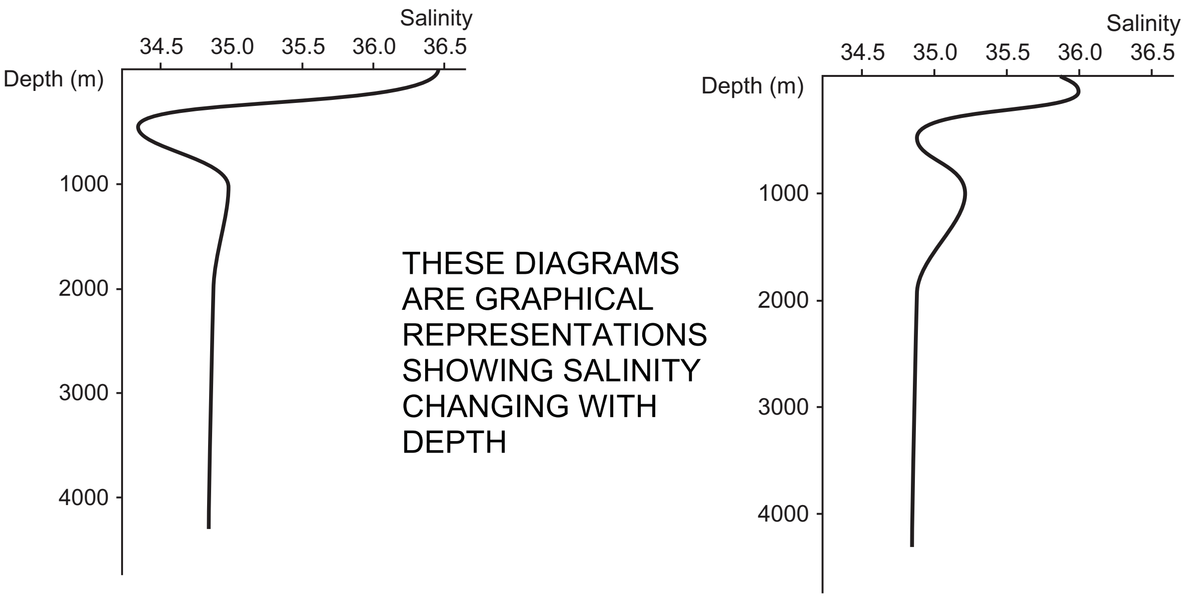
At the surface the salinity level depends on the rate of evaporation, (which increases salinity,) or rainfall (which decreases salinity.)



THE MAP SHOWS SURFACE SALINITY PROFILES ACROSS THE PACIFIC OCEAN

Key: Each number represents the weight of salts per litre of water

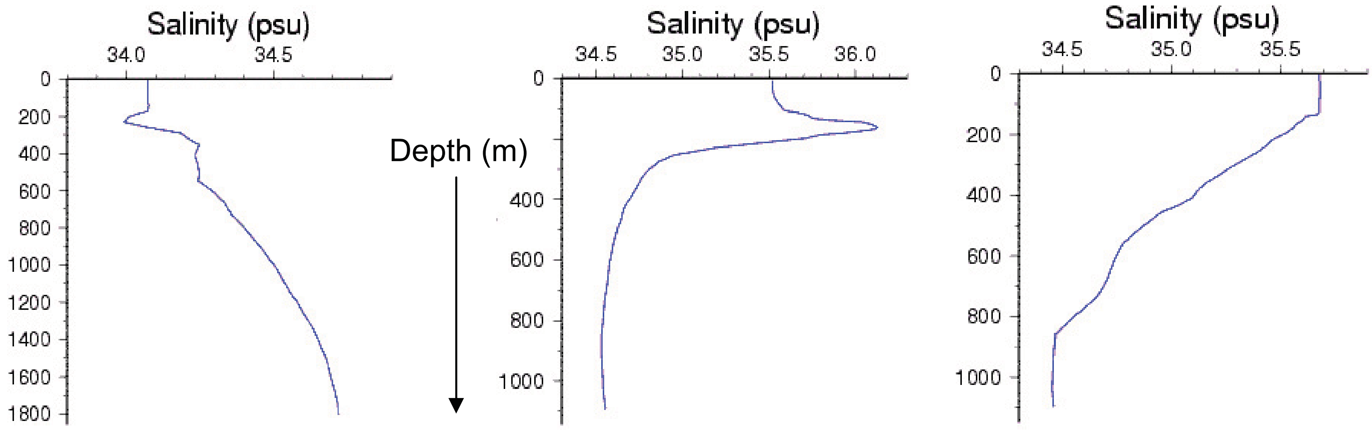
Argo floats provide a picture of the salinity changes with depth. The salinity is measured by using conductivity. Increase in salinity levels bring about an increase in conductivity.



Above about 1000m, salinities can vary depending on what is happening in the atmosphere above and the location of seawater. The mixing takes place as the ocean is disturbed by wind, distributing the heat energy and any fresh water layers down to deeper depths. (This is called the mixed layer). Below 1000 m, the effects of the surface changes are very small and the salinities are consistently between 34.5 and 35.0.

The zone on the salinity profile that varies is called a halocline. What is important is that it is like a fingerprint. Different locations show hardly any change in salinity levels from year to year even though the water is changing as evaporation or precipitation takes place. Changes that do occur in the ocean's weather are reflected in these profiles and this information can be used as part of the assessment of what is happening as climate change occurs.

Three examples of profiles taken from Argo floats with a similar longitude range and timeframe but widely differing latitudes. (The longitudes were in the region of 170 – 180°E)



Profile from latitude around 60°S in the Southern Ocean

Profile from a latitude around 35°S in the region of the Kermadec Trench

Profile from a latitude close to the equator in the region of theTokelau Islands

Seawater is more dense than freshwater. Some people recognise it is easier to float in seawater than freshwater. If you look carefully at the three profiles above, the further south you go, the salinity reading on and near the surface is considerably lower than the readings for further north. This means less dense freshwater must be on the surface (lower conductivity). This could have originated from melting ice or rain.

Comparing profiles in the tropics gives a good indication of high rates of evaporation or rainfall.

NOTE: Density is a measure of mass per unit volume of water. More particles packed in the same amount of space means an increase in density. When salt is dissolved in water, the volume does not appear to change. Yet the density is increased. The higher the salinity, the greater the density will be.

SEREAD

Activities for the Children

A Teaching Unit for 13 –16 year old children

ACTIVITY 1: WHAT CAUSES TIDES?

What you will need: Tide Tables: Map of the area related to tide times.
Paper, Thin Cardboard, Scissors. Paper Fastener

What to do:

Step 1:
Find a chart of the high and low tide times and tide heights for a particular month.
Also find the days on which there is a new and a full moon.

Pick four consecutive days. Write down the daily tide times for those days.
Draw a graph of the tide height against time for the high and low tides in the day.
(There may be 3 or 4)

Question: What is the period of time between the tides?

An Extension Activity

Step 2:
Repeat what you have just done for different days two weeks later.

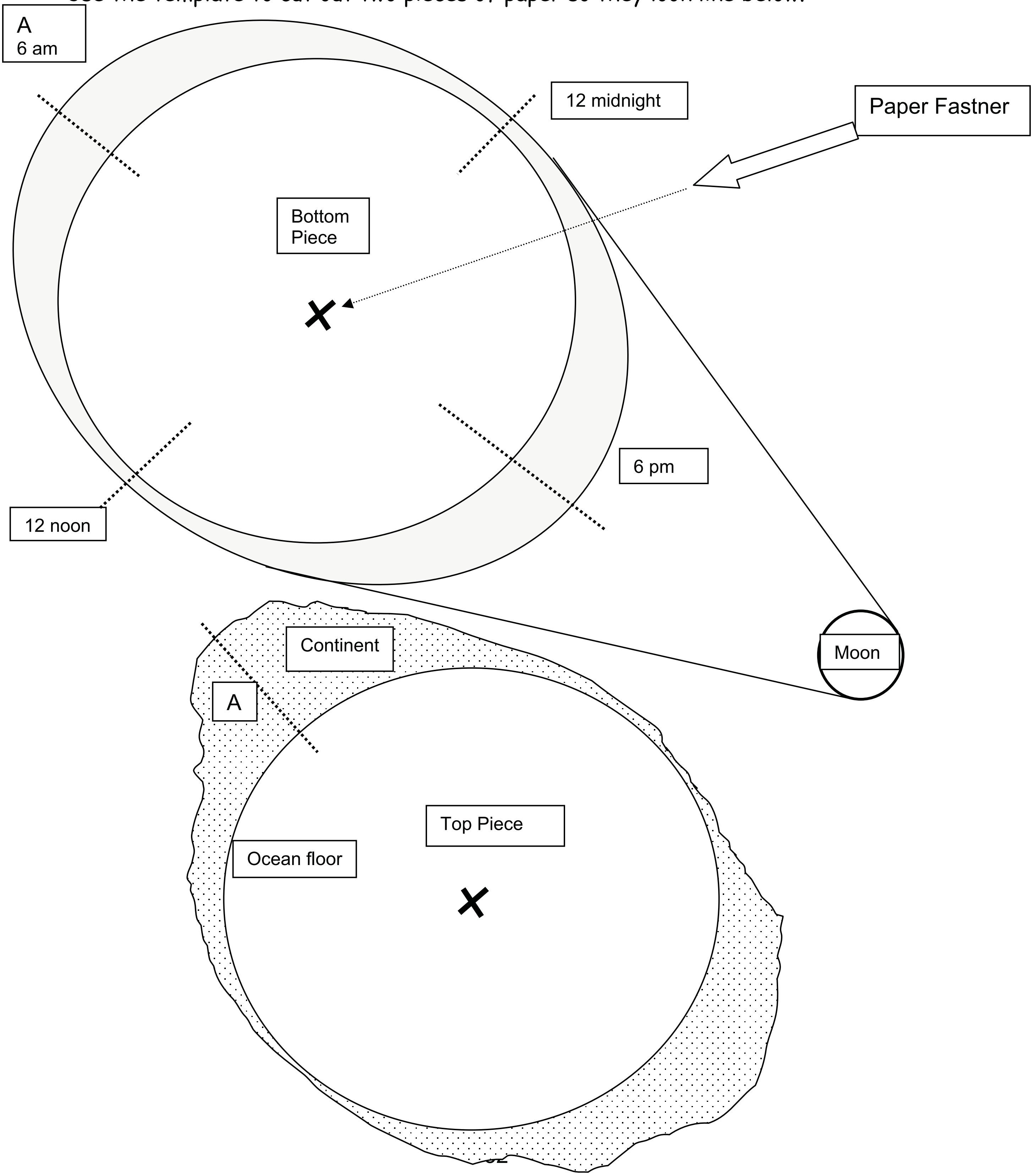
Question: Are the tides the some height?
Do the high and low tides occur at the same time?

Step 3: If you can get a map of your island, pick a particular day.
Find all the places you have tide information for.
Mark off the high tide times over the 24 hour period.

Something to think about?
Do you notice anything about the pattern?
Could you say that the pattern of the high tide times shows up like a wave that travels around island?
How would knowing this affect your planning of a fishing trip?

Modelling the tides.

Use the template to cut out two pieces of paper so they look like below.



What to do:
On the bottom piece colour in the water blue.
Paste this to a piece of cardboard.
Make sure you mark the points A, B, C, and D and the times.
On the top piece colour in the land a different colour.
Carefully push a paper fastner through the centre of the top piece and then through the bottom piece. Make sure that the two pieces can rotate.

Line up the A on the top piece with the one on the bottom piece.
Is this a high tide or low tide at A.

Now rote the bottom card so it is 12 noon at A.
Is this high tide or low tide?

Continue on to 6 pm and 12 midnight at A.

How many high and low tides are there in one day?
What does the ocean appear to be doing as the moon orbits around the earth?
Name the force that attracts the water towards it?

Something to think about?

Why is there a bulge of water at the opposite end?
Hint: This has to something to do a special force called centrifugal force. Here is an example, what happens when you swing a bucket of water over your head?

Do you think the gravitational force of the sun will have any effect on the tides?

Something to find out about?

The tide heights are not exactly the same over the 24 hour period. Why does this happen?
The tides do not exactly go through a 24 hour period. In fact it is slightly longer. Can you find out why?

What we want children to learn.

- Tides are cyclical. They are a natural event caused by gravity that causes the sea level to rise and fall.
- It is possible to follow the tidal pattern around islands, just as it is around the earth
- The period between each high tide is a little more than 12 hours and is created by time it takes for the moon to complete its orbit.

ACTIVITY 2: SPRING AND NEAP TIDES.

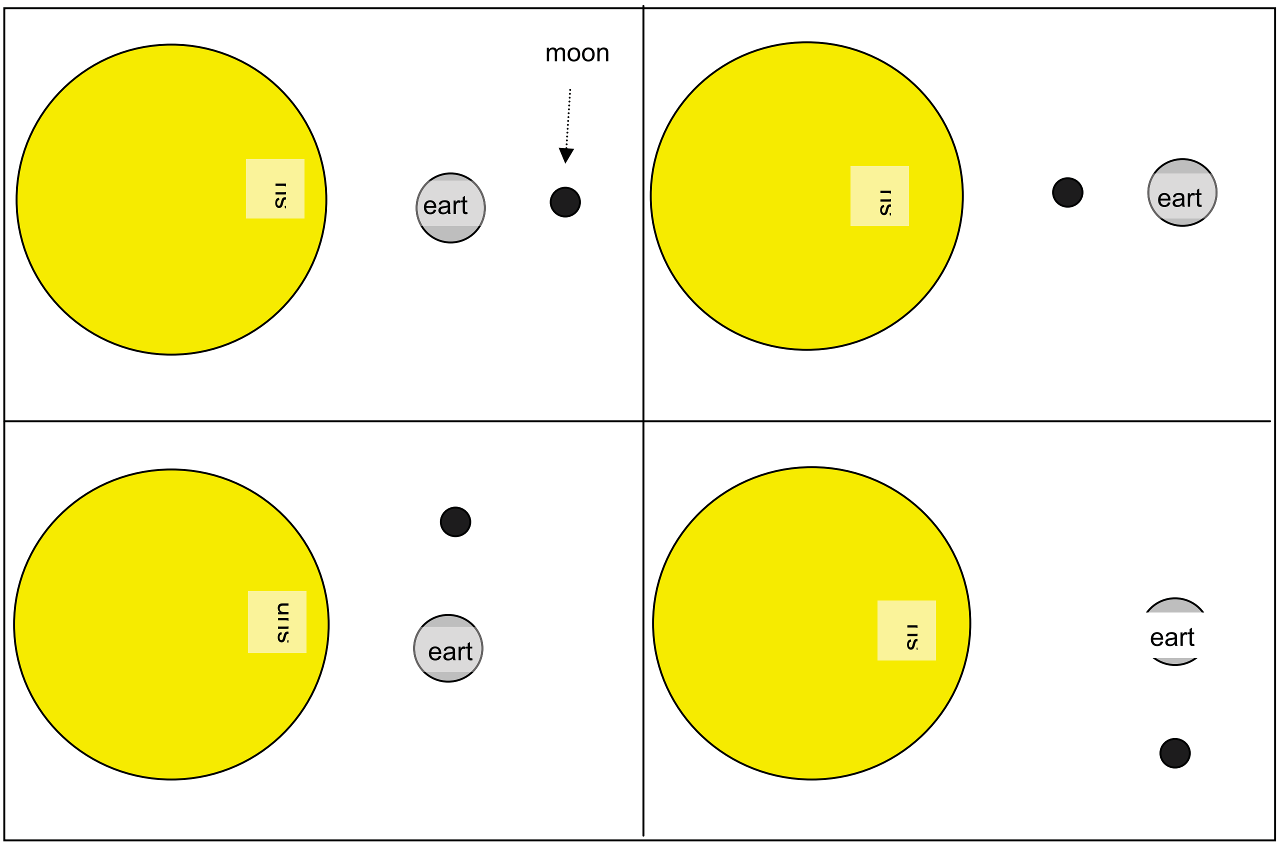
Predict: When do you think the tides will be at their highest?

What you need: A tide chart for a month. The dates for the new and full moon.

What to do;
Draw a graph of the tides for the month. Height is on the y axis. Date is on the x axis. Use only the highest and lowest tide for each day.
Mark on the graph, the day on which there is a full moon and the day there is a new moon.

Observe: What do you notice about the tide heights on these days?

Explain:
Use the four diagrams below to explain why there are changes in the tide heights? The diagrams show the moon's position in relation to the earth and sun as it orbits the earth.



What we want children to learn:

- Sun and moon both influence sea level.
- Their gravities can combine or work against each other.
- Spring tides (high sea levels) result from the combined gravitational forces.

ACTIVITIES: WILL GLOBAL WARMING CAUSE THE OCEANS TO RISE?

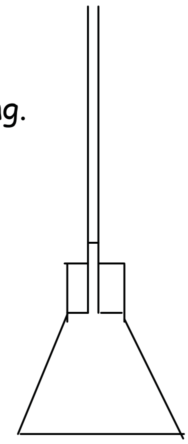
Prediction: What do you think? Discuss your ideas with your and write down your group explanation.

These two experiments may help you answer this question and confirm your ideas.?

Experiment: To demonstrate how much water expands on warming.

What you will need: A Flask or clear plastic drink bottle: Stopper: Glass tube: Food colouring.

What to do:
Fill the flask almost to the brim with water and a drop of colouring.
Put in the stopper and tube. Press down firmly. Water should rise up the tube.
When it has stopped rising mark the tube with a marker pen.
Put the flask out in the sun.
After 10, minutes take a look at the flask.



Measure: How far up the tube is the water level now?

Explain: Why has the water moved up the tube.

Something to think about: Can you redesign the experiment to measure the how far the water travels up the tube for every 2°C?

Something more to think about:

For each 1 degree centigrade that the temperature of the water increases, it increases in volume by a factor of 0.00021 or 0.021%.

What would be the effect on the volume of water in the ocean of a 1 degree temperature rise?

Well let's assume that the average depth of the ocean is 3.7 km. If the area that the oceans cover remains pretty much unchanged, then the change in depth will be:

$$3700 \text{ m} \times 0.00021 = 0.78 \text{ m}$$

That means that a 1 degree temperature increase in the oceans will give an almost 80 cm increase in sea level.

Measure 80cm on a wall up from the ground. Look around you, how much of the area you are standing would be flooded? How much would be clear above the new water level?

This is the worst case scenario for 2100, the turn of the next century!

Experiment: To demonstrate how much extra water is produced when ice melts.

What you will need: A bowl or container of water: Some ice cubes

What to do:
Fill a container 3/4 full with water.
Add 10 –12 ice cubes.
Mark the side of the container with a marker pen.
Let the ice cubes melt.

Prediction: What do you think will happen?

Measure: Has the height of the water changed once the ice cubes have melted.

Explain: Was there as much change as you expected? Can you explain what has happened?

Question: We know that the Greenhouse Effect is warming the oceans and melting the floating ice caps.
Which one do you think will have the greatest effect in your lifetime on sea levels?

What evidence do you have to support your answer?

What we want children to learn:

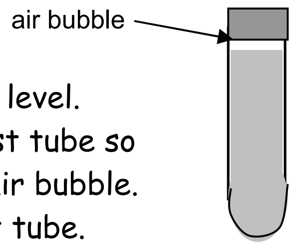
- When water warms it expands. Reason being that the water particles have more energy so need to occupy more space as they move around more.
- When icecaps melt they will not increase the amount of water in the oceans as the water that has originated from the ice merely takes up the volume originally occupied by the ice.

ACTIVITY: HOW DO WE FIND OUT THE MEAN SEA LEVEL?

What you will need: Long length of string, tape measure, meter ruler, sellotape, a marker, a level marker, small weight. Students will need to work in threes

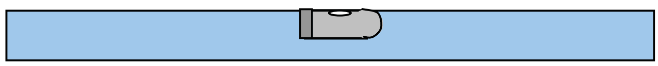
Note to the teacher. If the beach has only a small slope you may want to tie two rulers together before putting the level in place.

What to do: Getting the gear together.

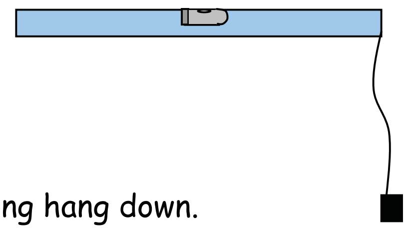


First thing to do is to make a level. This is a home-made spirit level. Find a small plastic test tube with a screw lid. Fill the small test tube so that it is almost full with water (or cooking oil). Leave a small air bubble. Screw on the lid. The air bubble should move freely in the test tube.

Secure the test tube to the middle of a metre ruler. Sellotape will do



At one end of the ruler tie a one metre length of string.



Finding the profile: Do this at low tide.

At the top of the beach, hold the ruler level and let the string hang down.
Make sure the ruler is level.
Another student lifts the string so the weight is just touching the sand.
Measure the length of string hanging from the ruler and touching the sand.
The third student can record the height.

Move the end of the ruler to the place in the sand where the string reached and do the same thing again.

Continue this until you reach the low tide mark.

Now use graph paper and use these measurements to draw a profile.

Mark the high tide mark and the low tide points.
This is an example

Now draw a line between the two marks, high water and low water. This is called the **foreshore.**

Mark a point on the fore shore halfway between the low tide and high tide marks. This is the mean point for the sea level.

What to do next:
You have measured the distance between high and low tides. If possible take this measurement over the period of a month and record the state of the moon and weather.

Can you explain:
What could be altering the height of the sea?
How large an effect is it having?

Can you guess:
How will the water level marks change if the oceans start to rise?
Will the water levels at high tide start to affect the land behind the beach?
How high will the sea level have to rise, allowing for everything else staying the same?

What we want children to learn;
Data is information gathering.
Gathering data over time provides evidence for what could be happening.

Scientific knowledge needs the assistance of mathematical tools.

ACTIVITY: SEA LEVELS, PAST PRESENT AND FUTURE!

What you will need: Graph paper, Ruler: Pencil.

What to do:

The sea has never been always at the same level. For a variety of reasons ranging from climate to geological the sea levels have changed.

Using a technique known as Thorium/Uranium dating, sea level has been estimated off the coral reefs of Papua New Guinea for the last 250 thousand years.

Thousand years before today	Metres below present sea level		
0 (Today)	0	130	5
10	23	140	16
20	119	150	123
30	54	160	11
40	44	170	30
50	72	180	57
60	55	190	87
70	71	200	46
80	22	210	32
90	59	220	7
100	20	230	25
110	48	240	12
120	27	250	32

Plot a graph showing how the sea level has changed over the last 250 thousand years.

Start with the x-axis on 250 thousand and work up to 0 (today).
On the y-axis start at 0 and go downward to a maximum of 140m

Question: How has the sea level varied over this period of time?
That was the past.
Now what do scientists predict for the future?
The data is based on models that scientists use to predict the changes in sea level as the oceans increase in temperature. These figures were dated from 1990.

Year	Change in average sea level		
	Lowest Estimate (cm)	Best Guess Estimate (cm)	Worst Case Estimate (cm)
1990	0	0	0
2000	1	4	10
2010	2	8	20
2020	3	14	30
2030	4	20	41
2040	4.5	25	52
2050	5	30	63

Draw a graph of the possible changes in sea level over the sixty years from 1990. Put the years along the x-axis. The average sea level should be on the y-axis. You will have a line for each estimate.

Something to think about:
What effect do you think the sea level change will have in your area?
(You could do this for each of the estimates).

Something extra:

- Can you predict how badly the coastal areas will be affected and to what extent? If you can, get hold of a map of your area or nearest coastal area showing the heights of the land above sea level. (These are shown by contours).
- Make a rough copy of the map, showing towns, villages, rivers, hills and valleys.
- **See if you can shade in the areas that will be most affected by a 30 cm increase in sea level.**
- **Go down to the beach. Work out where the low and high tide marks would be. How much higher would the high tide mark be?**
- **Could this affect any areas inland on your island?**

ACTIVITY: EL NINO: AN EXAMPLE OF WHAT CAN HAPPEN WHEN OCEAN TEMPERATURES CHANGE.

Ocean Temperatures and El Nino?

El Nino is a weather pattern that occurs periodically over the Pacific Ocean. Its effects are felt world wide.

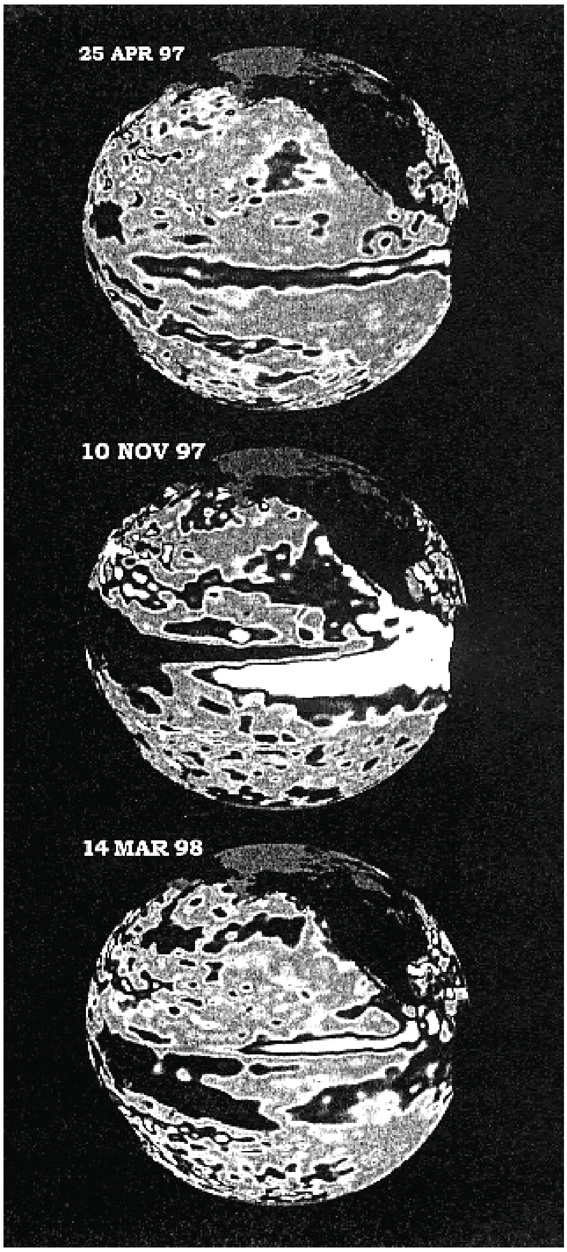
It involves a change in ocean temperatures across the mid Pacific Ocean linked to a decrease in the intensity of the seasonal South East Trade Winds. El Nino got its name from the fisherman of South America who recognised this weather pattern as being significant for its poor fishing.

The change occurs when the trade winds that blow from the east of the Pacific Ocean to the West weaken.

The information you are going to use originated with the El Nino of 1997 -1998

Look at the satellite information:

1. Which way did the warm water travel?
2. When was the El Nino at its maximum? How do we know?
3. How long did it take for the El Nino to disappear?



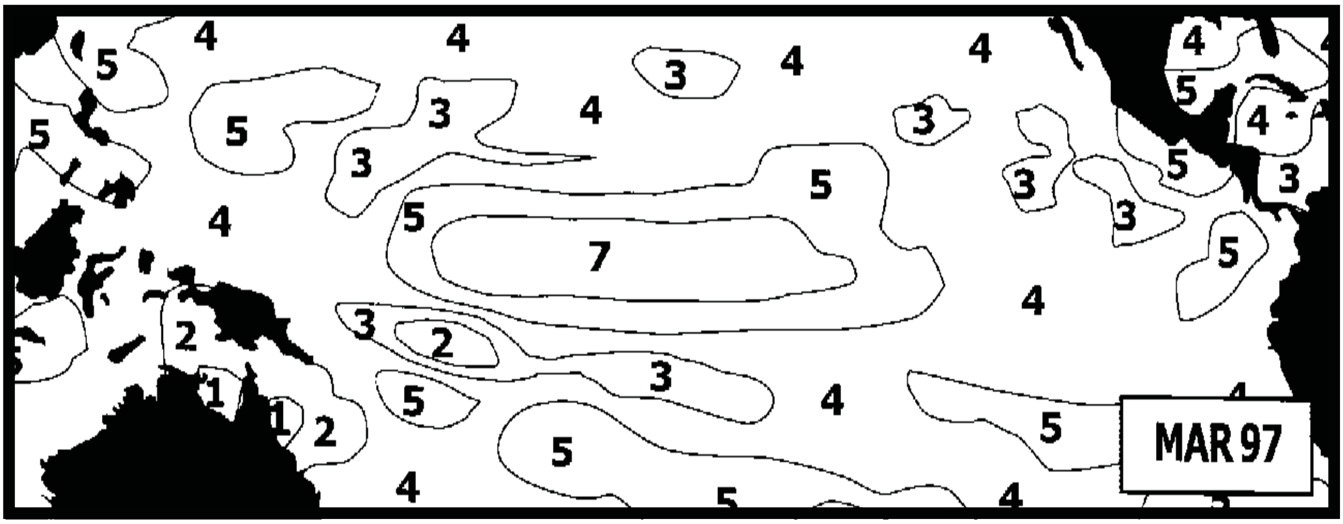
Key: The lighter area represents warmer ocean waters

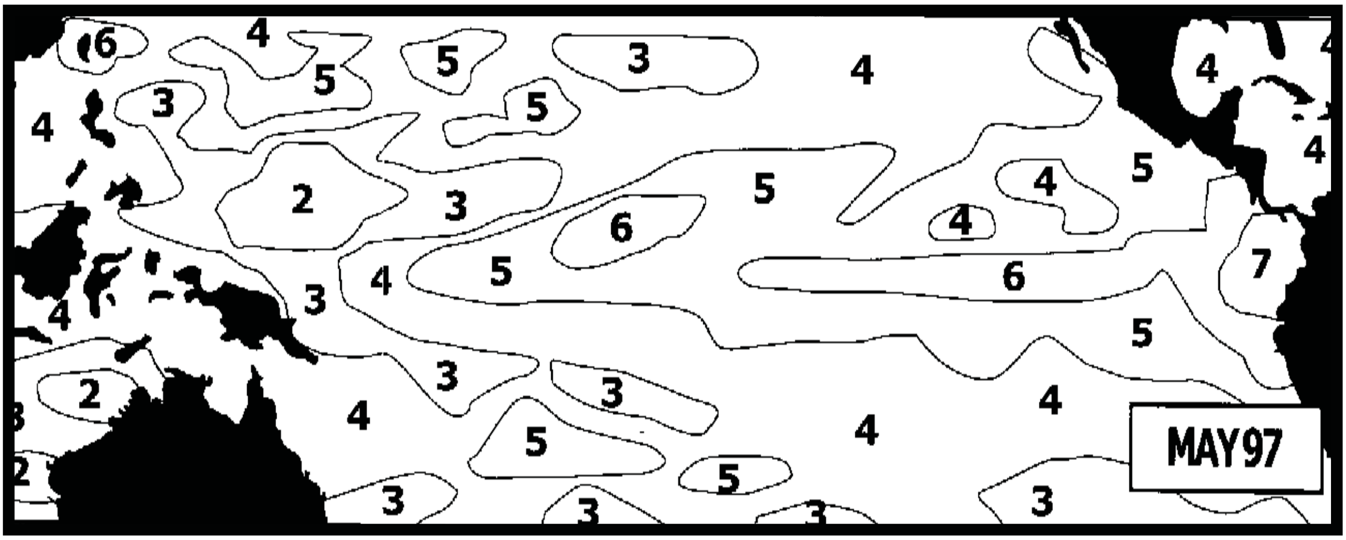
Activity: How does this affect the height of the oceans.

The Pacific maps you are given show contour lines, which give the changes in sea level height through the El Nino period 1997 to 1998.

Colour the maps using the following key:

Colour code	1 = Purple	2 = Blue	3 = Lt Blue	4 = Green	5 = Yellow	6 = Orange	7 = Red
Sea Level Height (cm)	- 20	-10		0		10	20

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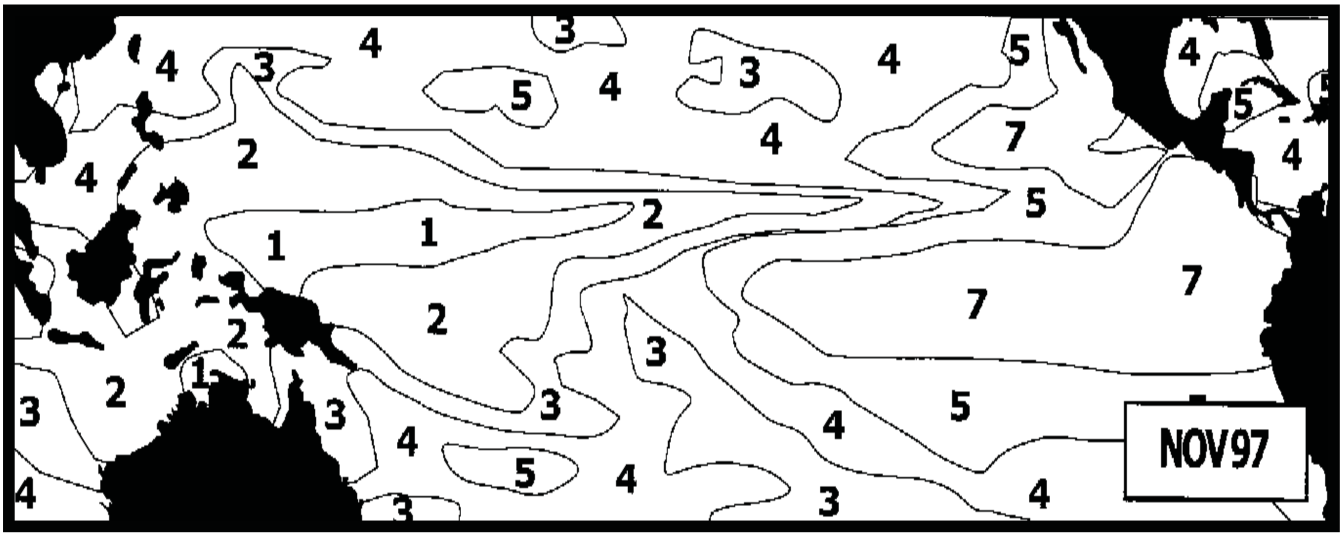
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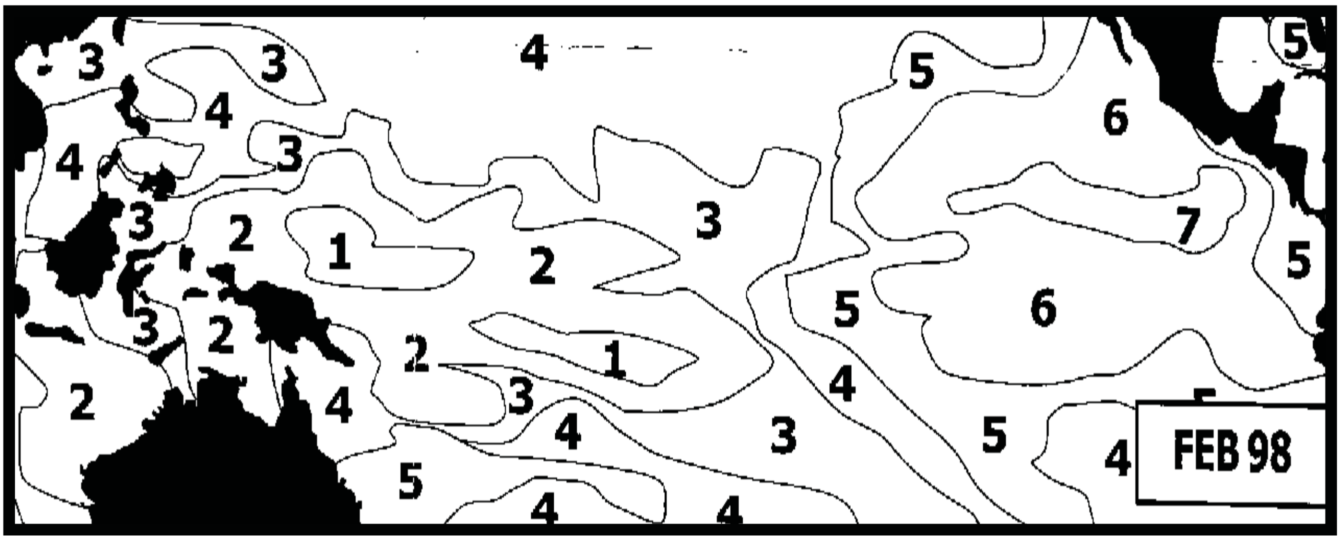
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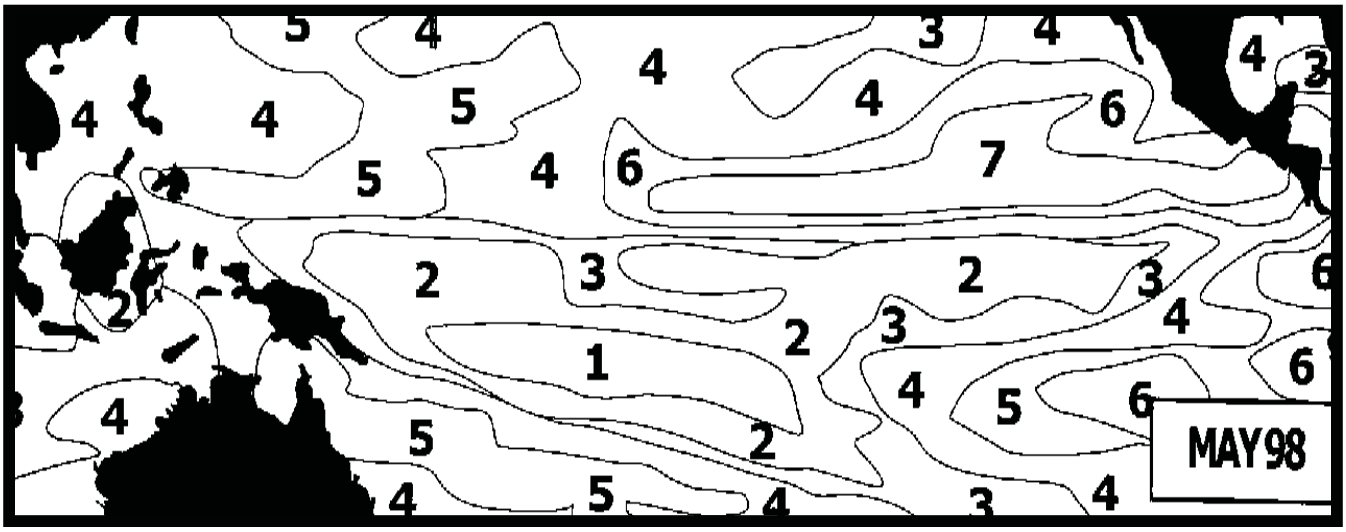


Questions:

1. What is the highest the sea reached? Where was this?
2. What is the lowest point the sea reached? Where was this?
3. What is the difference in sea level height?
4. Describe how the sea appeared to move over the year.
5. Can you locate your approximate Pacific location on the map?
6. What happened to the height of the sea in your location over the year?

Something Extra:

Place some tracing or clear paper on top of one of the maps.
Trace the contours of the surface by outlining each of the different colours.
Now trace a particular outline onto a piece of card. If possible use different coloured card for each contour outline.
Cut out the pieces of card.
Place them carefully on the traced out map in their corresponding positions.
Glue them in place.

What you have built is a model of the sea level surface.

How do you think this might affect the ocean currents? (Your teacher has a map of these currents.)

ACTIVITY: WHAT IS HAPPENING AND WHAT CAN WE DO?

A lot of work is being done by scientists to understand the role of the oceans, atmosphere and how they affect the weather.

One thing is definitely known: The Greenhouse Effect is changing our climate. The changes include:

- Warming of the earth's atmosphere,
- Sea levels rising,
- Change in weather patterns e.g. more droughts or more rainfall in some areas,
- Change in agriculture practices,
- New health threats caused by unfamiliar diseases,
- Lack of drinking water,
- Threats to wildlife and coral reefs,

Survey: What do people think is happening?

What you will need: Pen and large sheets of paper. Groups of 3-4 people.

What to do:
In your group decide on a series of questions that you think might tell you something about what people think about climate change.
They can be simple questions like:

- Do we seem to be getting more rain?
- Are we getting more storms?
- Is the fishing as good as it used to be?
- How has the reef near the village changed?
- Is the sea coming up the beach further?

There are many more, but decide on the five best ones.
Now decide who you are going to ask. Who would be the best people to get your information from? Who has lived in your village for a long time? Each group member should ask at least 3 people.

When you have the information:
Draw up a table to record people's comments. Think of ways that you can group their answers.

It could be something like this:

NAMES	More rain	More storms	More cloud	Less rain
Joe				
Mary				

Look for any common statements recorded by people in your group.
Is there anything in common about what the people you surveyed think is happening to the climate?

Could you rewrite any of these as issues.

Activity: Looking for Solutions

What you will need: Pen and large sheets of paper. Groups of 3-4 people.

What to do: The sheet below is called an Environmental Action Planner.

Divide up your large sheet of paper into the sections shown on the template.

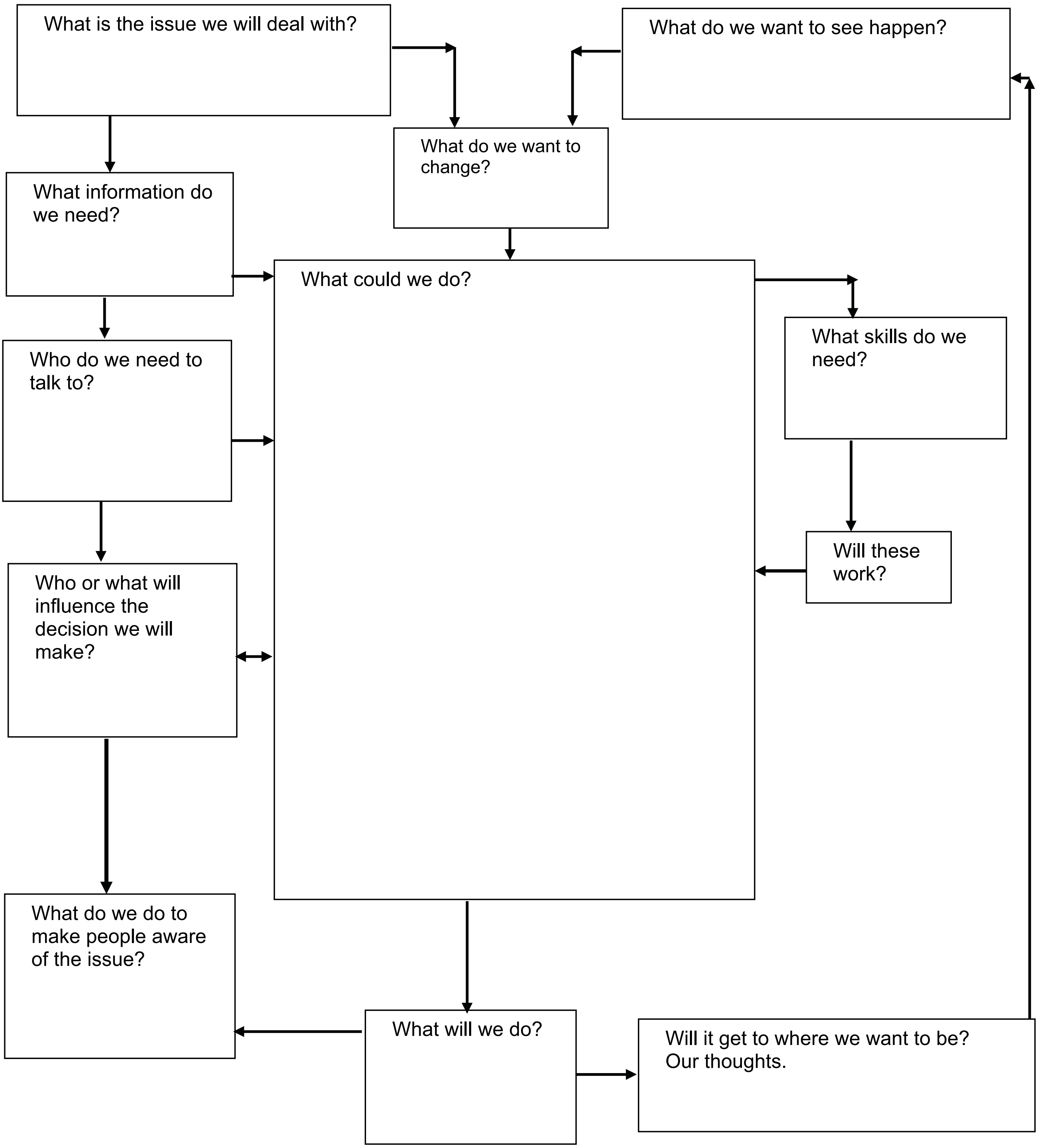
Pick one of the issues from your survey above.

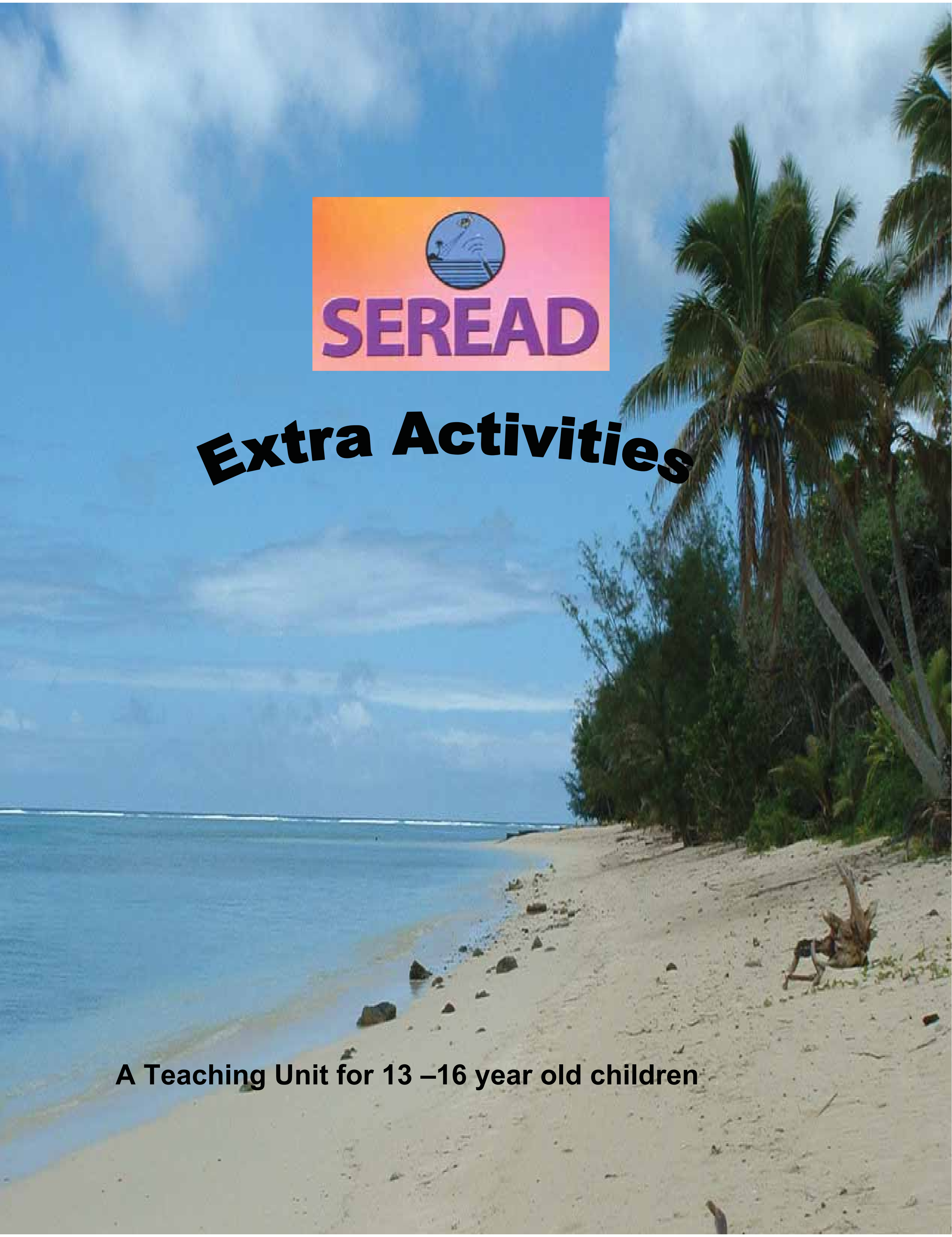
Write this into the box: "What is the Issue?"

Work your way through the rest of the boxes. You don't have to do them in any particular order.
You may find that there are a lot of things to consider and you have to cut down on these in order to make it workable.

Remember: Your solutions need to be workable for you.

Environmental Action Planner





Extra Activities

A Teaching Unit for 13 –16 year old children

APPENDIX: SOME ACTIVITIES LOOKING AT SALTWATER.

A STARTER ACTIVITY: WHAT IS DENSITY?

Note for the teacher: This activity is a starter activity to introduce students to the concept of density. (This concept becomes apparent in later activities related to the composition of seawater.)

What you will need: Some blocks of wood (preferably cubes): A block of plastic: A book: Blocks of different metals: A set of scales: A ruler.
(Note for the teacher: To make life easier use rectangular blocks of different materials and with dimensions that are close to exact centimetre measurements.)

What to do:
Rank the objects in what you think is from the densest to the least dense.

Using the ruler, measure the length, width and height of the objects to the nearest centimetre.
Use these measurements to calculate the volume of the object. (This will give the volume in cubic centimetres).
The formula is:
Volume = Length x Width x Height

Now weigh each object on the scales to the nearest gram.

When you have recorded this information, calculate the density of each object.
The formula is:
Density = Mass/Volume

Now rank the objects in order of the densest to the least dense.
How close were you to your original ranking?

Something to think about:
Density tells us something about how tightly packed the particles are.
Which object would be the densest of the ones you measured?

The density of fresh water is very close to $1g/cm^3$.
Objects that are denser than water will sink. Those, which are less dense, will float. Group your objects into those that will sink and those that will float.

Extension: Find out a way of measuring the density of unusually shaped objects such as stones.

What we want children to learn;

- All matter is made up of particles.
- Density is a measure of how closely these particles are packed together.
- The tighter the packing, the more dense the material.
- Density is measured in units of mass per unit volume,

ACTIVITY: STUFF TO DO WITH SEA WATER. (AN INTRODUCTION TO SOME OF THE PROPERTIES OF SEAWATER.)

Explain: Why is Sea Water salty? Where does the salt come from? Discuss your ideas as a group and draw or write out your final ideas on a large sheet of paper for class discussion.

Activity: Where does the salt go?

Prediction: Does adding salt to the water change the volume occupied by the water?

What you will need: A large jar (or a large measuring cylinder): Marker pen: Salt: A tablespoon: Water.

What to do: Fill the large container 3/4 full with water.
Mark the level of the water in the container.

Add a tablespoon of salt. Stir and wait until it has dissolved.
Keep doing this until there is just a little bit of salt left on the bottom of the container.

Check the water level on the side of the container.

Observe: What happens to the water level before and after adding salt?

Explain: If the water and salt are made up of particles how can what has happened be explained? (Use pictures to help you explain what has happened if you wish).

Teacher: Use pebbles in a measuring cylinder and then add sand to show how the salt particles can take up the spaces between water molecules without increasing the volume).

Question: Density is a measure of how tightly the particles of something are packed in the same amount of space. For instance a kilogram of salt occupies more space than a kilogram of lead.
Would one litre of Sea Water weigh **more**/ **the same**/ **or less**/ then one litre of Freshwater?
Can you explain why?
What do you think the density of Sea Water would be like compared to Fresh Water?

What we want children to learn:

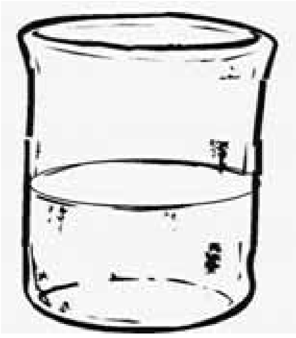
- Salt has come from the land – runoff and sedimentation
- Salt dissolves in water.
- The dissolved salt does not change the volume of the water.
- Since the volume of the water does not change, the density of the water has increased.

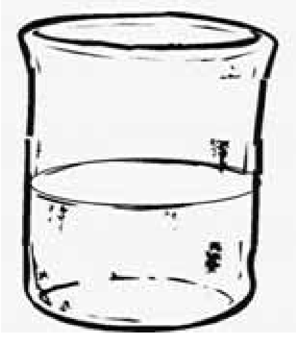
ACTIVITY: WHAT MAKES SEAWATER DIFFERENT?

Prediction: Will seawater and freshwater mix?

What you will need: 2 x 250ml beakers or large glass jars: Salt: Blue food colouring: Green food colouring: 2 small clear containers about 50 ml will do: 2 droppers: Tablespoon: Marker pen.

What to do:





Pour enough water into the large glass containers so they are half full.
Put a tablespoon of salt into one of the containers and stir until the salt has dissolved.
Write salt water on this container.
Write fresh water on the other container.
Pour some of the salty water into one of the small containers so it is 3/4 full.
Add green colouring to this salty water until it is dark green.
Label the small container "Salt Water."

Pour some freshwater into the other small container until it is 3/4 full.
Add the Blue food colouring so that the water turns light blue.
Label it "Fresh Water."

Use a dropper and gently add some drops of the "green" salt water to the large container of clear fresh water.

Observe: Draw what happens to the green seawater? Does it mix with the fresh water? Does it float or sink? Use colours in your drawing to show what is happening?

Now use a clean dropper and add some drops of blue freshwater to the clear seawater in the large container.

Observe: Draw what happens to the blue fresh water? Does it mix with the seawater? Does it float or sink? Use colours in your drawing to show what is happening?

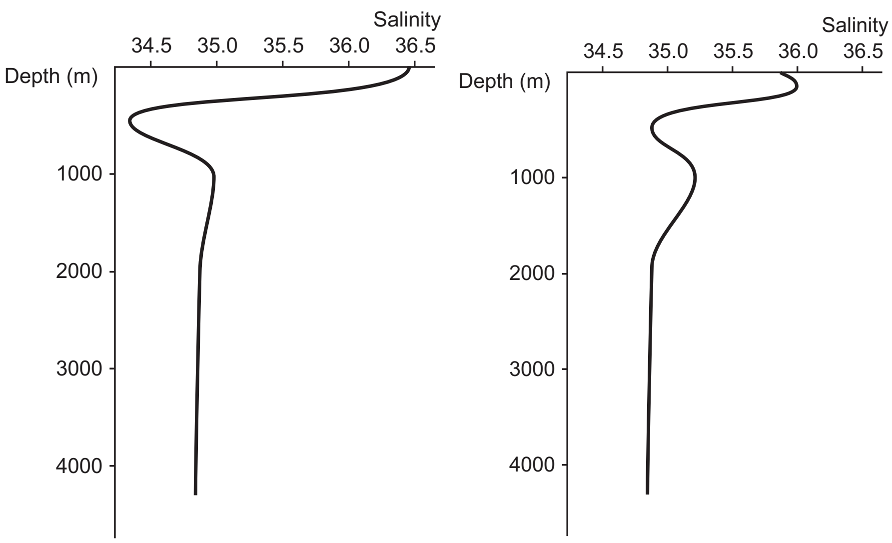
Explain: Can you think of a reason for what you see happening when freshwater and seawater come together?

Questions:
What do you think happens when it rains out at sea? Does the rainwater and sea water mix straight away?

What we want children to learn:

- Seawater is denser than freshwater.
- When it rains the freshwater reduces the salinity of the saltwater on the surface.

Something Extra:
An Argo float looks at the amount of salt (salinity) of the water as it comes to the surface. The profiles below come from the data from two floats that were close to each other in the equatorial regions. How could you explain the difference in the salinity levels of the water? (Hint: before and after a heavy rainstorm)



Why could this be important information?

What would cause the rainwater and sea water to eventually mix?

ACTIVITY: COMPARING THE BEHAVIOUR OF WARM WATER TO COLD WATER.

The temperature of sea water varies all over the world. The ocean waters near the Artic and Antarctic will be considerably colder than the water near the Equator. The temperature of the water affects its density. This in turn affects how the water moves in the ocean, and the way deep ocean currents move.

Prediction: What do you think will happen when warm and cold water meet each other?

What you will need: Iced water: Very hot water: A large clear container (500 ml beaker): 2 small containers (30 ml beakers): Red and Blue food colouring: 2 droppers.

What to do:
Fill the large container 3/4 full with tap water and place it on a table to allow the water to settle. This allows it to reach the same temperature as the room.
Pour some hot water into one of the small containers so that it is half full.
Put some drops of RED food colouring into the hot water to make it dark red.
Pour some iced water into the other container.
Put some drops of BLUE food colouring into the iced water to make it dark blue.
Using the dropper gently add some drops of hot red water to the water in the large container. Then add drops of blue iced water to the same large container of water.

Observe: What happens to the hot and cold water. Do they mix?

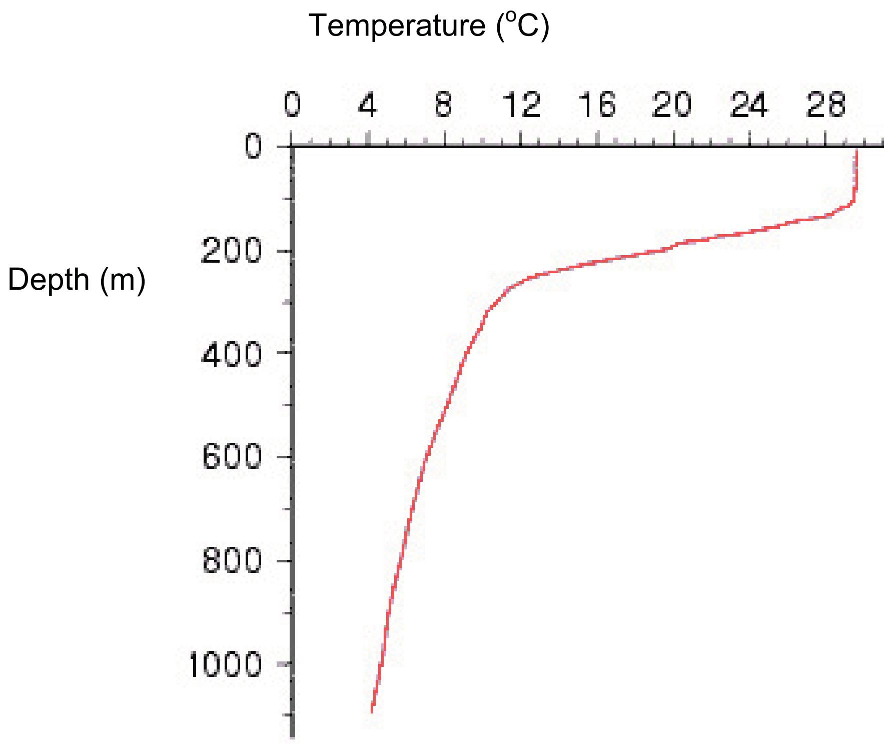
Draw pictures using Red and Blue colouring pencils to show what happens to the water. You may need to do several pictures over a period of time.

Explain: What happens to the cold water? Why do you think this happens?
What happens to the warm water? Why do you think this happens?
What do you think will happen when cold water from the Polar Regions meets up with warmer water from the equator?

Extension: Hold a straw at the edge of the top of the beaker so that it is parallel to the water surface. Blow gently through the straw. What happens to the water?

What we want children to learn:
Cold water sinks below warm water. It is more dense.
Warm water will sit on top of cold water.
Wind will mix up the layers of warm and cold water.

The picture shows the temperature profile taken from an Argo float near the equator.



ACTIVITY: WHERE DOES THE MELTED ICE WATER GO?

Prediction: What do you think will happen to the water as the ice melts on the surface?

What you will need: Beaker, Water, Ice cubes (coloured with food colouring).

What to do:

Fill the beaker 3/4 full with water.
Place the coloured ice cube on the surface of the water.
Watch what happens.

Explain:
Why do you think this is happening?
What so this mean will happen to the fresh cold water from the molten ice caps?

What do we want children to learn?
The cold water from the melting ice caps sinks.
The deep water of the oceans is very cold.
The deep water of the oceans travels along the ocean floor.