SEREAD

Oceans Rising?

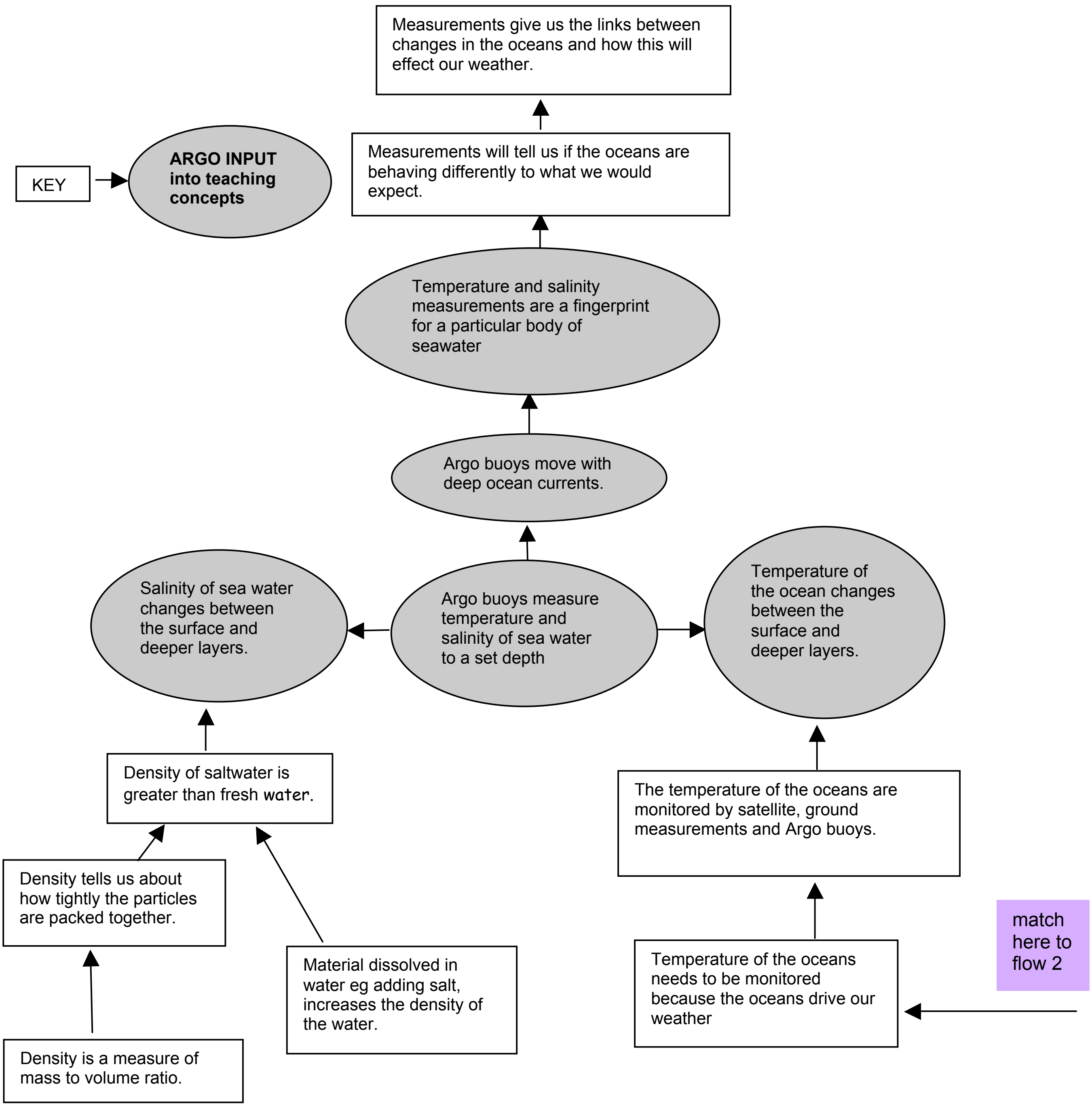
A TEACHING UNIT FOR YEARS 8 - 12 CHILDREN

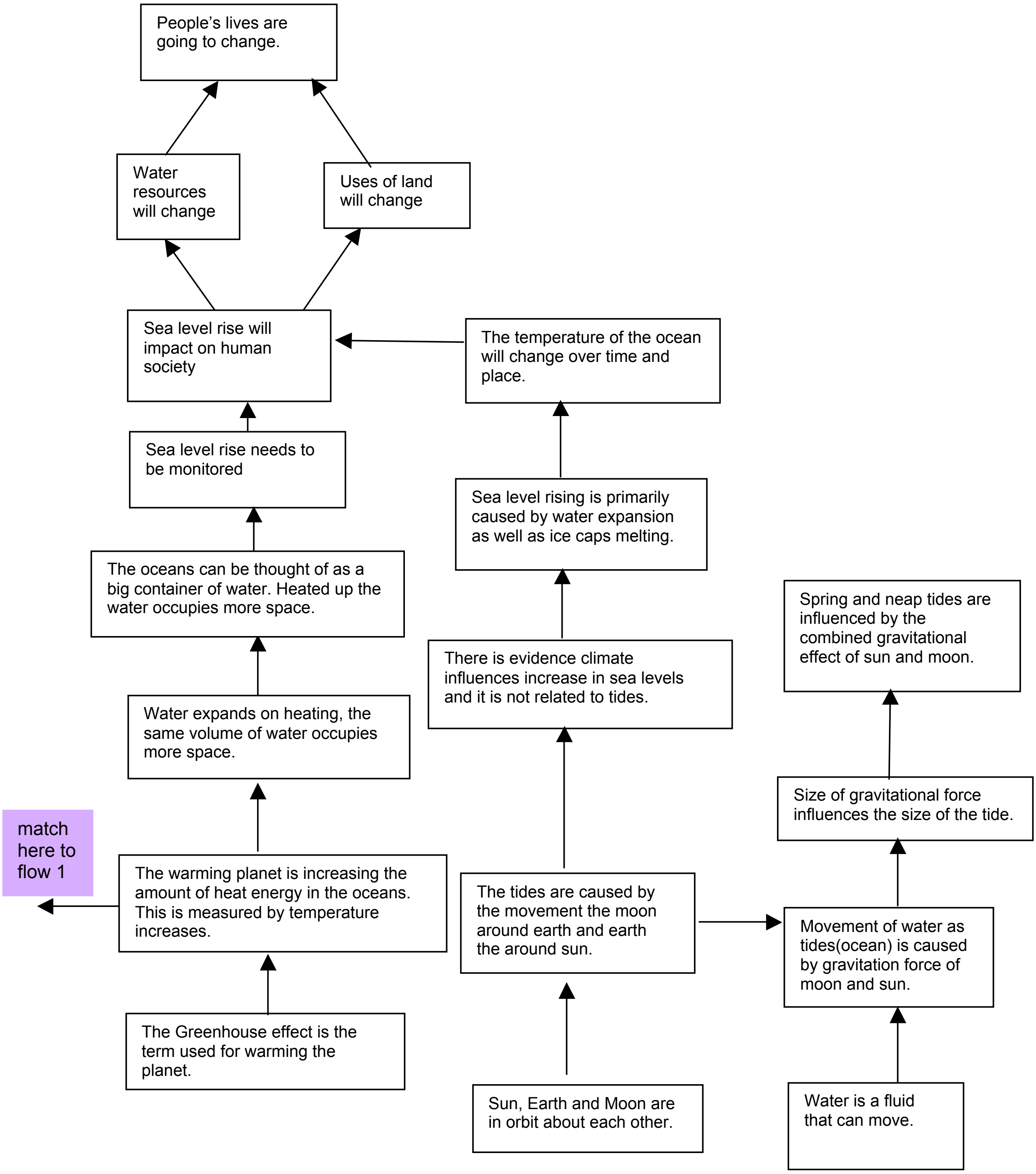
SEREAD and ARGO: Concept Overview

This is the overview for the third part of the SEREAD programme link with ARGO.
The overview progresses from low-level concepts to higher level and establish the progression between the essential concepts for this level. One of the primary purposes of this programme is to lay the foundation for linking weather to ocean matters and Argo.

Unit: Oceans Rising (Years 8 – 12)

Big Idea: Climate change is having an effect on the oceans, and this in turn will have an impact on the way we live. Scientists are monitoring the oceans to build up a picture of what is happening.




People's lives are going to change.
Water resources will change
Uses of land will change
Sea level rise will impact on human society
The temperature of the ocean will change over time and place.
Sea level rise needs to be monitored
Sea level rising is primarily caused by water expansion as well as ice caps melting.
The oceans can be thought of as a big container of water. Heated up the water occupies more space.
Spring and neap tides are influenced by the combined gravitational effect of sun and moon.
There is evidence climate influences increase in sea levels and it is not related to tides.
Water expands on heating, the same volume of water occupies more space.
Size of gravitational force influences the size of the tide.
match here to flow 1
The warming planet is increasing the amount of heat energy in the oceans. This is measured by temperature increases.
The tides are caused by the movement the moon around earth and earth the around sun.
Movement of water as tides(ocean) is caused by gravitation force of moon and sun.
The Greenhouse effect is the term used for warming the planet.
Sun, Earth and Moon are in orbit about each other.
Water is a fluid that can move.

Flow 2

TABLE OF CONTENTS:

THIS WORKSHOP AND THE SEREAD PROGRAMME ARE SPONSORED BY:

- The International Oceanographic Institute, University of the South Pacific (IOI)
- UNESCO Office, Apia
- Argo Science Team
- Partnership of Observation for the Global Ocean
- National Oceanic and Atmospheric Administration. U.S.A.
- South Pacific Applied Geoscience Commission
- International Oceanographic Commission, Perth Regional Office
- National Institute for Water and Atmosphere, New Zealand. (NIWA)

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.

This Booklet supports the following Workshop topics:

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 Booklet and Workshop are:

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.

SEREAD

Science for the Teacher

A TEACHING UNIT FOR YEARS 8 - 12 CHILDREN

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.

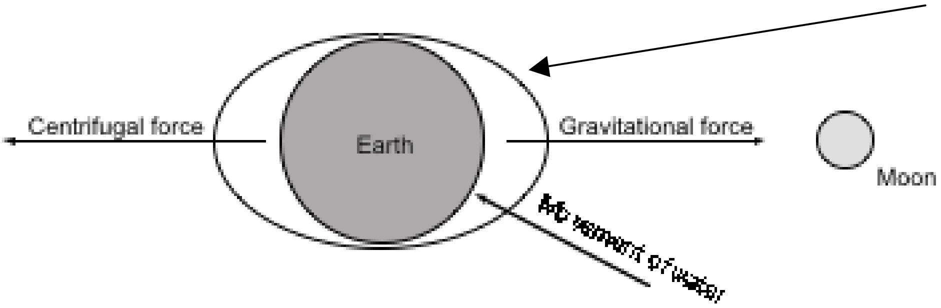
THE TIDAL WAVE, OR AS IT MORE COMMONLY KNOWN, TIDES.

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

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

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.

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.

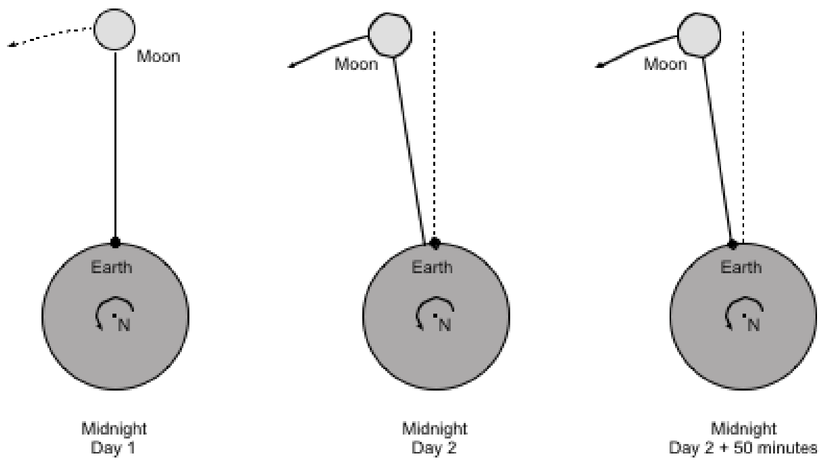


DIAGRAM SHOWING THE ROTATION OF MOON RELATIVE TO EARTH OVER THE 24 HOUR DAY

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.

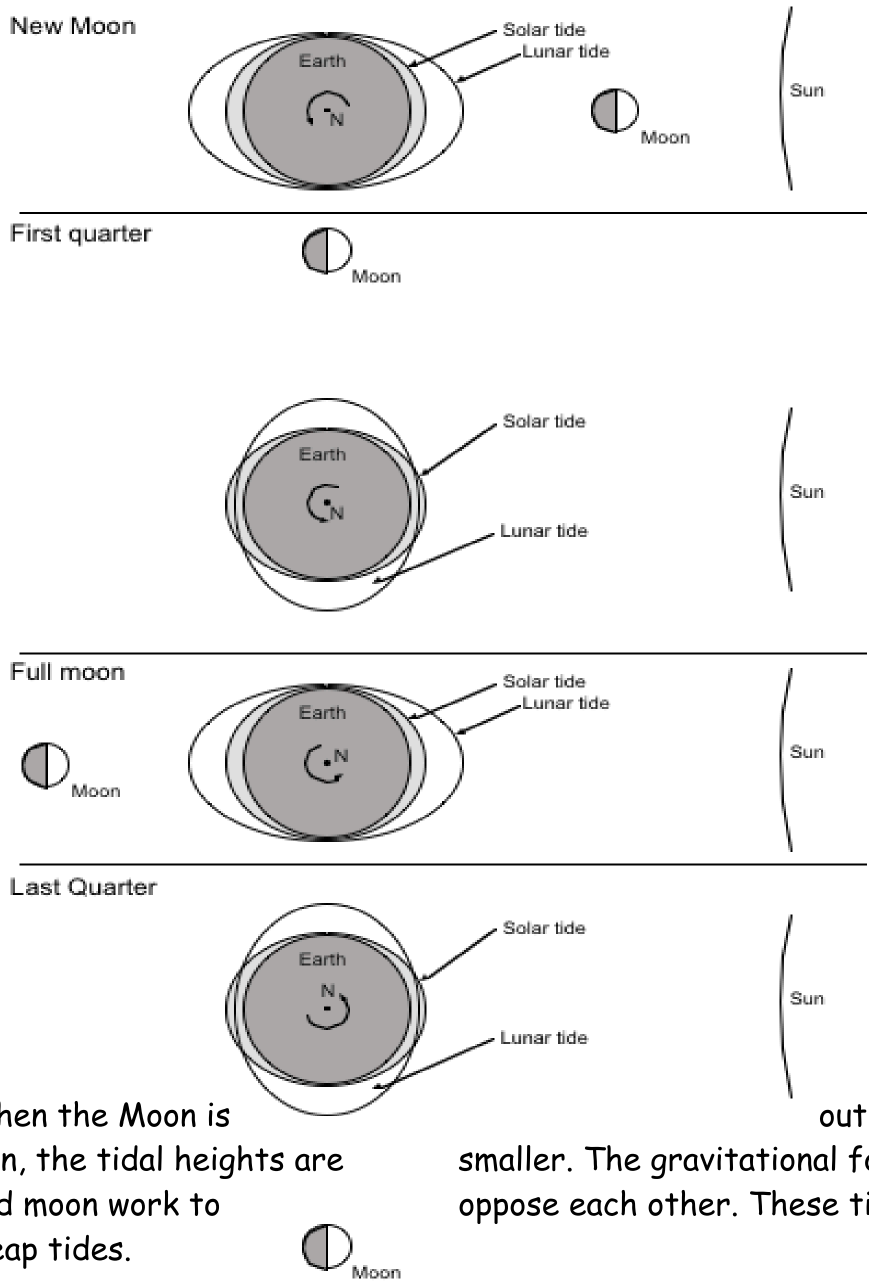


DIAGRAM SHOWING THE SPRING – NEAP TIDE CYCLE RELATION TO PHASES OF THE MOON.

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.

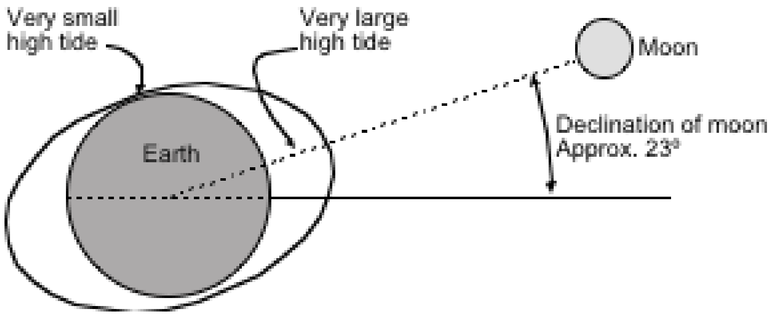


DIAGRAM SHOWING HOW THE MOON'S DECLINATION ALTERS TIDE HEIGHT.

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.

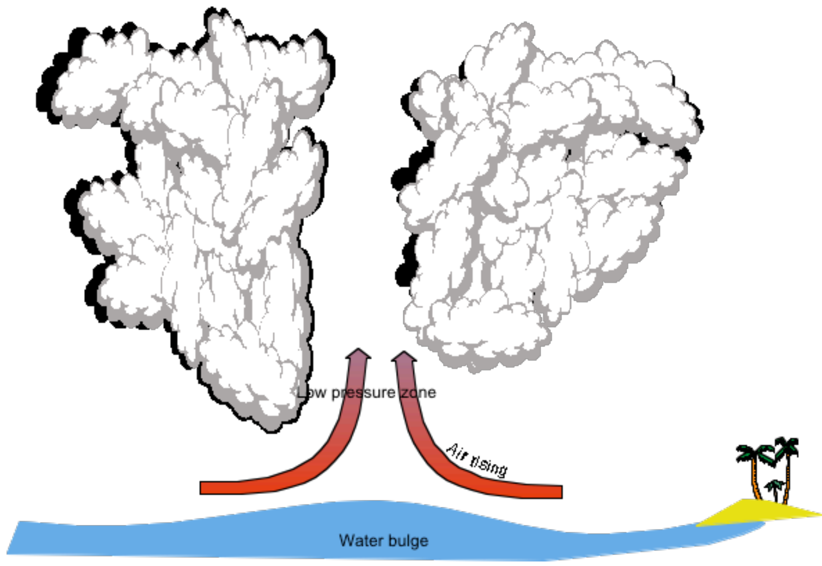
So when the moon is closer its gravitational effect on the earth is that bit larger. Since the oceans are the most easily influenced by the gravitational force, the tide heights will alter with the increase and decrease of this distance.

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.



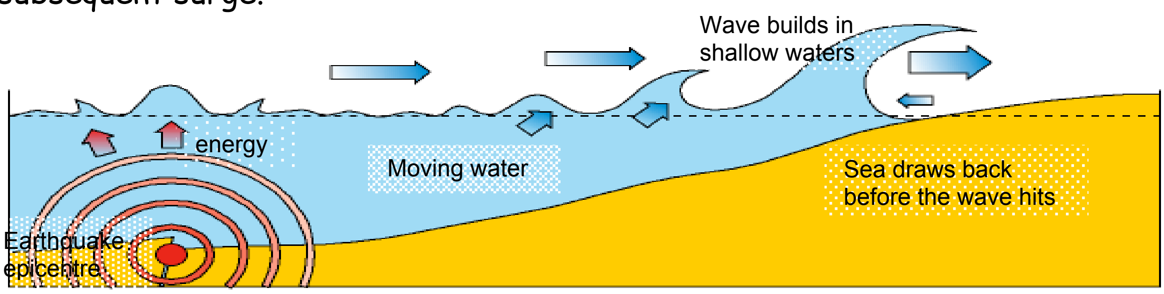
Combine this with the effect of storm driven waves and the result are islands being swamped far inland by seawater, as was seen in Niue 2004

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 create "energy waves". These waves are created by water being moved as the seabed rises or falls at the earthquake site. This energy is carried by the waves over very long distances and at speeds up to 800km/hr or more.

As the wave approaches land, the sea gets shallower and the wave slows down. The effect is to create an increase in the height of the wave, and the subsequent surge.

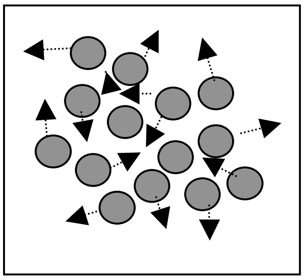


An increase in ocean height will lead to possible increase in the heights of these waves. In turn, leading to more devastation further inland.

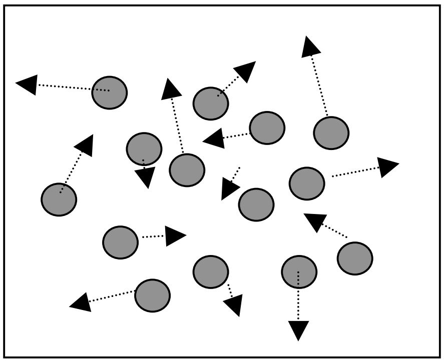
LONG TERM EVENTS: HOW DOES HEAT EFFECT THE OCEANS?

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?

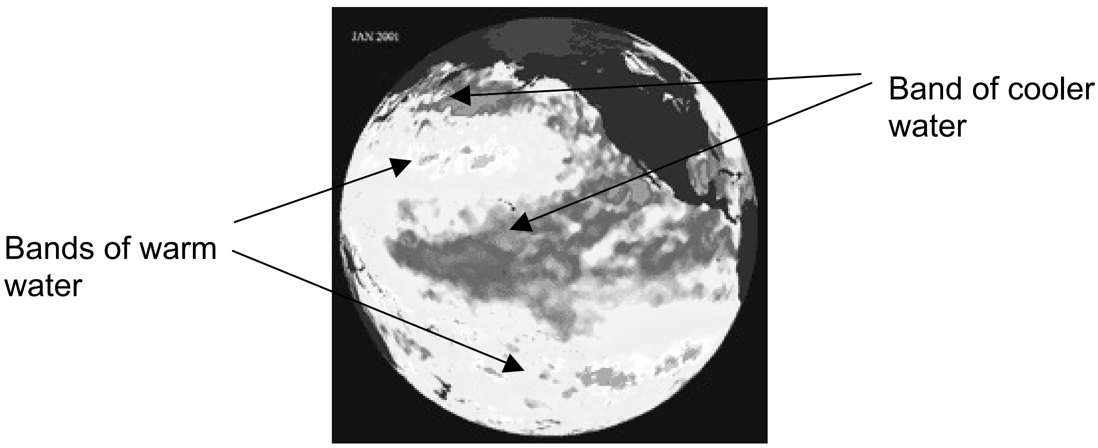
We need to develop a picture to see what is going on, and work out what changes are going on in sea levels. Satellites provide one part of the story. The satellites look down from above and measure the surface temperature of the ocean, and sea level changes through the year. This helps establish a pattern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

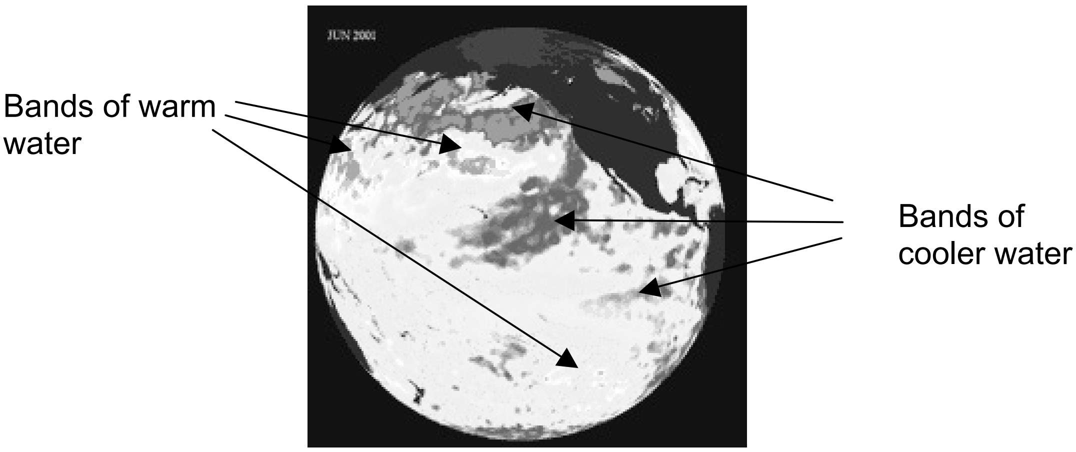
The problem is that satellites may show what happens on the surface, but what happens beneath?

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

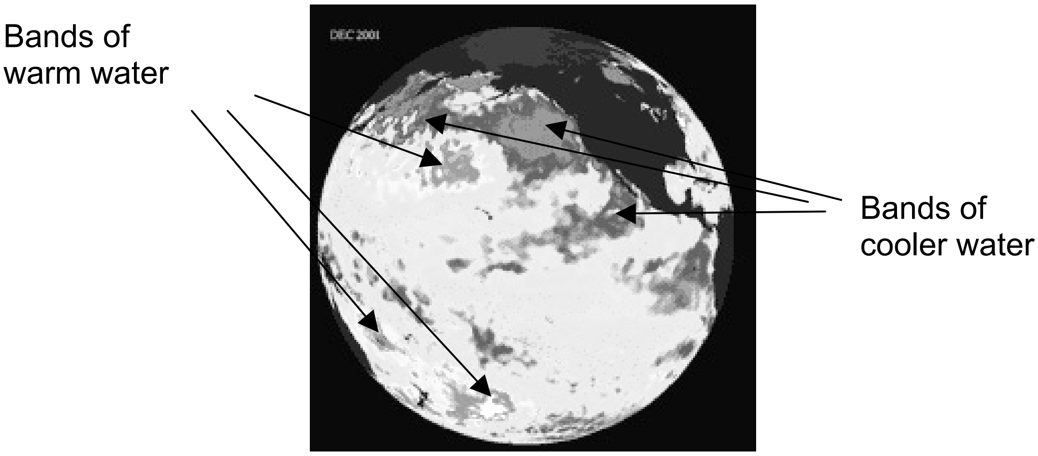


JAN 2001



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.

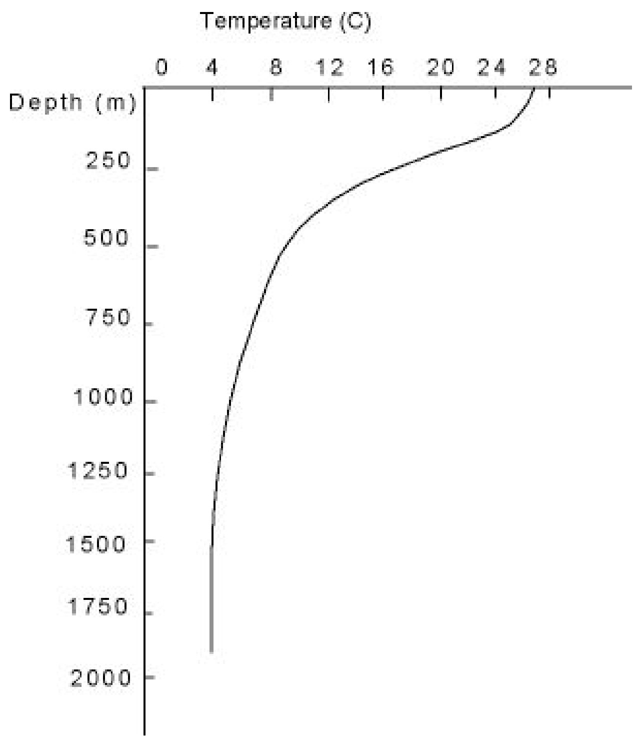


DIAGRAM SHOWING A TYPICAL TEMPERATURE PROFILE FROM AN ARGO FLOAT

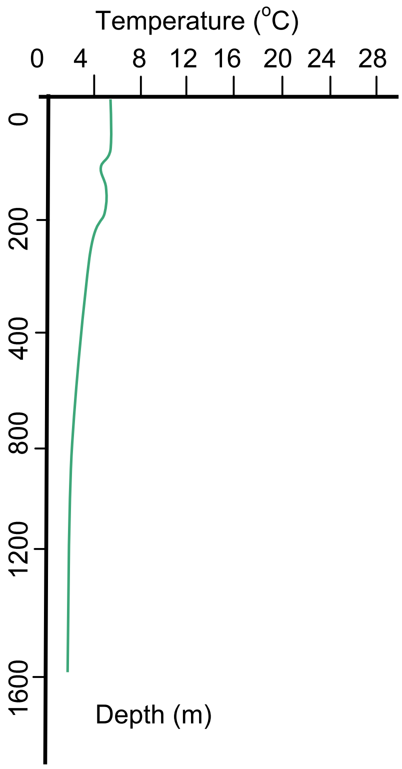
This is known as a thermocline.

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

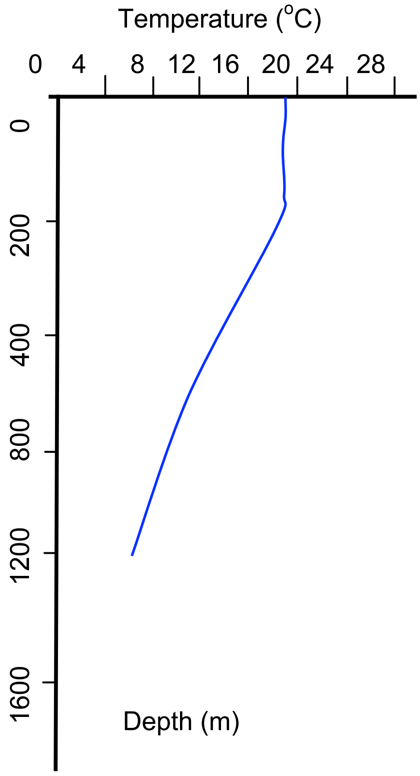
The main method of distributing the heat energy in the ocean comes through the action of wind. The turbulence created by the wind carries the heat energy deeper. But below 1000m the profiles are fairly constant and cold with temperatures in the range of 0 to 5°C.

Different locations have different characteristics.

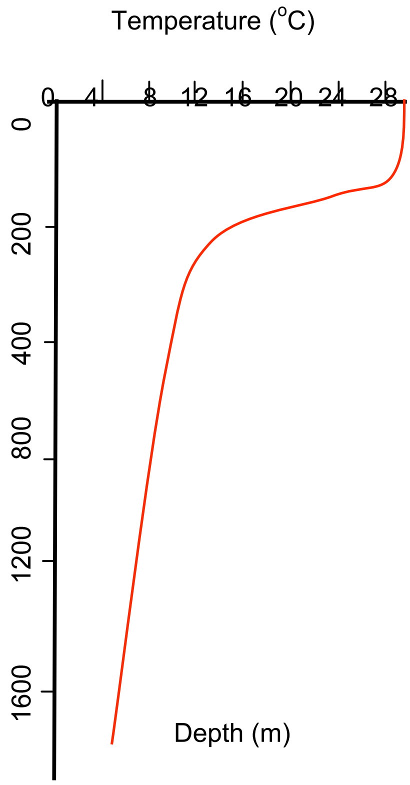
These profiles show thermoclines for equatorial, mid and polar regions.
(The longitudes were in the region of 170 – 180°E)



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



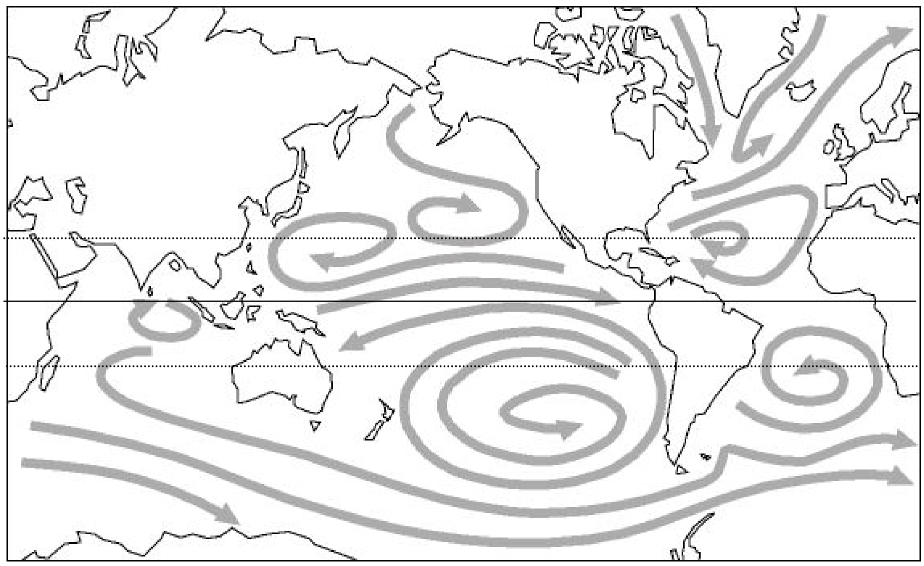
Profile from a latitude around 35°S in the region of the Kermadec Trench



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.

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

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.

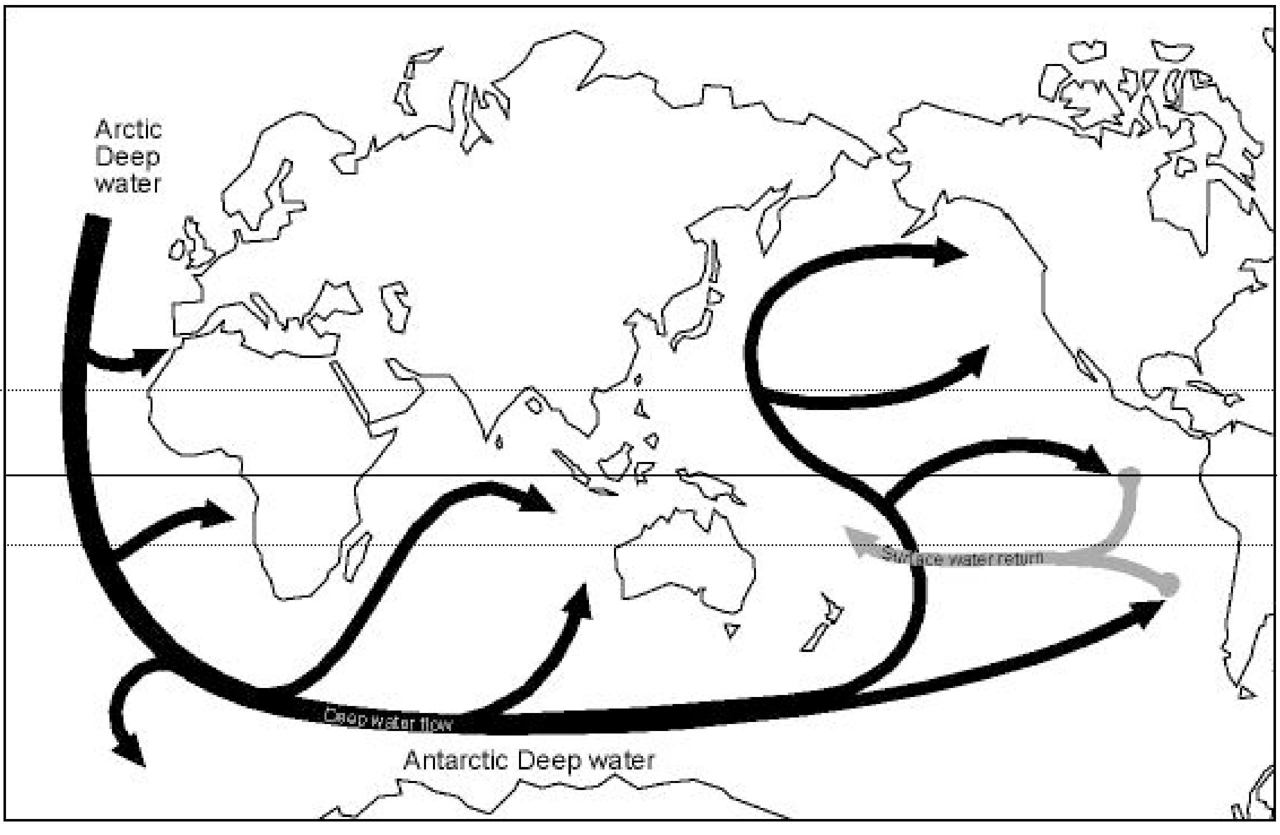
Very low temperatures are maintained at depths throughout Earth's oceans. It is the cold dense saltwater sinking in the Polar Regions that causes this.

The question is why does this happen?

In the polar region's, water on the ocean surface will freeze. This leaves denser salt water, which 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.

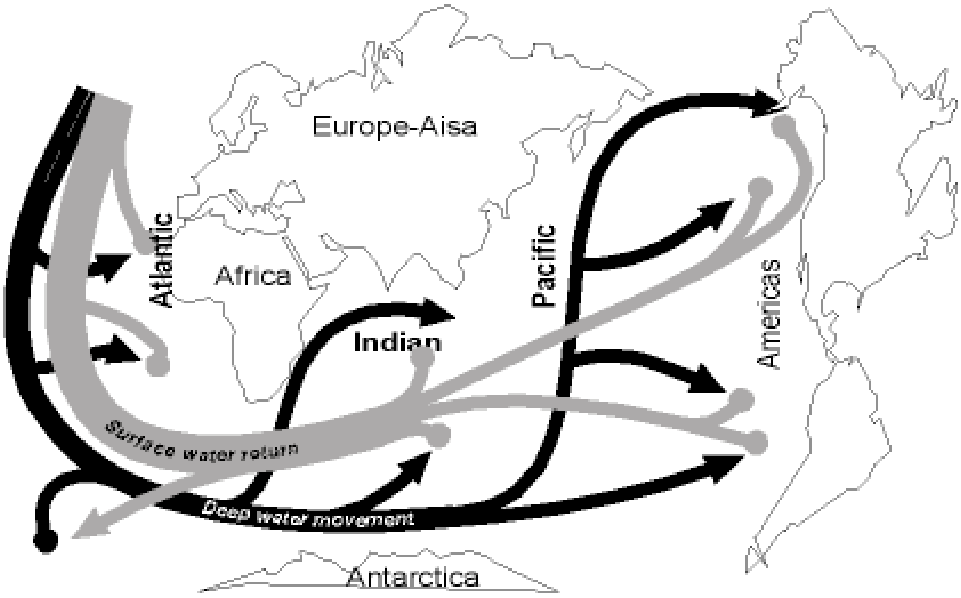
THIS MAP SHOWS THE MAIN DEEP OCEAN CURRENTS THAT AFFECT THE PACIFIC WITH THE EQUATORIAL SURFACE CURRENT AND THE UPWELLING OFF THE WEST COAST OF SOUTH AMERICA



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 CURRENTS 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.

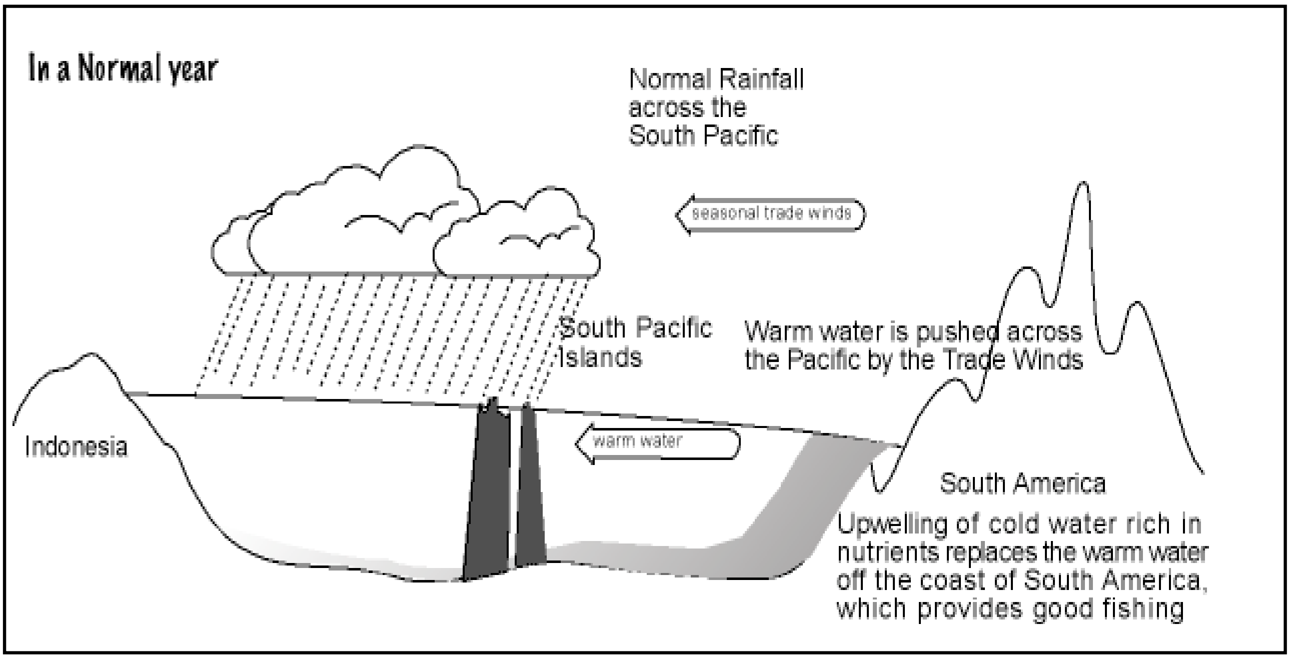
SO WHAT IS AN EL NINO EVENT?

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.

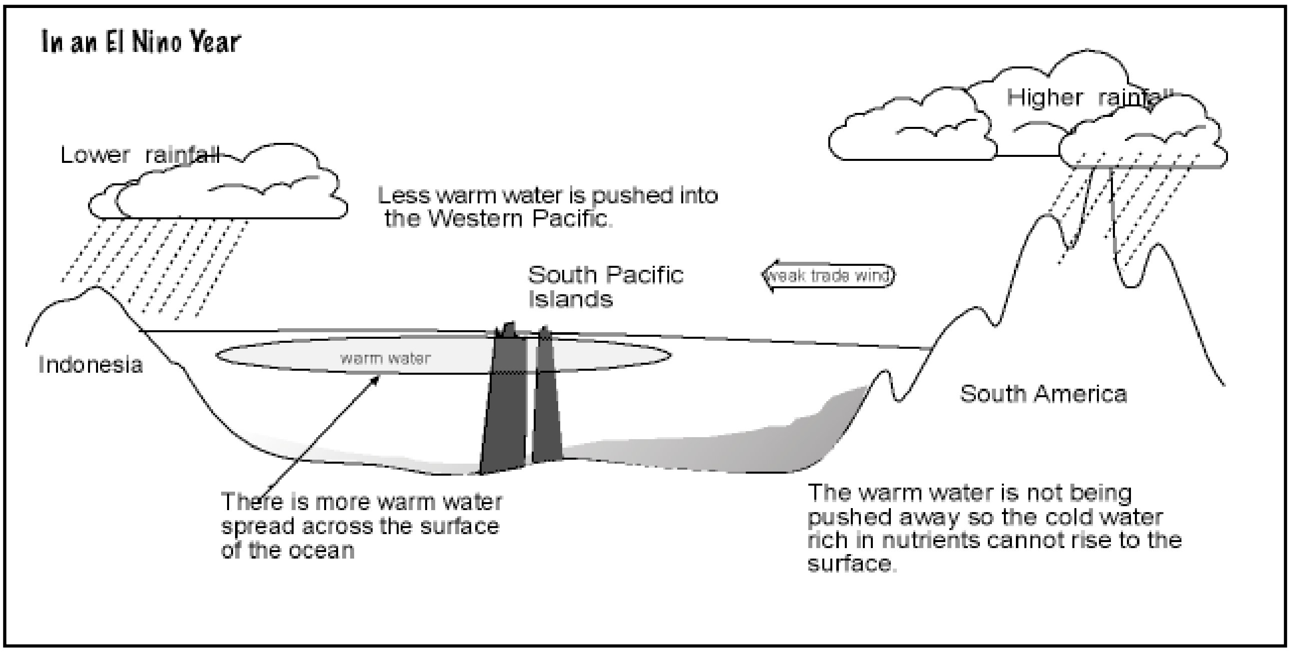
It happens when the easterly trade winds than run along the Equator weaken. Normally these winds blow from east to west, but they can for some reason weaken or even change direction and blow from west to east.
This slows the spreading of warm surface water across the equatorial Pacific and prevents the 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 .

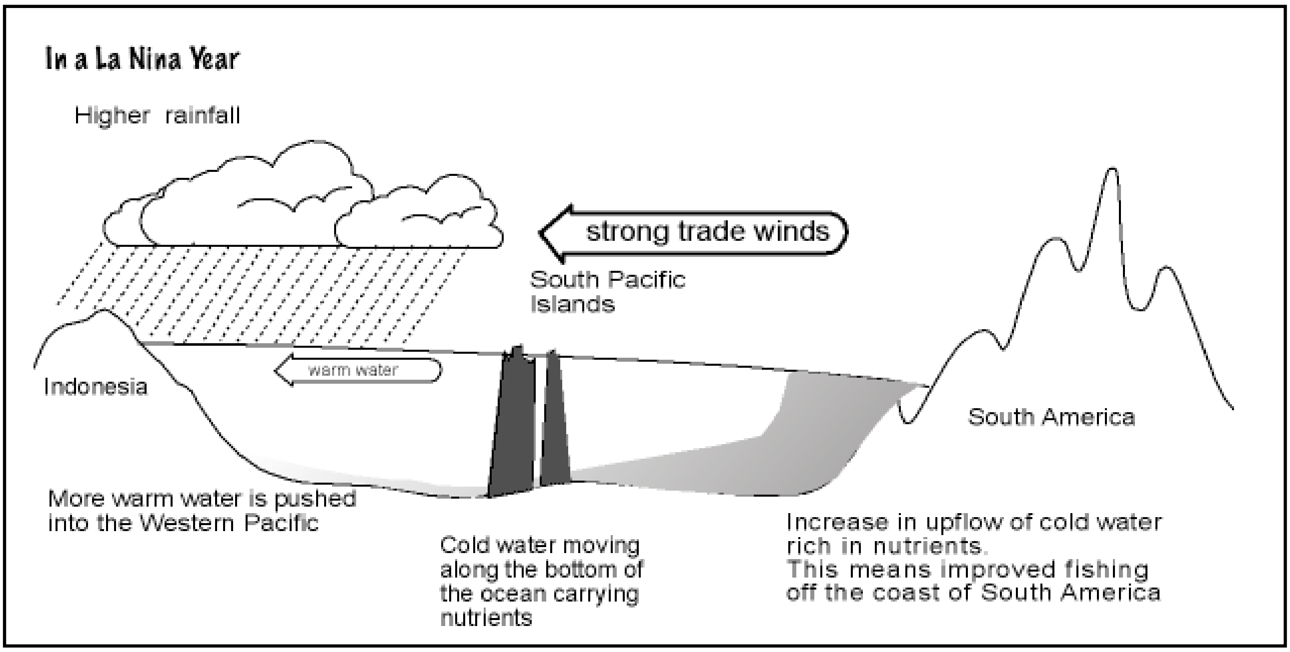
Under normal conditions what we would see is:



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.

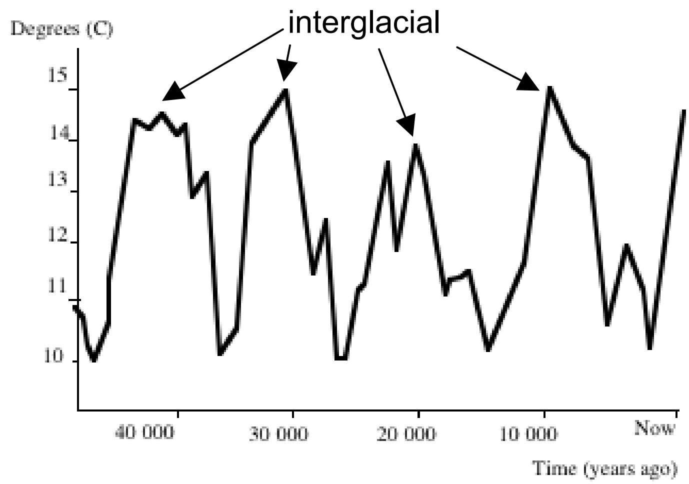
There is still more left unexplained!

THE IMPACT OF CLIMATE CHANGE.

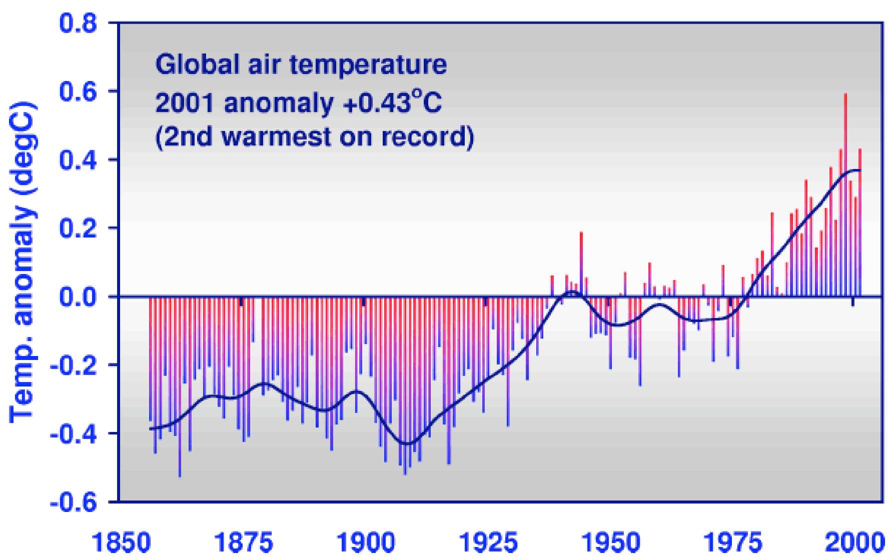
Measurements indicate the planet is getting warmer. It has happened in the past, but these temperature variations were more than likely part of the natural cycles related to volcanic activity or ice ages.

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.

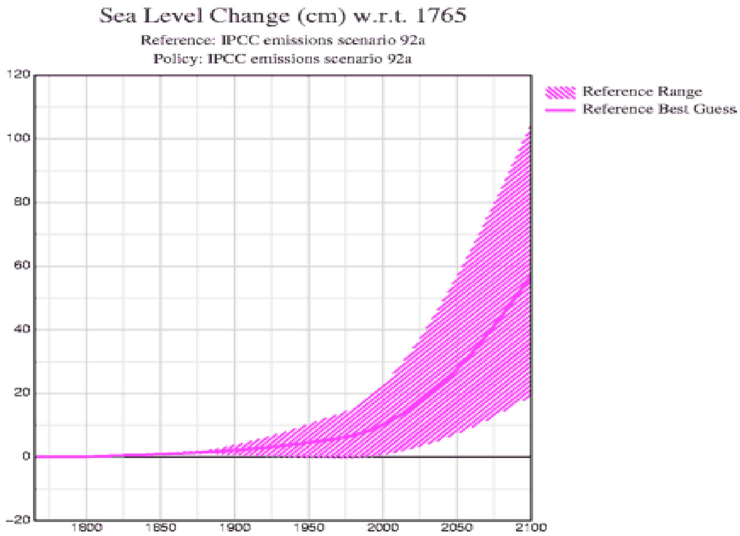
One in ten year weather events such as El Nino patterns, or even one in one hundred year events will become more frequent. Weather extremes will become common place.

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?

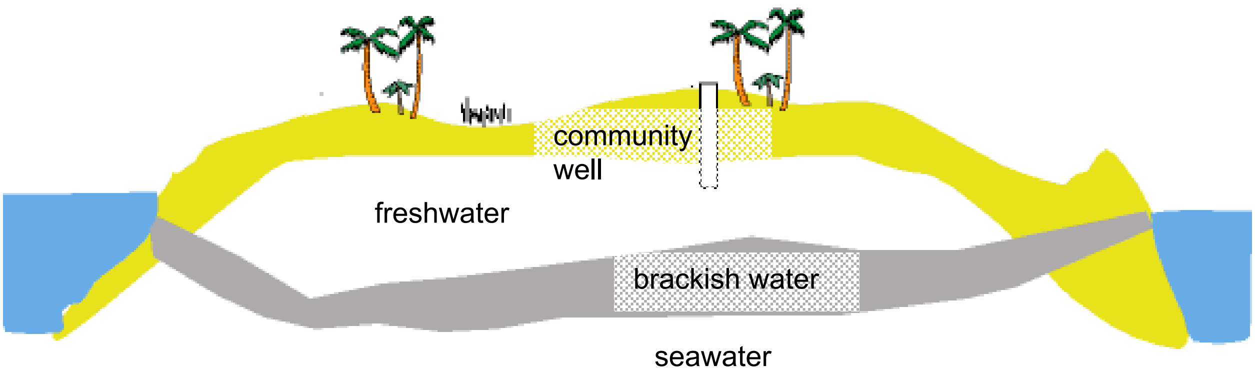
For the Pacific Islands, coral reefs in particular are under threat. As sea levels rise so the water over the coral reefs becomes deeper and the plant algae die through being unable to cope with less light and higher temperatures. The relationship between the algae and animal life that make up the coral 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.

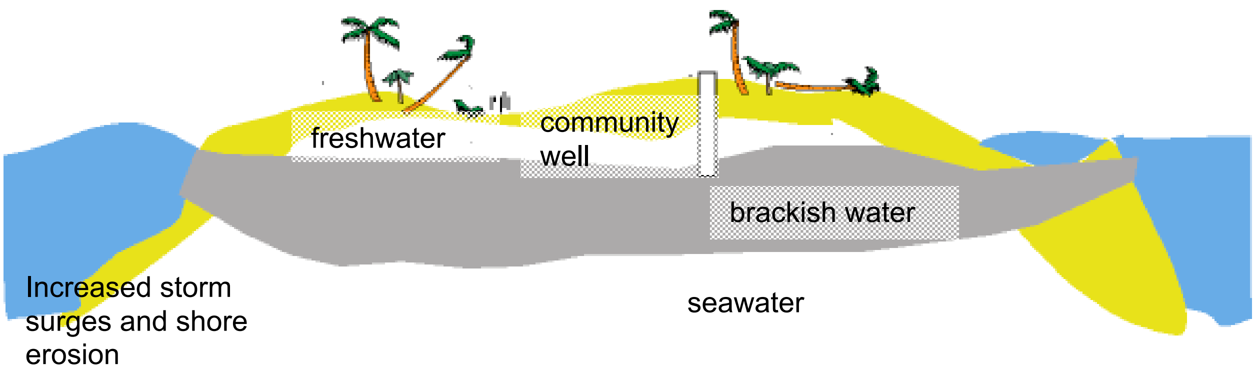
The land that makes up the island's landmass is usually porous. That means freshwater can filter through them. This is a natural way for water to be stored. The layer of freshwater stored this way is called an aquifer.

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?

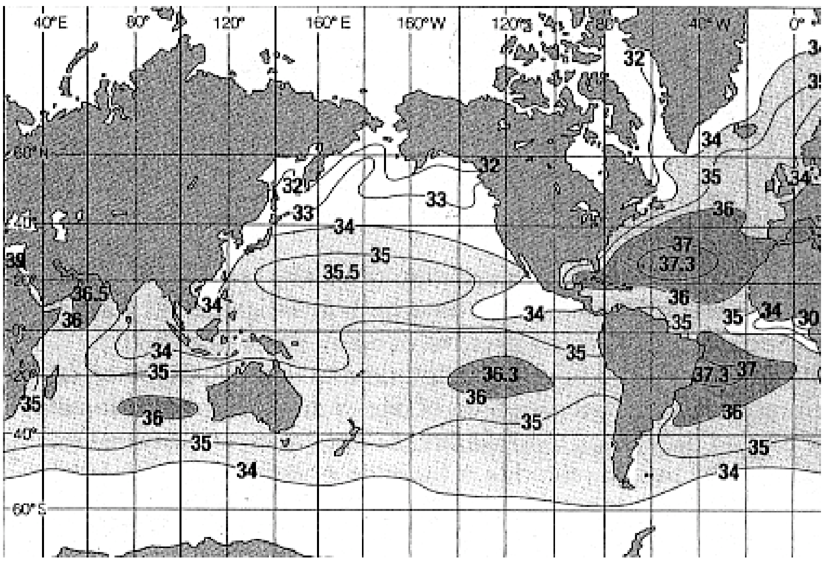
Most people would distinguish between seawater and fresh water by the fact that one of them tastes salty. That's true but there is more to it than that!

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.)

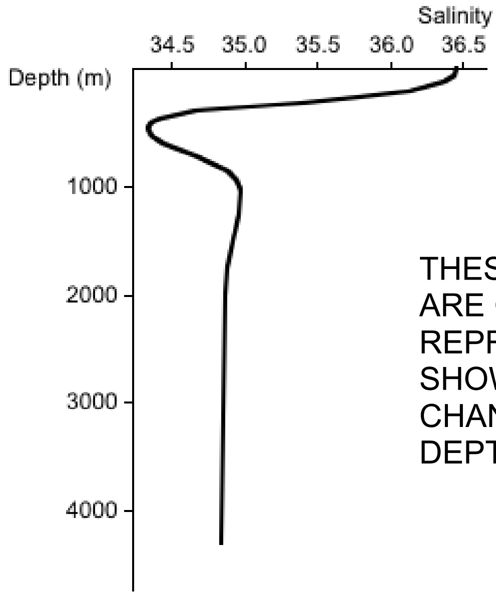


THE MAP SHOWS SURFACE SALINITY PROFILES ACROSS THE PACIFIC OCEAN

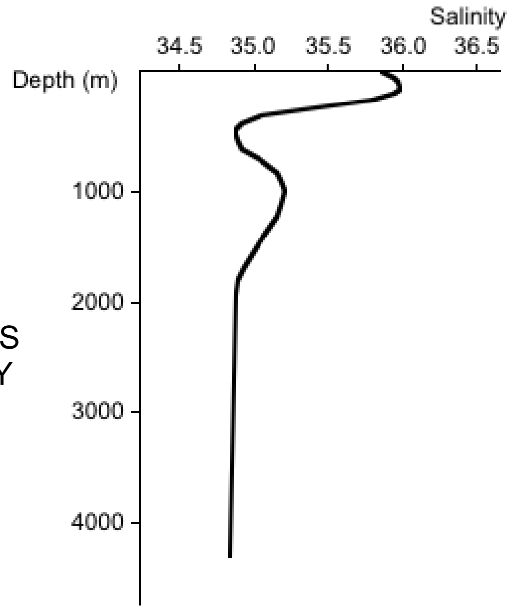
Key: Each number represents the weight of salts per litre of water

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.



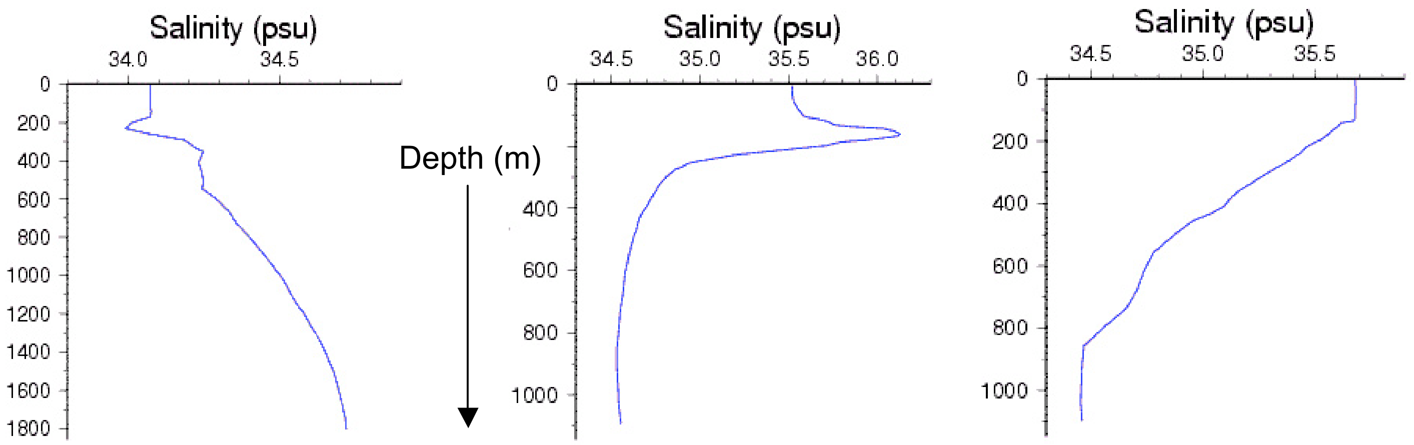
THESE DIAGRAMS ARE GRAPHICAL REPRESENTATIONS SHOWING SALINITY CHANGING WITH DEPTH



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.