Leeuwin Current - Reading

Leeuwin Current

At 5,500 kilometres, the Leeuwin *is* our longest ocean current!

One of Australia's most influential natural features, the Leeuwin Current, has been confirmed as the longest continuous coastal current system in the world.
Marine scientists have linked what was originally thought of as three separate coastal currents, with the same oceanographic signature, from Western Australia's North West Shelf to South Cape in southern Tasmania.
"The intriguing aspect is that the current remains connected at all because very different factors must act together with perfect timing."

- large-scale circulation in the Indian Ocean sets up the flow off WA and delivers it to the south coast, just as the seasonal winds change direction and push it further to the east
- The Leeuwin is one of four currents influencing life in the Australian region, by regulating rainfall and temperature, fostering coastal recreation and distributing marine species
- currents and associated ocean eddies, which spin from it, govern nutrient distribution to the food chain and distribution of larvae from seafood species such as salmon and the western and south-eastern rock lobsters

The Leeuwin originates near North West Cape in Western Australia and flows southward towards Cape Leeuwin before turning eastwards into the Great Australian Bight

From south-eastern South Australia it was known as the South Australian Current and flowed to north western Tasmania

It then turned south again down the Tasmanian west coast to become the Zeehan Current, reaching as far as South Cape — and in winter flows north as far as the Freycinet Peninsula

This current had been shown, in earlier research, to be vital to a range of ecological mechanisms; it provides a free ride for many marine species, assisting their migration and subsequent distribution, from the tropical north to the temperate southern waters.

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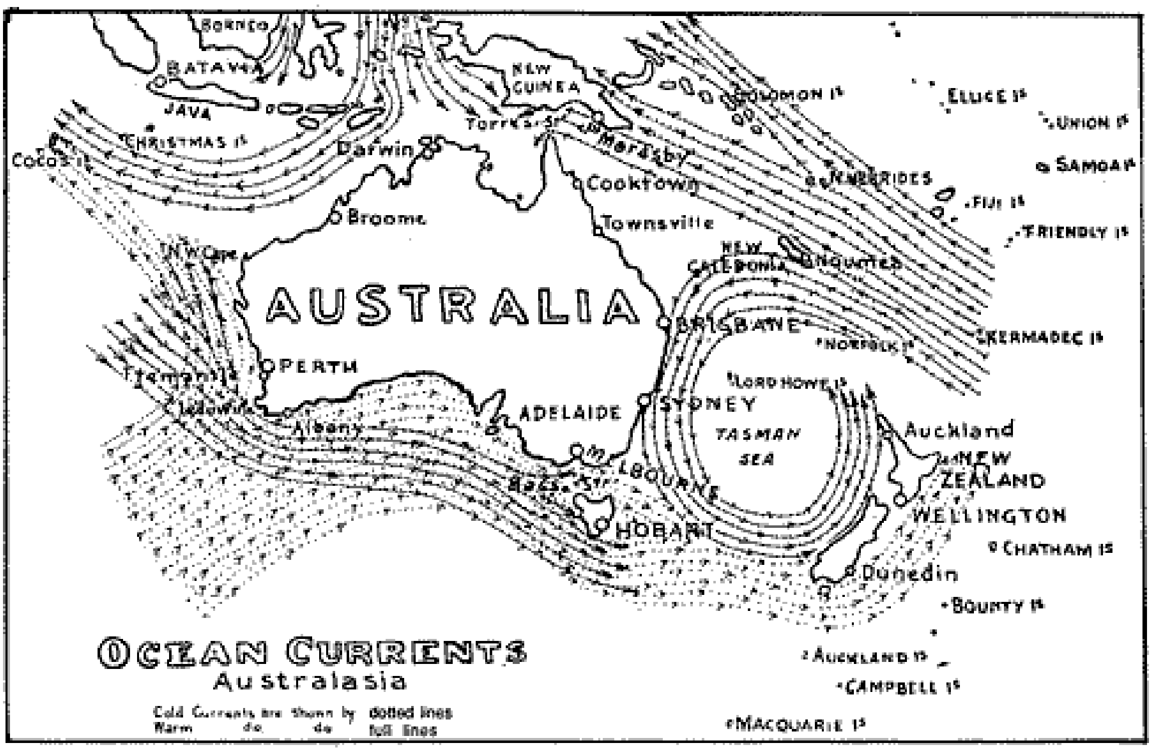

Australia is influenced by four major ocean currents:

- The Leeuwin Current
- The East Australian Current — southward flowing from near Fraser Island to Tasmania
- The Indonesian Through flow — a system of westward flowing currents from the Pacific to the Indian Ocean
- The Antarctic Circumpolar Current — the world's largest ocean current and considered the powerhouse for global climate.

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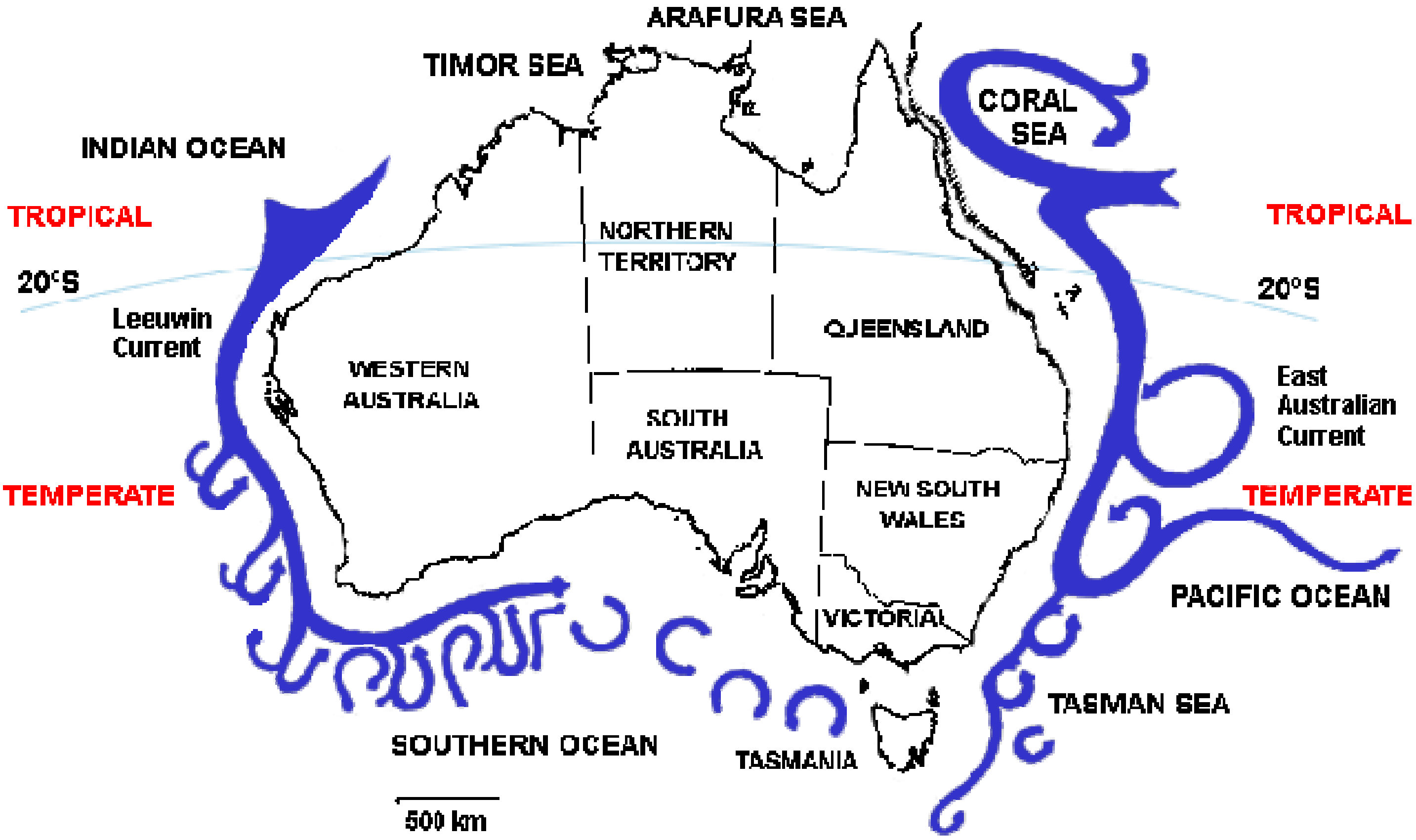
The Leeuwin Current takes an opposite course to geographically-similar currents which flow northward up the **African (Benguela)** and **South American (Humboldt)** continents.
Partly formed from the system of currents draining the Pacific Ocean into the Indian Ocean, through Indonesia, its characteristics are detectable throughout the course of its long winter journey

The journey is governed by seasonal conditions and prevailing winds, with the current generally following the edge of the continental shelf

- The southward flow of the Leeuwin is weakest from November to March when the winds tend to blow strongly northwards and reaches its greatest flow in autumn and winter, when the opposing winds are weakest.
- The Leeuwin Current is about 300 m deep (quite shallow for a major current system, by global standards), and beneath it is a northwards counter-current called the Leeuwin Undercurrent



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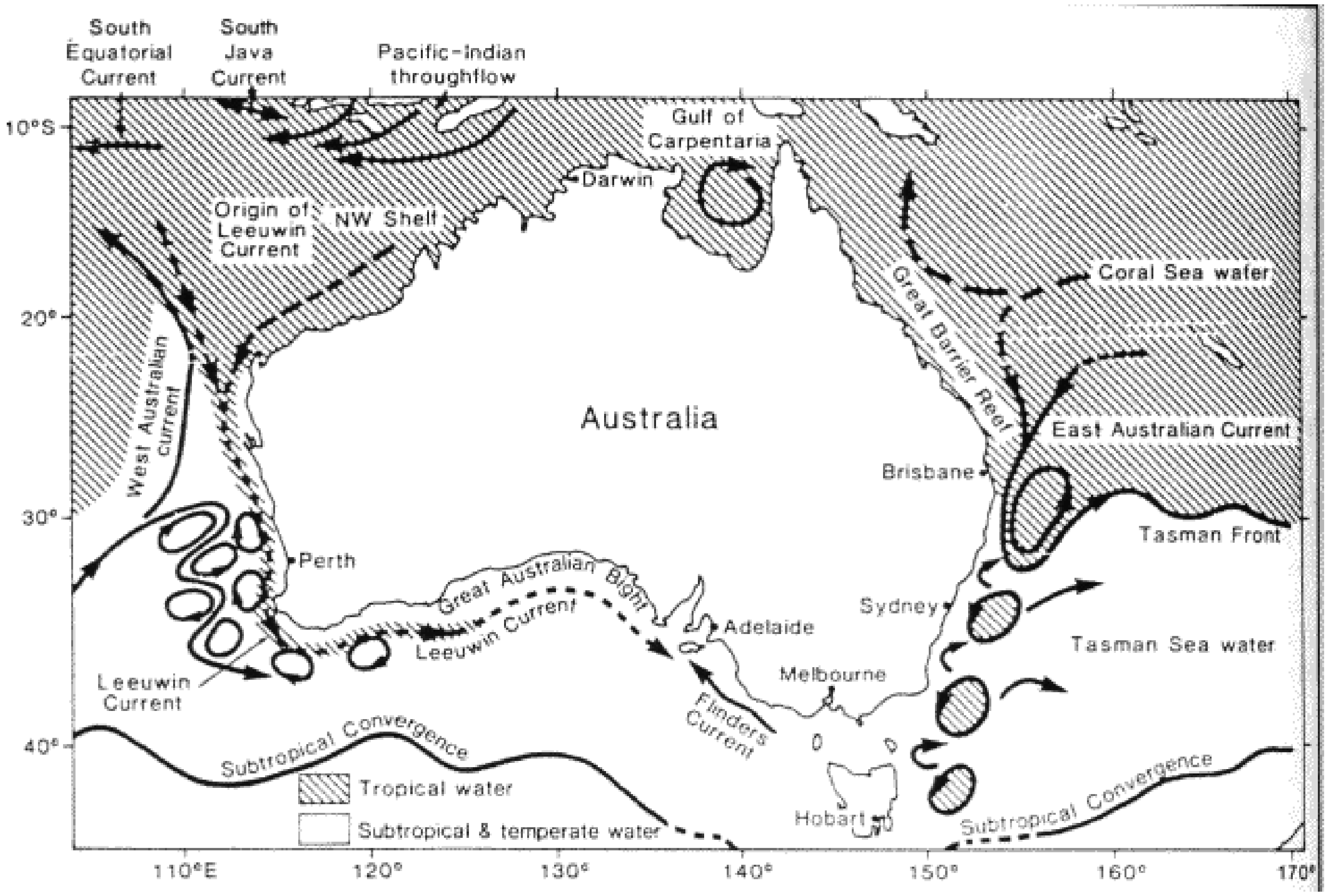
SEC - South Equatorial Current:



SEC South Equatorial Current
BSW Bass Strait Waters
EAC East Australian Current
LC Leeuwin Current
IOI Indian Ocean Inflow
TF Tasman Front
SAW Subantarctic Waters

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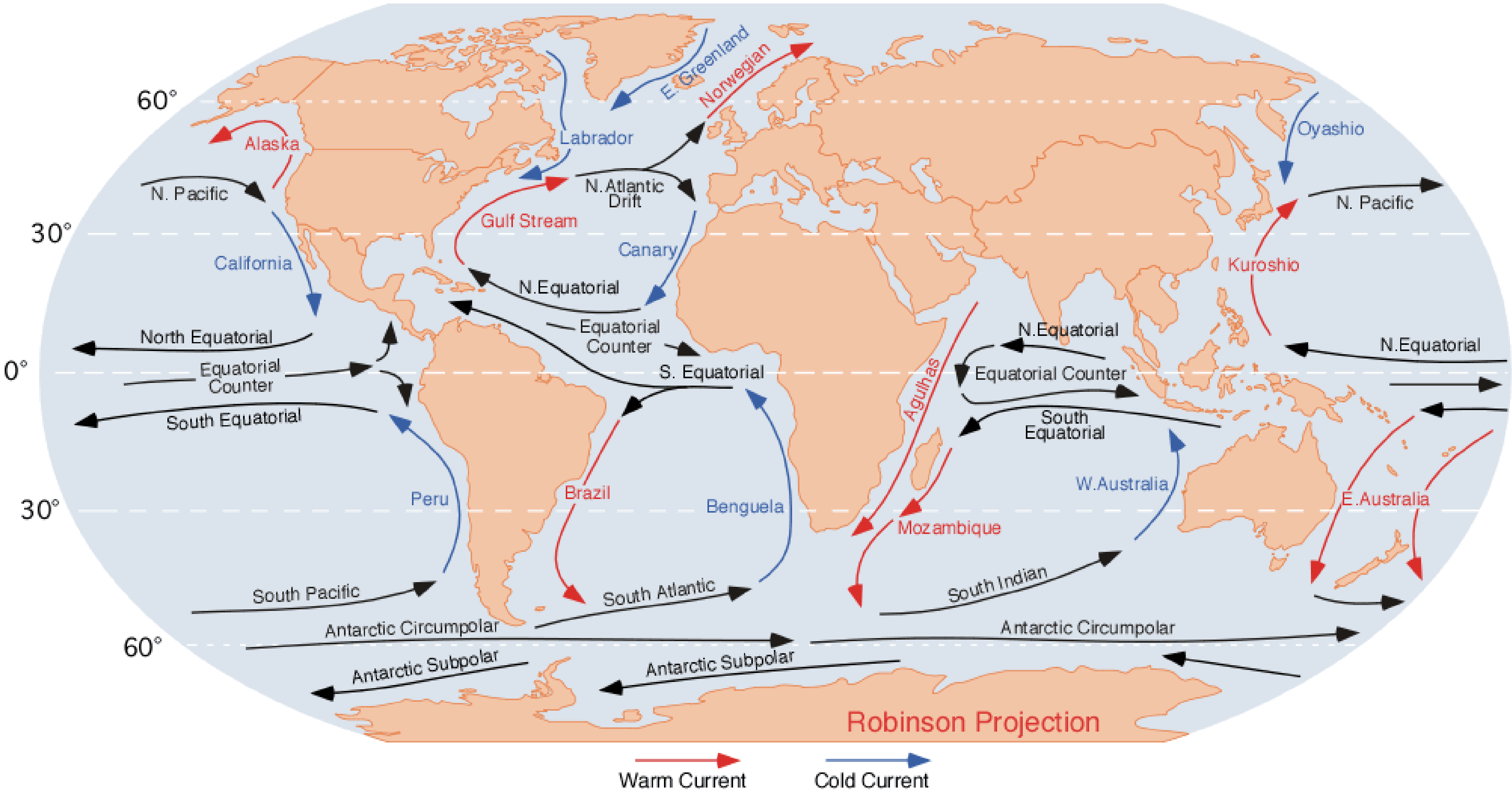
Map of the World's Ocean Currents:



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When it rains, blame ocean currents:

- Indian Ocean currents influence rainfall in Australia and Indonesia
- Potentially the biggest payoff of these findings will be its use with atmospheric data to better predict major weather events, including El Nino and La Nina phenomena, which have devastated communities over ages with droughts, floods and fires

Near the end of each year, as the southern hemispherical summer is about to peak, a weak, warm counter-current flows southward along the coasts of Ecuador and Peru, replacing the cold Peruvian current.

Centuries ago the local residents named this annual event El Niño (Spanish for "the child"), based on Christian theology.

Normally, these warm counter-currents last for, at most, a few weeks when they again give way to the cold Peruvian flow

However, every three to seven years, this counter-current is unusually warm and strong. Accompanying this event is a pool of warm, ocean surface water in the central and eastern Pacific

Forces Causing Surface Currents:

Winds blowing across the surface of the ocean create friction that sets water in motion. Motion is a function of wind speed and, consequently, of the energy transferred to the ocean's surface (e.g. a 15m/s wind may create only a 0.5m/s current). Winds moving across the ocean surface also raise sea level downwind. The surface of the tropical Pacific is 50cm higher off Asia than off South America.

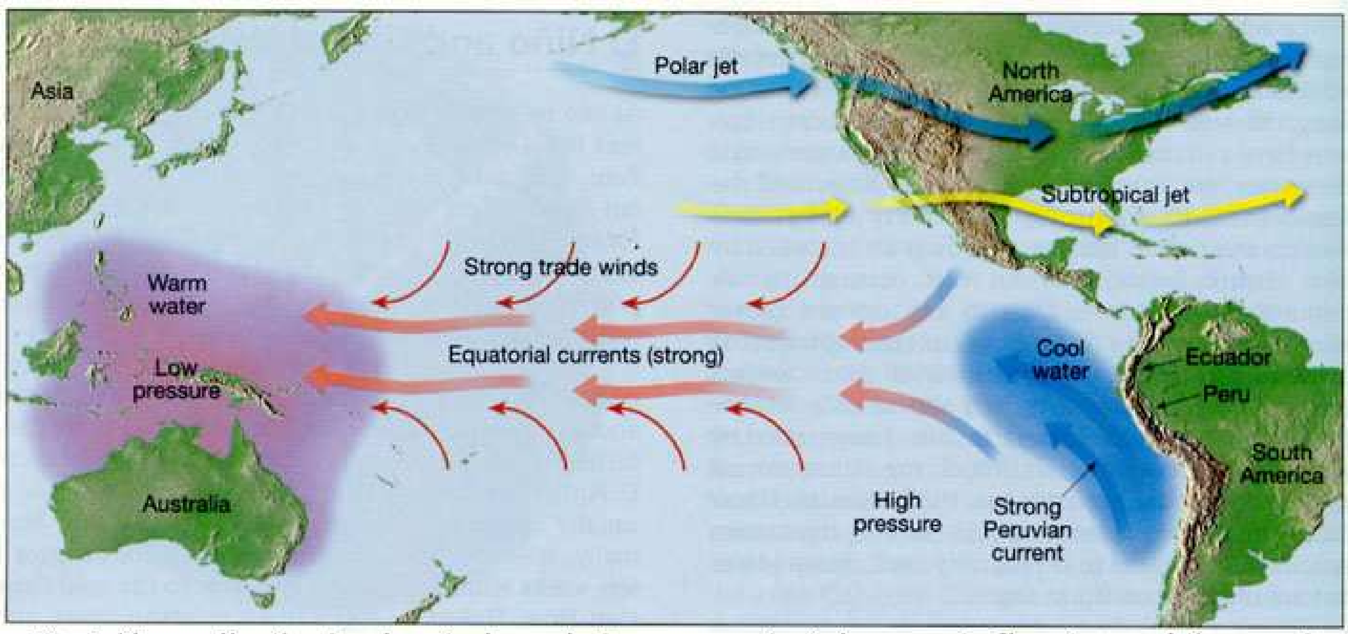

Fig.6 Normally, the trade winds and strong equatorial currents flow toward the west. At the same time, an intense Peruvian current causes upwelling of cold water along the west coast of South America.

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The Peruvian (Humboldt) Current:

- The cold Peruvian current (an eastern boundary current) flows towards the equator, along the coast of Ecuador and Peru. It flows with a speed of 0.1 to 0.15[m/s].
- As an eastern boundary current it is slow and thus not very strong.
- Near the coast, it is only about 200m deep, while increasing to 700m offshore.
- In the absence of an El Niño, prevailing surface winds cause Ekman transport away from the coast, with subsequent upwelling.
- This upwelling of deep, nutrient-filled waters is the primary food source for millions of fish, particularly anchovies along the Pacific Coast of South America.

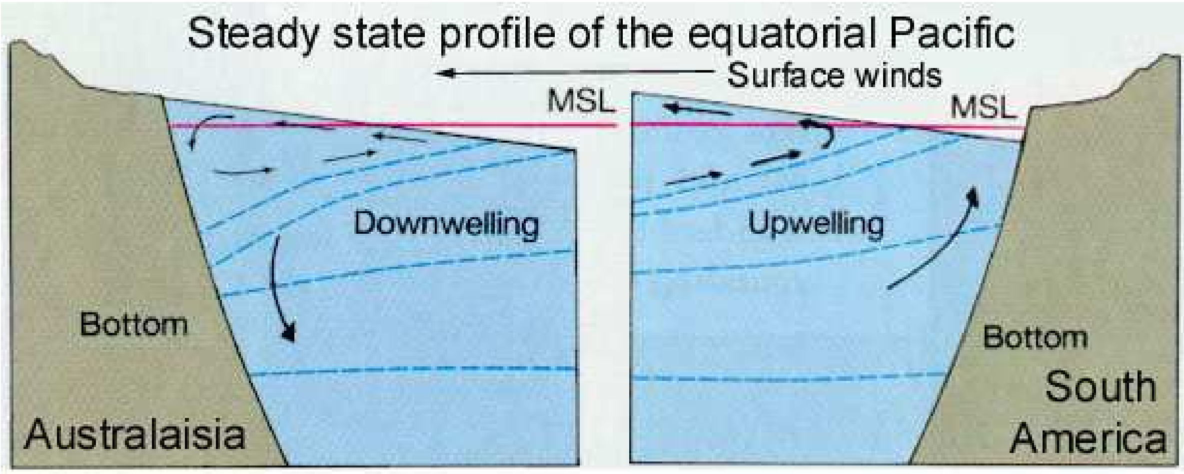

Fig7. For downwelling to occur (according to Ekman), a southbound wind must be present - this is the case at the east coast of Australia; while a northbound wind must blow at the west coast of South America for upwelling to take place.

1. Upwelling commonly occurs in the eastern regions of the oceans
2. In the Southern Hemisphere the winds must blow north for upwelling to occur (usually happens during the northern winter)
3. Coastal upwelling of this sort takes place because the South-American west coast sharply drops off to considerable depths. Prevailing, converging westward surface winds causes the water beneath to converge as well
4. Where water parcels meet in a convergence, they form a slight hill, thickening the surface layer
5. The mixed water is usually of higher density than the surrounding water, and consequently it sinks
6. Because the Peruvian current steadily feeds its waters into the westward surge, it creates an equatorial divergence zone
7. In such a divergence, the surface waters move away from one another causing deeper waters to move up to the surface
8. This action thins the surface layer and usually (adiabatically) lowers its temperature further

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Major El Niño events related to large-scale atmospheric circulation:

Each time an El Niño occurs, the barometric pressure drops over large portions of the south-eastern Pacific, whereas in the western Pacific, near Indonesia and northern Australia, the pressure rises. As a major El Niño event comes to an end, the atmospheric pressure difference between these two regions swings back in the opposite direction. This see-saw pattern of atmospheric pressure between the eastern and western Pacific is known as the "Southern Oscillation".

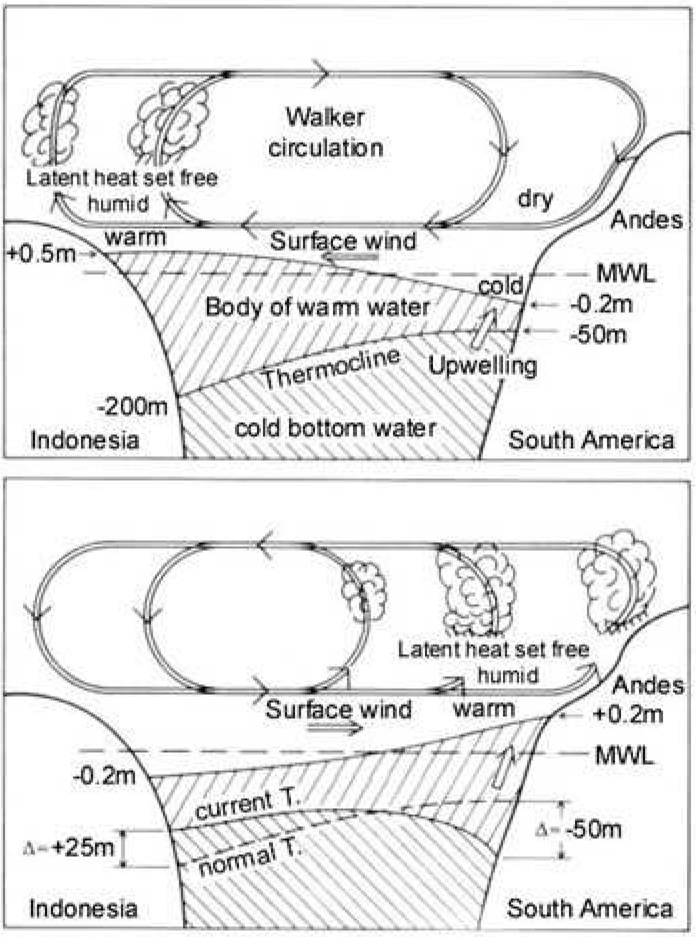

Fig.11 Idealized schematic diagram reflecting the ENSO Phenomenon. Normal non-ENSO conditions are shown above, while a the climax of a ENSO event is pictured below. In either cases both the slope of the sea level as well as the thermocline change considerably.

- parts of the Pacific Ocean are characterized by high air-pressure systems and low rainfall
- equatorial regions of the Indian Ocean are, at the same time, characterized by low air pressure and abundant rainfall
- The existing high pressure system in the eastern Pacific forces trade winds to blow toward the moist, low-pressure system residing over Indonesia
- These westward trade winds maintain the ocean surface-currents moving towards Indonesia and cause water to pile up in the western Pacific, causing the sea level in south-east Asia to rise as much as 46cm higher than along the west coast of South America

In the months preceding an El Niño event, the normal weather pattern breaks down

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Effects of El Niño:

- marked by abnormal weather patterns that drastically affect the economies of Ecuador and Peru
- abnormally strong winds, originating from the west push masses of warm surface water from the equatorial region against the South-American coast, and are ultimately deflected towards Mexico, Peru, and Ecuador, creating an area of warm water thousands of kilometers in length
- mixed layers deepen, and the deeper cold waters are buried underneath
- sun warms the surface layer still further, thus enhancing the effect
- thermocline falls, and along with it the pool of nutrient rich water
- in an immediate effect, this warm blob of water blocks off the upwelling of colder, nutrient rich water driving anchovies into starvation
- in a long-lasting ENSO event, the dissolved seawater oxygen content becomes depleted. This favours production of foul-smelling hydrogen-sulfide and other gases, blackening the "lead paint" on ships and producing other discolouring effects (**Callao Painter)** at the same time, some inland areas that are normally arid receive an uncommon abundance of rain
- here pastures and cotton fields have yields far above the norm. These climatic fluctuations have been known for years, but were always considered local phenomena

El Niño is part of the global circulation and affects the weather patterns far beyond Peru or Ecuador

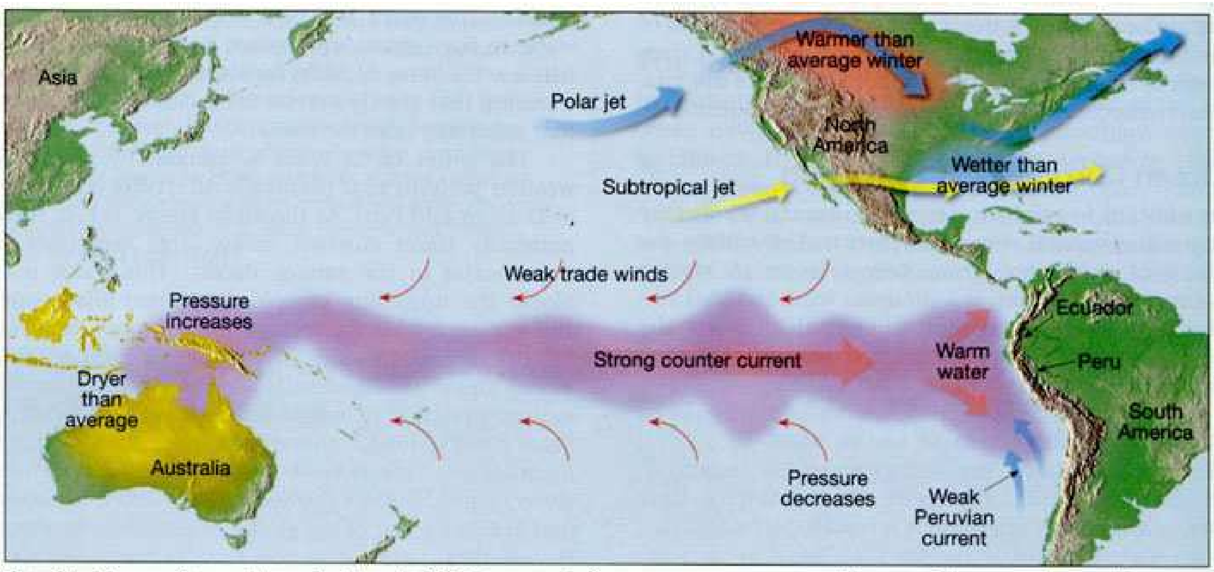

Fig.14 Upon the advent of an ENSO event, the pressure over the eastern and western Pacific flip-flops. This causes the trade winds to diminish, leading to an eastward movement of warm water along the equator. As a result, the surface waters of the central and eastern Pacific warm, with far-reaching consequences to weather patterns.

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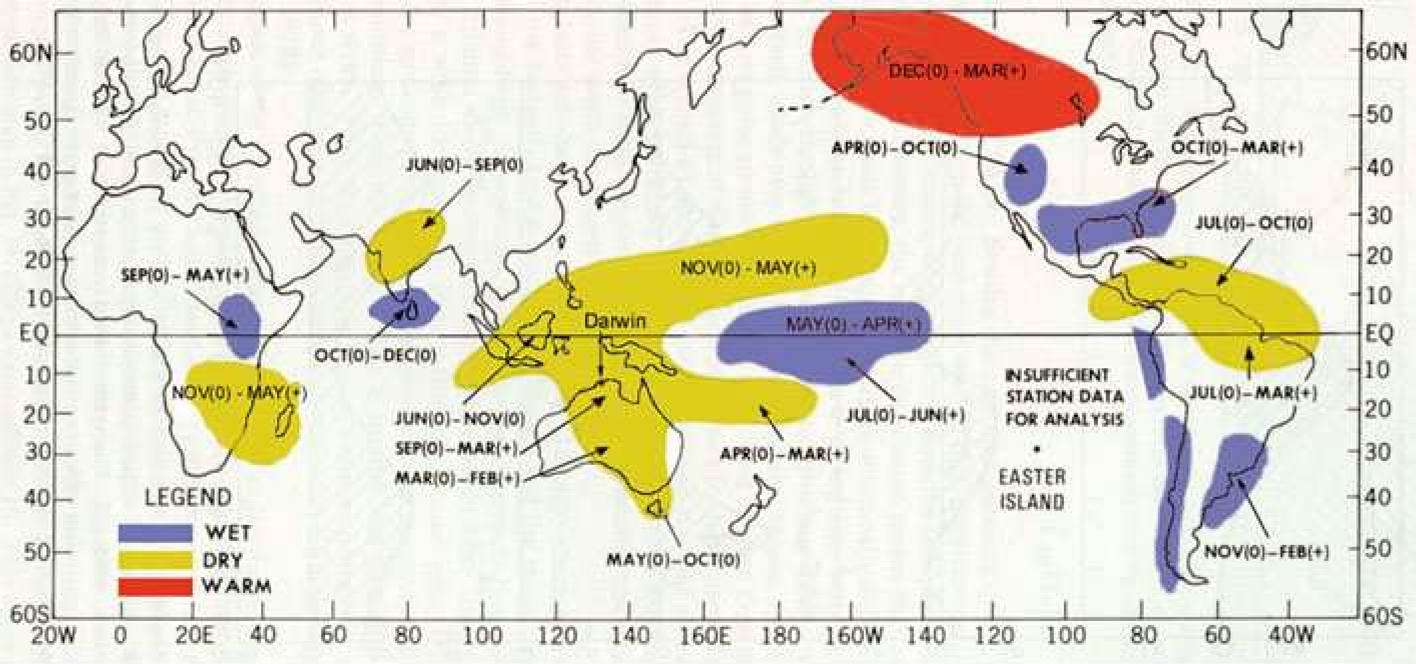
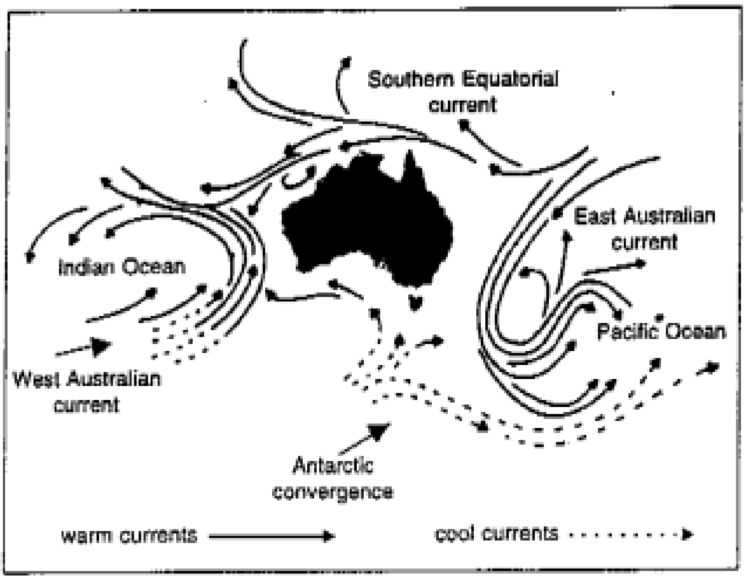


Fig.16 Schematic representation of typical ENSO-related precipitation anomalies over the globe. Red encloses relatively warm regions and blue encloses relatively wet regions. The approximate period of extreme conditions relative to the typical El Nino year (0) is also shown (adapted from Peixoto 1993)



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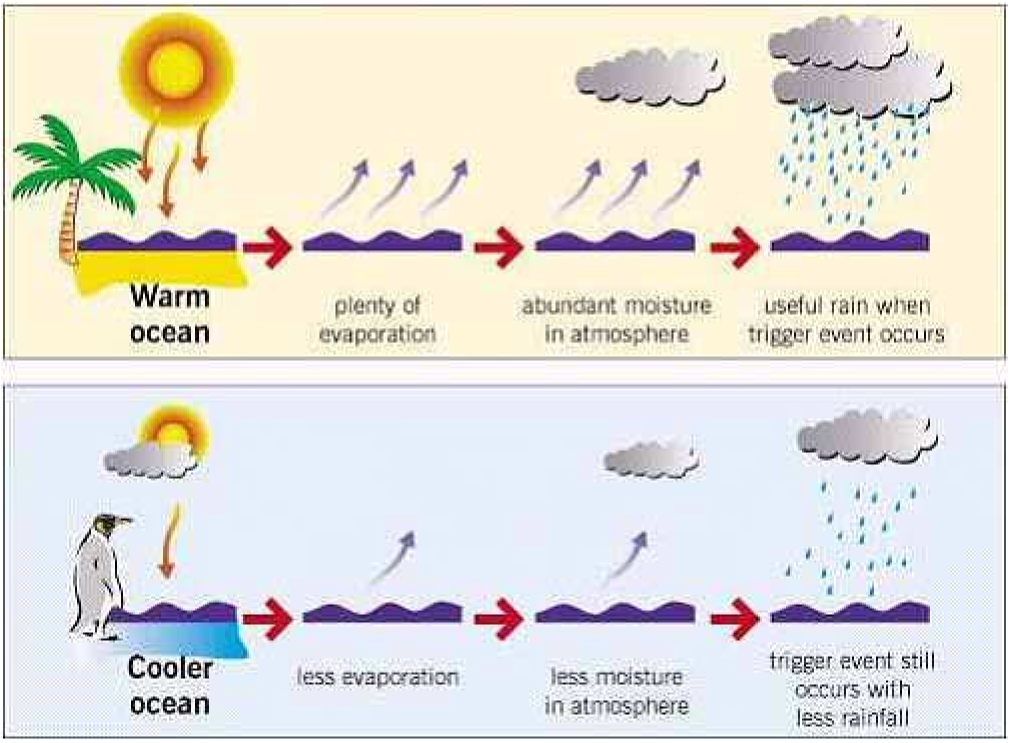
El Niño - a sustained warming, in excess of 1° C above normal, of the central and eastern tropical Pacific ocean, typically centred around the NIÑO 3 region (see Fig. 20). This warming is usually accompanied by negative values of the SOI, a decrease in the strength of the Pacific Trade winds, and a reduction in rainfall over eastern and northern Australia, which often results in drought. The most recent strong El Niño began in Autumn 1997 and ended Autumn 1998.

La Niña - a sustained cooling, in excess of 1° C below normal, of the central and eastern tropical Pacific Ocean, typically centred around the NIÑO 3 region (see Fig. 20). This cooling is usually accompanied by positive values of the SOI, an increase in the strength of the Pacific Trade winds and higher than normal rainfall over eastern and northern Australia, sometimes with serious flooding. The most recent strong La Niña was in 1988/89; a fairly weak event occurred in late 1995 and through much of 1996.



Sea surface temperatures (SSTs) off the West Australian coast may also be useful in estimating the probability of rain over the continent. SSTs in summer and autumn have an effect on the probability of rainfall in early winter over parts of southern and eastern Australia, through the formation of north-west cloud-bands

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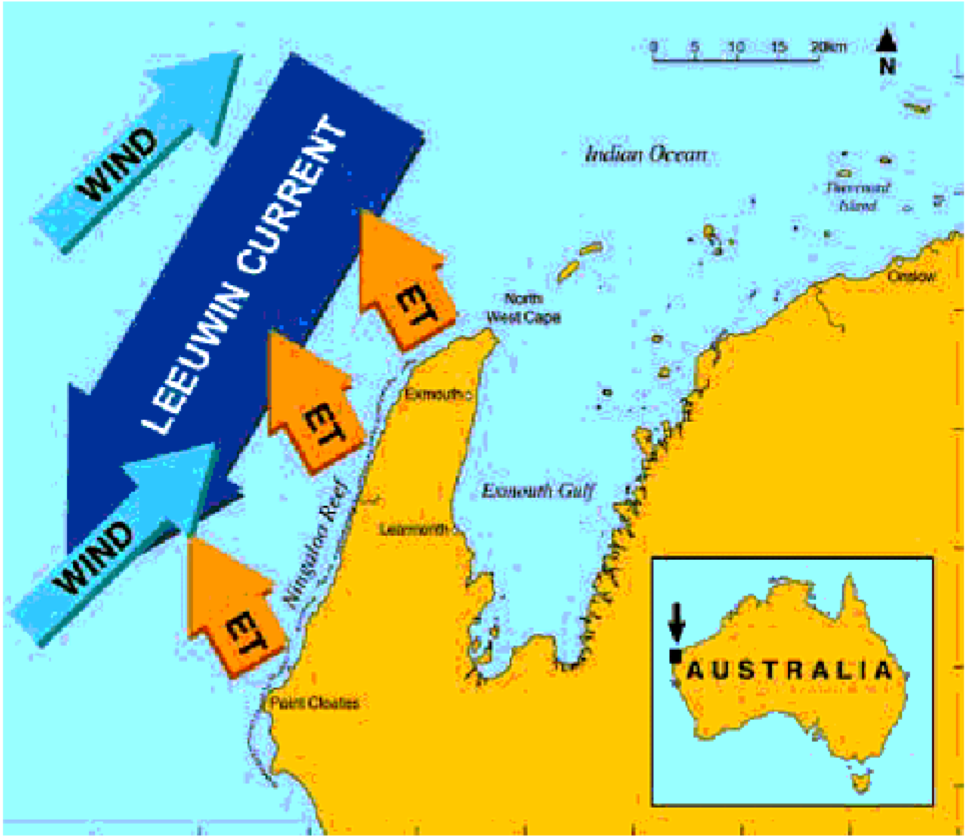


1. Prevailing winds in the area of North West Cape are from the south-west
2. This has the effect of forcing surface waters offshore, in a process known as Ekman Transport (ET)
3. This facilitates upwelling, in which cold nutrient-rich waters from the deep Indian Ocean are brought to the surface, fuelling the production of phytoplankton
4. **However, the antagonistic effect of the Leeuwin Current prevents this in La Nina years**
5. **In El Nino years, the Leeuwin Current is weaker, and there is more upwelling and hence higher phytoplankton production**

Leeuwin Current - Reading

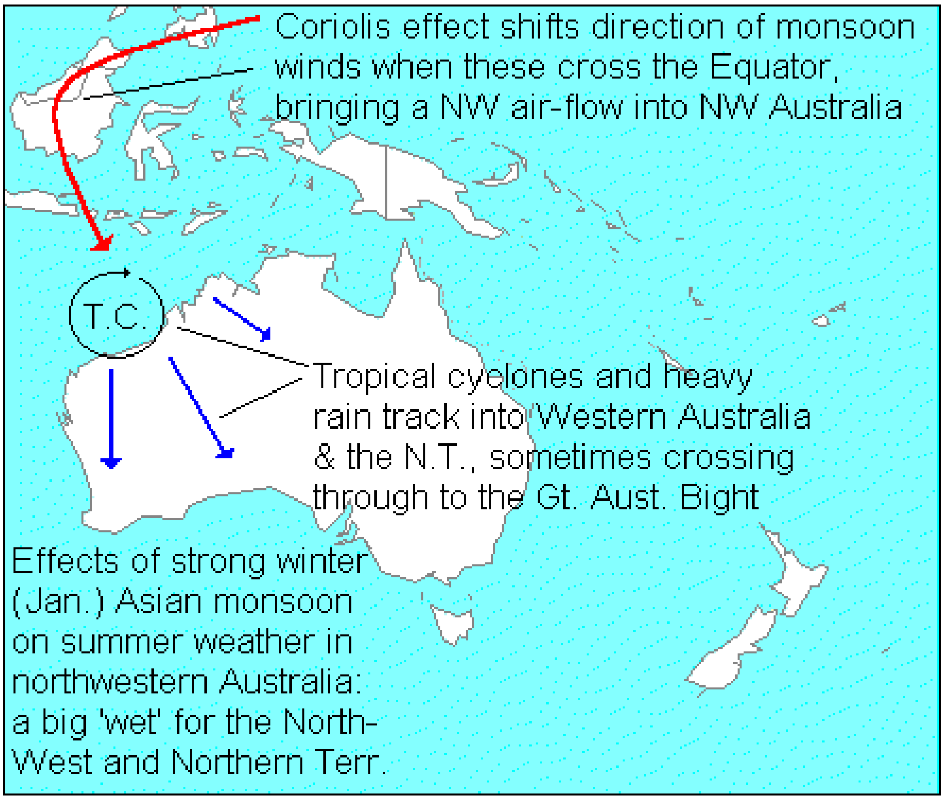
In recent years two major regional influences on Australia's weather and climatic conditions have been identified.
These are the:

1. strength of the winter Asian monsoon
2. phenomenon known as 'El Nino' or the 'Southern Oscillation'

Asian (winter) monsoon

In the period December to March, the Tibetan region of Central Asia becomes the site of an intense high pressure system (which means a strong high is located there most of the time).

In the Northern Hemisphere, high pressure systems create clockwise spiralling winds. In some years this winter Asian monsoon (the summer one is based on a low pressure system in the same region, with winds moving in the reverse direction) is very strong. Figure 1 illustrates the winter Asian monsoon.



When the winter Asian monsoon is strong, winds pass over the equator and reverse their direction of movement (due to the reversal of the Coriolis Effect when you cross the equator); these now north-westerly winds spill over into north-western Australia.

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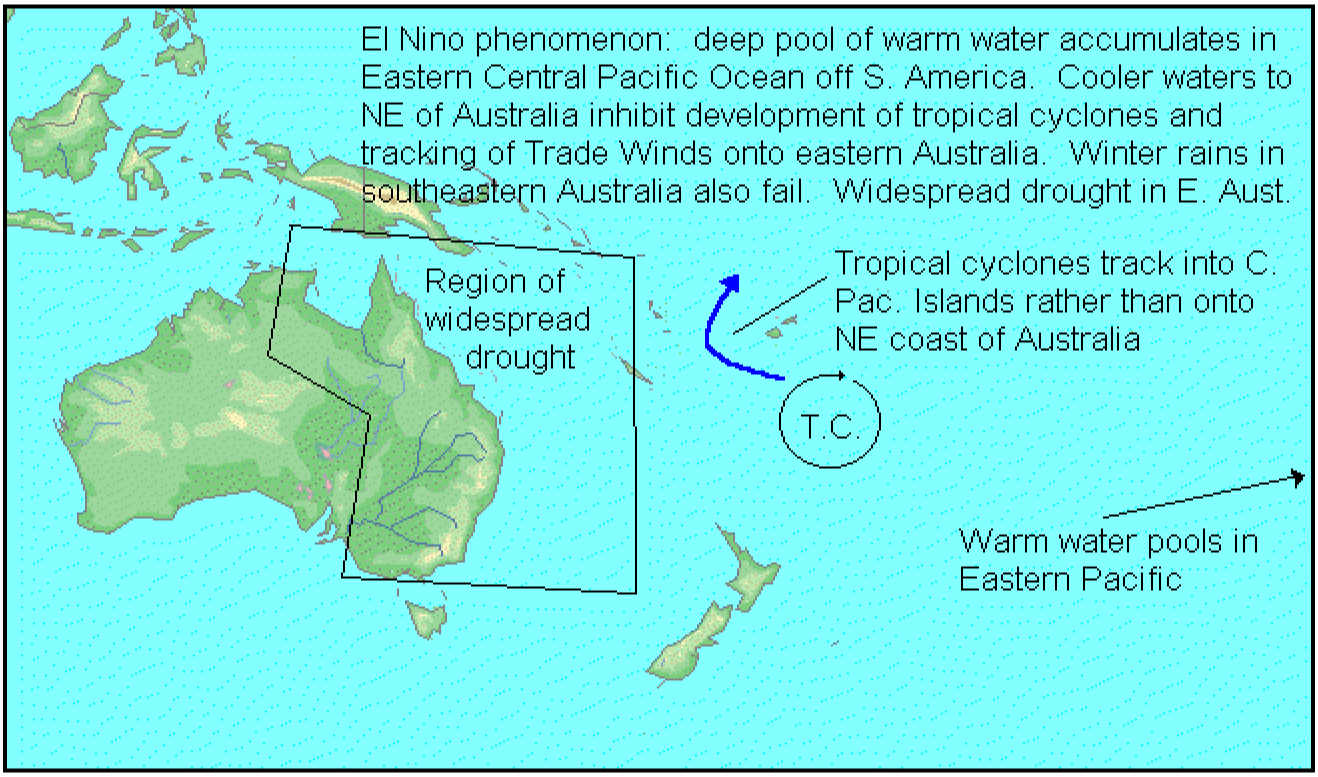
This happens in our summer months, and tends to push both rain-bearing winds and tropical cyclones into north-west Western Australia and adjacent parts of the Northern Territory. These conditions are likely to help create a 'big wet' in that part of the country, which is otherwise **not** strongly correlated with the effects of El Nino/La Nina.



During the early- to mid-1970's a series of what are now recognised as La Nina years occurred, giving exceptionally high rainfall over much of eastern Australia at that time.

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