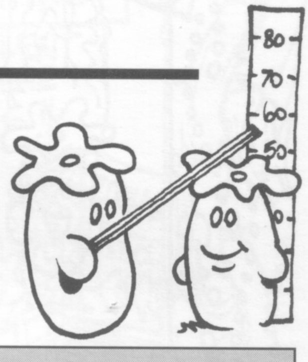
Coral growth

How fast does coral grow?



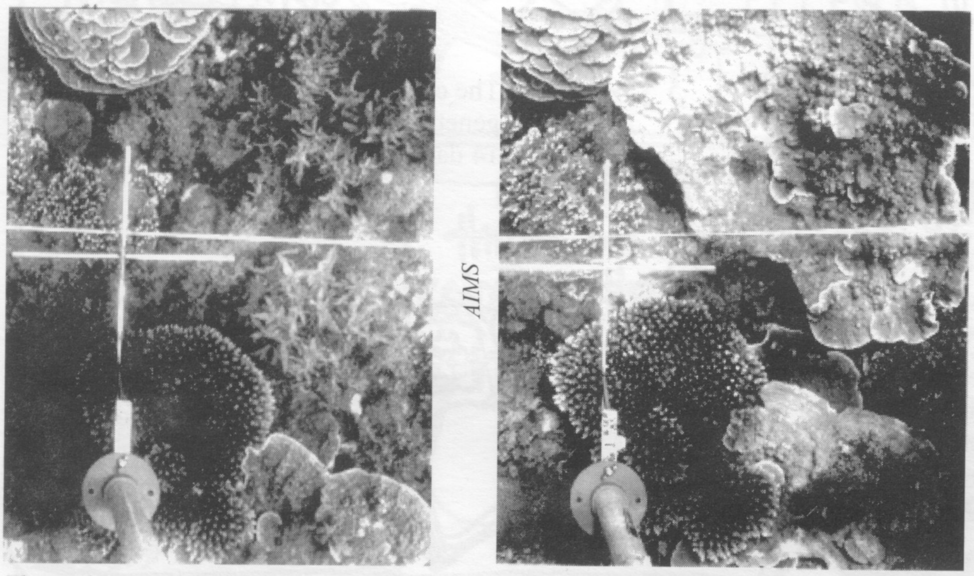
The short answer is 1-3cm a year for *Porites* and other massive coral colonies such as brain corals and 3-10cm a year for the branching corals such as the staghorns (*Acropora* sp.).

However, that's the average. Staghorn corals, which are about the fastest-growing of all corals, can increase their branch lengths by as much as 15cm in a year. Researchers who photographed the same patch of reef, each year for 10 years, found that growth rates were very unpredictable. Some corals grew and died back, sometimes by as much as 60 percent, only to then regrow. One *Montipora* coral (see photos) which had been growing steadily at the rate of about 1-2cm a year, suddenly added more than 40cm in 12 months.

Growth rates depend, to a certain extent, on conditions:
Available sunlight: This is necessary for the plant cells which live within the coral and is affected by depth, cloud cover and water clarity.
Temperature: Coral grows best in water temperatures between 20deg. and 26deg. Above and below these temperatures coral growth slows and in temperatures just slightly above the normal average they can bleach and die.
Distance from the shore: Some corals flourish in turbid (unclear) water while others require clear water. Therefore, some species grow better inshore than on the outer reef and vice versa.
Latitude: Light and temperature vary with latitude. In addition, turbid water extends further from the coast in the south of the Great Barrier Reef than in the north.
Pollution: Sewage, oil spills and agro-chemicals all affect coral growth.

Different types of coral colonies grow in different ways. Those which grow as sheets add polyps to the edges of the colony while branching corals add more branches, one single polyp growing increasingly longer and budding new polyps around its top as it extends. In mound-like colonies polyps are added within the surface of the mound. As the structure grows outwards, each polyp pulls itself up and lays down a new 'floor' of skeleton, the thickness of which depends on environmental factors. The accumulation of these layers can be used to calculate the age of the coral.

Spot the difference!



These photos were taken one year apart. Most corals had grown a little, but Montipora, *top right, had expanded dramatically in the second photo.*

Young, robust but vulnerable

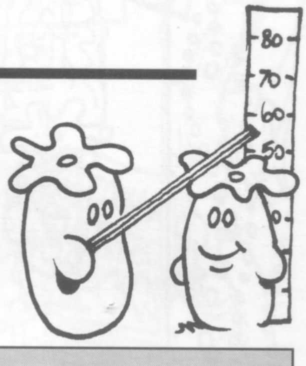
Until recently, it was thought that the Great Barrier Reef was several million years old. However, by drilling into the rock below the present reef, Prof. Peter Davis and a team from the University of Sydney showed that it was, instead, a mere half million years old. Although that makes it the youngest coral reef system in the world, it has grown to be the largest.

The past half million years, however, have not been a time of continuous growth. During the Ice Ages, when sea levels fell, the continental shelf became a dry plain through which rivers meandered. Former reefs became limestone hills which were eroded by the weather. At the end of each Ice Age, when the sea flooded back on to the continental shelf, new corals (having survived on raised areas beyond the continental shelf) recolonised the bare hills. The reef we see today is a veneer which is a mere 8000-6000 years old, growing on top of previous reefs.

In general, the Great Barrier Reef, is a robust 'creature'. Having been destroyed more than a dozen times during the period of its existence by fluctuating temperatures and sea levels, it has always bounced back. However, it is now being affected by human pressures. Pollution and physical threats such as anchor, boat and fin damage can be damaging and now global warming, blamed on the rapid release into the atmosphere of large amounts of carbon dioxide previously held in fossil fuels, is blamed for widespread coral bleaching (see page 8). Increased carbon dioxide in the atmosphere is also thought to be making sea water more acidic and thus making it harder for corals to form their skeletons.

Coral growth

How fast does coral grow?



The short answer is 1-3cm a year for *Porites* and other massive coral colonies such as brain corals and 3-10cm a year for the branching corals such as the staghorns (*Acropora* sp.).

However, that's the average. Staghorn corals, which are about the fastest-growing of all corals, can increase their branch lengths by as much as 15cm in a year. Researchers who photographed the same patch of reef, each year for 10 years, found that growth rates were very unpredictable. Some corals grew and died back, sometimes by as much as 60 percent, only to then regrow. One *Montipora* coral (see photos) which had been growing steadily at the rate of about 1-2cm a year, suddenly added more than 40cm in 12 months.

Growth rates depend, to a certain extent, on conditions:

Available sunlight: This is necessary for the plant cells which live within the coral and is affected by depth, cloud cover and water clarity.

Temperature: Coral grows best in water temperatures between 20deg. and 26deg. Above and below these temperatures coral growth slows and in temperatures just slightly above the normal average they can bleach and die.

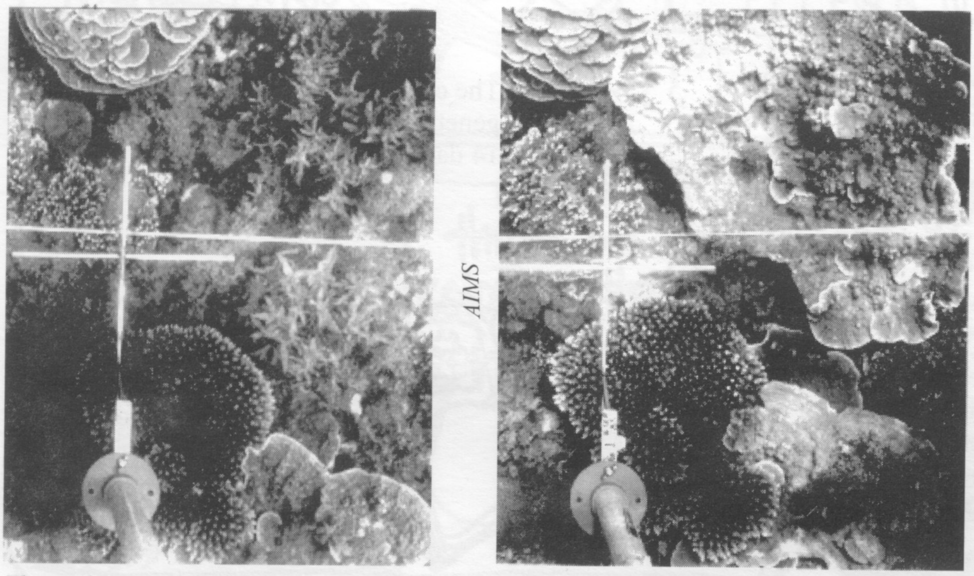
Distance from the shore: Some corals flourish in turbid (unclear) water while others require clear water. Therefore, some species grow better inshore than on the outer reef and vice versa.

Latitude: Light and temperature vary with latitude. In addition, turbid water extends further from the coast in the south of the Great Barrier Reef than in the north.

Pollution: Sewage, oil spills and agro-chemicals all affect coral growth.

Different types of coral colonies grow in different ways. Those which grow as sheets add polyps to the edges of the colony while branching corals add more branches, one single polyp growing increasingly longer and budding new polyps around its top as it extends. In mound-like colonies polyps are added within the surface of the mound. As the structure grows outwards, each polyp pulls itself up and lays down a new 'floor' of skeleton, the thickness of which depends on environmental factors. The accumulation of these layers can be used to calculate the age of the coral.

Spot the difference!



These photos were taken one year apart. Most corals had grown a little, but Montipora, *top right, had expanded dramatically in the second photo.*

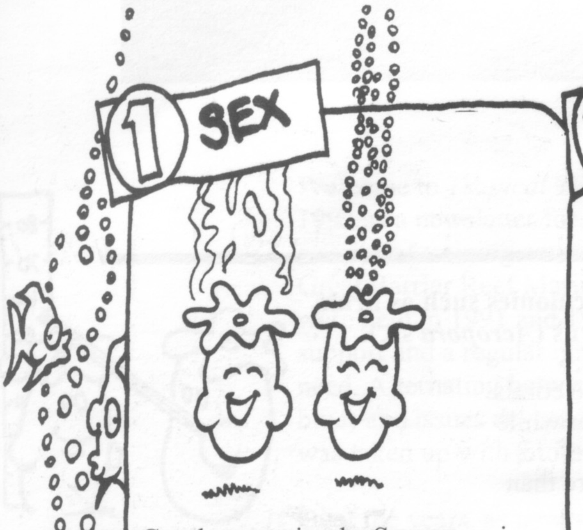
Young, robust but vulnerable

Until recently, it was thought that the Great Barrier Reef was several million years old. However, by drilling into the rock below the present reef, Prof. Peter Davis and a team from the University of Sydney showed that it was, instead, a mere half million years old. Although that makes it the youngest coral reef system in the world, it has grown to be the largest.

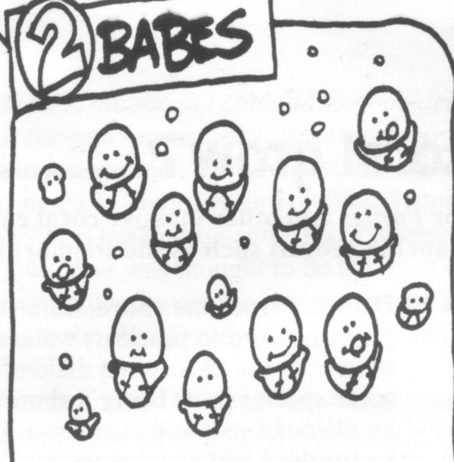
The past half million years, however, have not been a time of continuous growth. During the Ice Ages, when sea levels fell, the continental shelf became a dry plain through which rivers meandered. Former reefs became limestone hills which were eroded by the weather. At the end of each Ice Age, when the sea flooded back on to the continental shelf, new corals (having survived on raised areas beyond the continental shelf) recolonised the bare hills. The reef we see today is a veneer which is a mere 8000-6000 years old, growing on top of previous reefs.

In general, the Great Barrier Reef, is a robust 'creature'. Having been destroyed more than a dozen times during the period of its existence by fluctuating temperatures and sea levels, it has always bounced back. However, it is now being affected by human pressures. Pollution and physical threats such as anchor, boat and fin damage can be damaging and now global warming, blamed on the rapid release into the atmosphere of large amounts of carbon dioxide previously held in fossil fuels, is blamed for widespread coral bleaching (see page 8). Increased carbon dioxide in the atmosphere is also thought to be making sea water more acidic and thus making it harder for corals to form their skeletons.

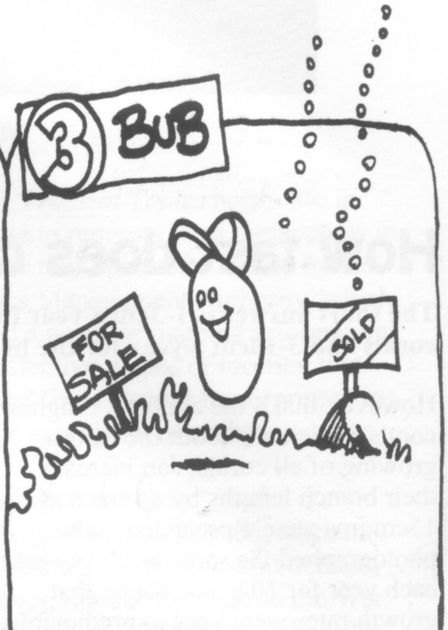
It's a coral's life



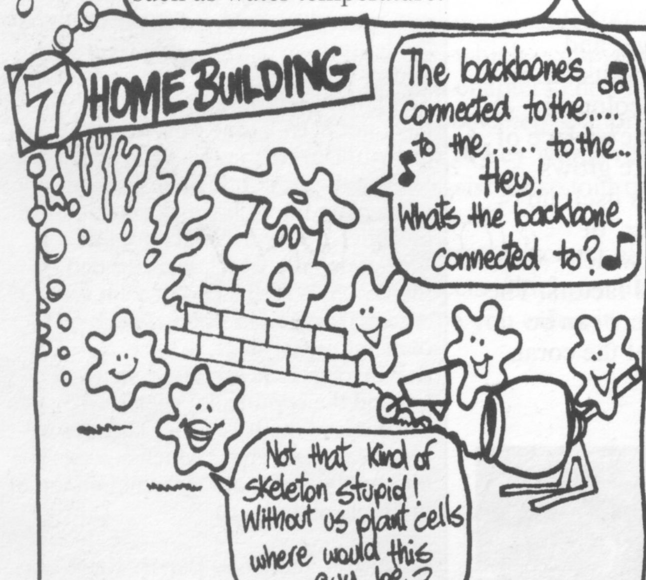
Corals are animals. Some species have separate sexes while others are both sexes in one. During their annual spawning (see page 61), corals release thousands of eggs and sperm which rise to the surface forming thick pink slicks. This occurs a few hours after sunset two to six days after the full moon in October, November and/or December, depending on factors such as water temperature.



The floating slick 'pick-up joint' is a soup of sperm and eggs which all hope to meet and successfully fertilise. Sperm will live several hours and eggs three to six hours. By 'the morning after', fertilised eggs have developed into embryos. The pink, floating slick of embryo soup will last only for 12 hours before disintegrating.

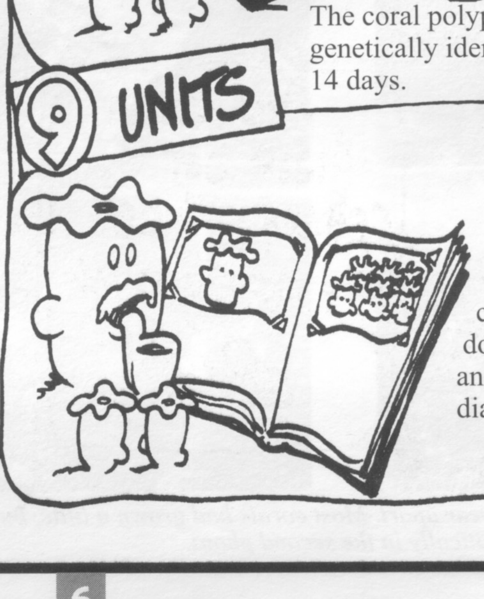


One day after fertilisation, the embryo develops into a little worm-shaped juvenile — a planula. Although ready to swim down to the reef in search of a home within four days, the planula can probably survive up to 20 days floating at sea.

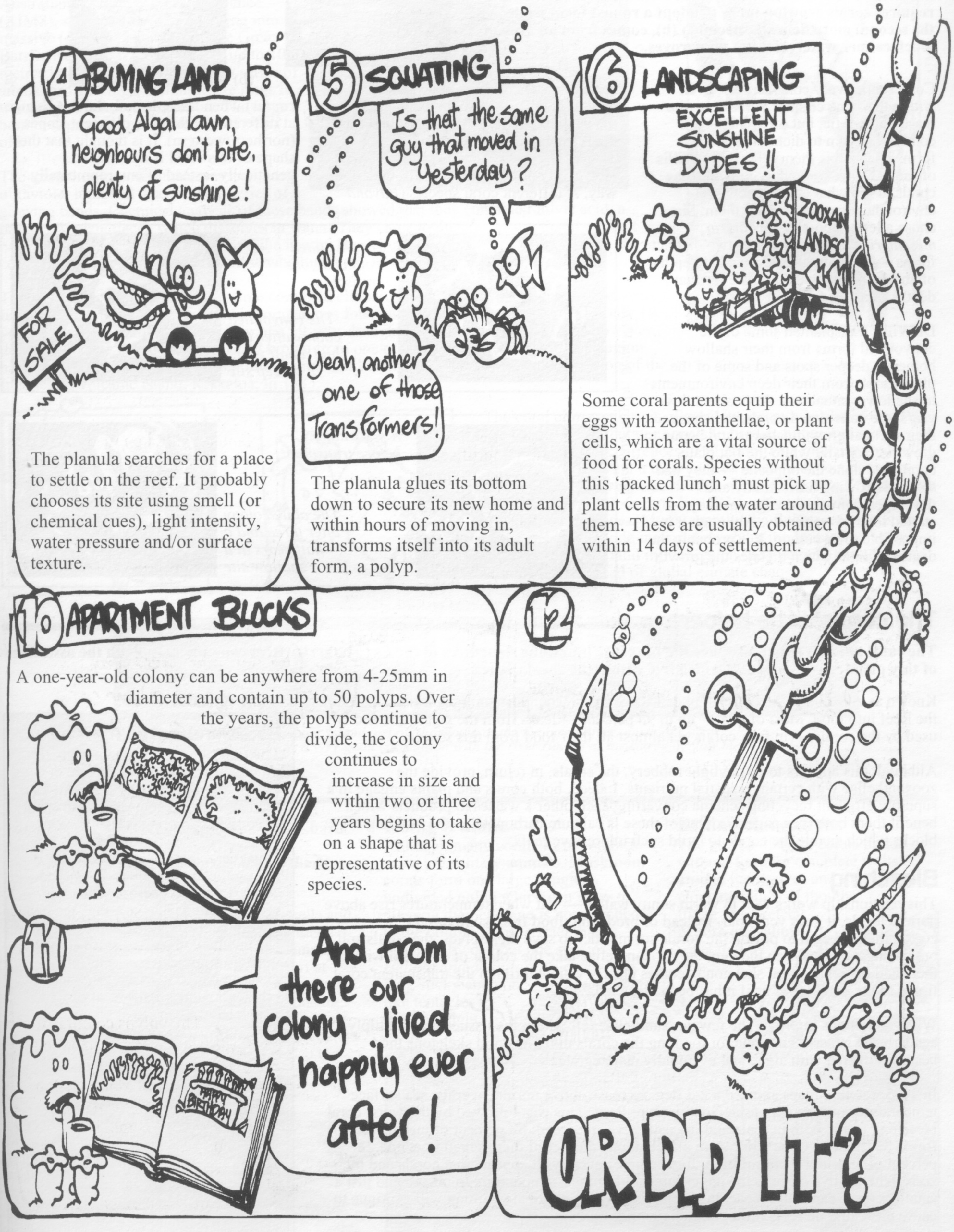


Twenty-four hours after settlement, the polyp, with the help of its resident plant cells, begins to lay down its hard, calcium carbonate skeleton. After several weeks or months, this skeleton is a small (2-5mm) cup shape visible to a searching human eye.

The coral polyp will divide into two, genetically identical, polyps after just 14 days.

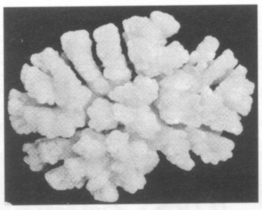


The polyps continue to divide and at six months the little colony could consist of at least half a dozen individual polyps and be 5-10mm in diameter.

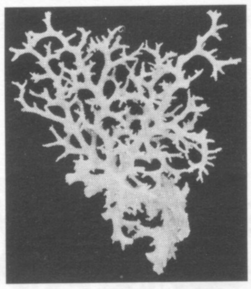

4 BUYING LAND
Good Algal lawn, neighbours don't bite, plenty of sunshine!
FOR SALE
The planula searches for a place to settle on the reef. It probably chooses its site using smell (or chemical cues), light intensity, water pressure and/or surface texture.
5 SQUATTING
Is that the same guy that moved in Yesterday?
Yeah, another one of those Transformers!
The planula glues its bottom down to secure its new home and within hours of moving in, transforms itself into its adult form, a polyp.
6 LANDSCAPING
EXCELLENT SUNSHINE DUDES!!
ZOOXAN
LANDSC
Some coral parents equip their eggs with zooxanthellae, or plant cells, which are a vital source of food for corals. Species without this 'packed lunch' must pick up plant cells from the water around them. These are usually obtained within 14 days of settlement.
10 APARTMENT BLOCKS
A one-year-old colony can be anywhere from 4-25mm in diameter and contain up to 50 polyps. Over the years, the polyps continue to divide, the colony continues to increase in size and within two or three years begins to take on a shape that is representative of its species.
11
And from there our colony lived happily ever after!
HAPPY BIRTHDAY
12
OR DID IT?
Jones '92

Coral shapes

How do you identify corals? Just look at the shape? Well, it's not always that easy. The two drawings here are of the same coral species (*Pocillopora damicornis*) but growing in different locations. The first (a) is from the reef flat where wave action requires corals growing there to adopt a robust form while the second, more delicate specimen (b), comes from an area of much calmer water, close to mangroves.



(a)



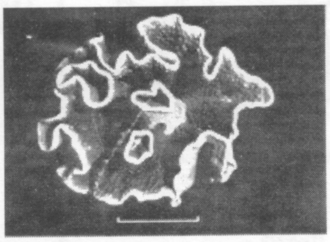
(b)

Photos courtesy J.E.N. Veron

Coral shapes vary considerably, even within the same colony. Sometimes the reason is genetic, but often the local conditions seem to dictate the growth form. To test this theory, Dr Bette Willis of James Cook University moved some corals to see what effect a new environment would have on them. She chose a lettuce coral, (T*urbinaria mesenterina*) which grows in two distinct forms — as a convoluted shape at depths of about 2m and as a flat plate form at depths of about 6m.

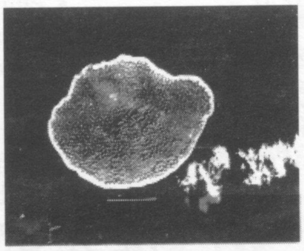
Dr Willis transplanted some of the convoluted forms from their shallow homes to deeper spots and some of the plate forms from their deep environments to shallower situations. After about three years, the convoluted corals had changed their vertical growth patterns and begun to grow horizontally while the flat plate corals had done the opposite — they had stopped growing horizontally and developed convoluted edges as they started to grow vertically. Although it is impossible to be certain, it is probably the degree of light which dictates the growth form of these corals. A plate shape, at greater depths, is likely to catch more of the available light — necessary fuel for the resident zooxanthellae.

However, not all corals react in the same way. A different coral species (*Pavona cactus*) when transplanted, did not change at different depths or at different slopes (northern/western). It is thought that the shape of this coral is determined genetically instead of environmentally.

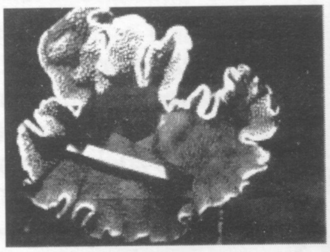


A convoluted colony before transplant

The convoluted colony after two and a half years at a deep site



A plate colony before transplant



The plate colony after three and a half years at a shallow site

Photos courtesy Dr. Bette Willis

The corals' little helpers

The coral animals which produce the immense limestone structures of the Great Barrier Reef can only do so with the assistance of tiny plant cells — algae — which live within the coral tissues.

Known as zooxanthellae, these algal cells convert the abundant sunlight which shines on the Reef into food. Most of this — up to 98 percent — leaks from the algal cells and is used by the corals — in fact, corals get almost all their food from this source.

Although this appears to be daylight robbery, the corals, in return, provide the zooxanthellae with certain essential nutrients. Indeed, both corals and plants engage in a superbly efficient recycling scheme converting each other's wastes to products which benefit them both (see page 47). One of these is calcium carbonate — the building blocks which enable the corals to build such impressive reefs.

Bleaching

This relationship works well in warm sunny waters — but when temperatures rise above normal levels, it goes very sour. Instead of producing food from sunlight, the zooxanthellae begin to poison the corals so, in order to save themselves, the corals spit out the algal cells. When they go, the zooxanthellae take the colour of the coral with them and the white coral skeleton becomes clearly visible through the transparent coral tissue so the coral looks as if it has been bleached.

When conditions improve, the few zooxanthellae left within the tissues may multiply again, but if stresses continue for too long the corals die. The coral skeletons then become covered with algae and eventually disintegrate.

In 1998, satellite maps showed a 2-3 deg. increase above normal average sea surface temperatures over much of the Great Barrier Reef. This was followed by the worst coral bleaching event, both in scale and intensity, ever recorded: 88 percent of inshore reefs from Gladstone to Cape York were affected, one quarter of them severely, while 28 percent of midshelf reefs suffered, five percent severely. It appears that corals and their zooxanthellae live close to the upper threshold of their temperature tolerance and just a small increase can cause bleaching. Scientists fear that global warming will continue to cause bleaching on reefs throughout the world.

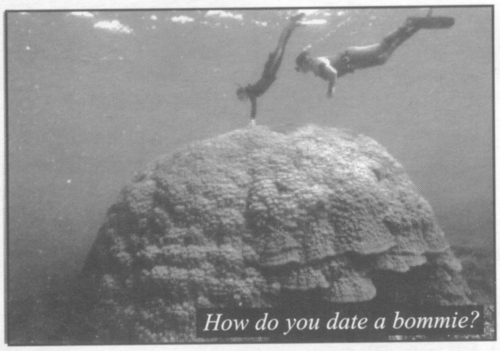
Bleaching details

The first stage of the photosynthetic process is the chemical capture of energy from photons of sunlight. The second stage involves using the energy to convert carbon dioxide to sugars.

However, above about 30deg, the zooxanthellae lose their capacity to convert trapped energy. When this second stage is blocked, then the light energy being captured in the first stage has nowhere to go, but since energy must go somewhere, it goes into electron donation to oxygen — in other words, nasty forms of oxygen which have a bad effect on the cells. This super oxide degrades the zooxanthellae, which poison the host cell in the coral and must then be released by the coral animal. This means that as long as water temperature remains high, the light needed for coral growth becomes poisonous — which explains the shaded effect observed, those parts of the corals most directly exposed to sunlight suffering the worst bleaching in warm conditions.

Boring the bommie

If you want to find out the age of a bommie don't watch it, bore it!



How do you date a bommie?

AIMS

Bore it!

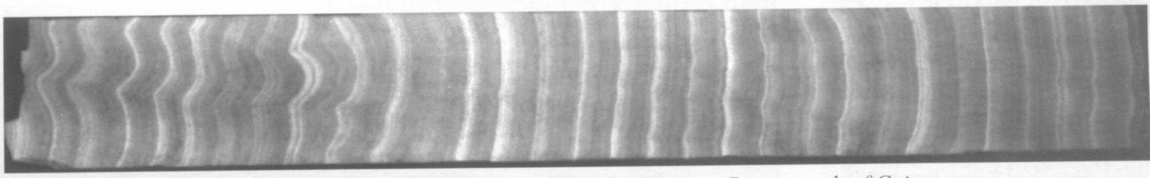
AIMS

Using a drilling system developed by the Australian Institute of Marine Science (AIMS), scientists have been boring into massive (*Porites*) bommies on the Great Barrier Reef and removing cores up to 10 metres long. Examination shows a series of annual growth rings, similar to the rings in a tree trunk, in the coral skeleton. The large bommies proved to be hundreds of years old.

The team then exposed the cores to ultraviolet light and discovered a series of glowing bands. Chemical analysis of these bands showed that they contained fulvic acid, a product of plant decay which dissolves in water. They came to the conclusion that the bright bands corresponded to flooding from the nearby Burdekin River. A comparison between the cores and records of the monthly flow which go back to 1922 confirmed this theory.

This discovery meant that the bommie core held climatic records going back hundreds of years. It told us that, in 1770, Cook and his companions found a lush tropical coastline which only 10 years previously had been in the grip of a 19-year drought. Had they arrived in 1830, however, they would have found the sea stained brown from one of the most extreme floods the region had experienced. Researchers even found a red band which corresponded to the explosion of the Indonesian volcanic island, Krakatoa, in 1883.

The coral climate diary is of great importance to climatologists who depend on accurate records to predict future weather patterns such as occurrences of El Niño. This information is vital for farmers who want a clear idea of when to expect droughts and floods. Engineers also need to allow for extreme events, such as the floods which occurred in 1830, when designing everything from dams to bridges. More recently, the fluorescent bands are being used to provide information about the frequency, extent and magnitude of land influences on the Reef and to understand the extent and speed of global climate change.



AIMS

This coral core is from Snapper Island just off the mouth of the Daintree River, north of Cairns. The fluorescent bands show a very good correlation with the river run-off as measured by flow meter 1969-1986.

Coral types

There are two distinct groups of corals — hard corals (scleractinians) and soft corals (alcyonaceans). The hard corals are further divided into two groups:

Hermatypic corals contain resident plant cells and get almost all their food from the photosynthetic efforts of these zooxanthellae converting sunshine into nutrients. They make only a token effort at capturing their own food, extending their tentacles at dusk when plankton are at their most abundant. (Plankton tend to hide during the day, coming out as darkness falls, when most of their main predators — fish — have retired.) These corals are also the reef builders, the relationship providing them with the necessary calcium carbonate.

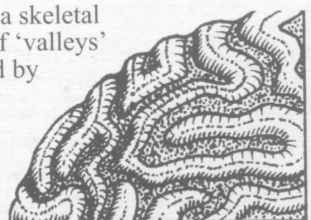
Ahermatypic corals do not have plant cells and have to capture all their own food. They therefore have their tentacles extended most of the time. The advantage is that they do not need to live in sunny places. The cave-dwelling orange daisy corals (*Tubastrea*), their bright colours unaffected by the zooxanthellae's, brown colour belong in this group.

Going it alone

Although many corals form colonies, some are solitary animals. Mushroom corals form one large, single, undivided polyp which can grow to 50cm in diameter and is not attached to the bottom. Most retract their tentacles by day but one species, *Heliofungia actiniformis*, extends its long sticky anemone-like tentacles by day and night.

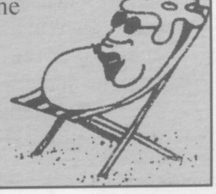
Brainy elongations

The polyps of brain corals divide without forming complete walls around themselves and thus create elongated lines of mouths living in a skeletal pattern of 'valleys' separated by ridges.



Coral screen

How does a coral avoid getting sunburnt when the tide recedes and leaves it high and dry in intense sunshine? A coral needs to allow light to reach the zooxanthellae within its tissues but is also at risk from the high UV radiation. Investigating scientists from AIMS discovered the secret — it makes its own sunscreen! By isolating the chemicals produced by the corals they have been working to adapt this for human use. Well on their way to production, coral sunscreens are expected to have a very high sun protection factor and may be useful for people who are allergic to current screens.



Facts and stats

on coral growth

The first true coral reef communities developed between 450 and 550 million years ago. Modern (scleractinian) corals first developed in the area of southern Europe about 230 million years ago. By 150 million years ago, most major groups of modern corals had evolved.

Although each individual polyp in a massive *Porites* coral colony lives for only 5-6 years, the colony as a whole can be regarded as one of the longest living animals in the world, some surviving for several hundred years.

Corals aren't restricted to tropical waters — some even live in Antarctica. These ahermatypic corals are not reef-builders and grow very slowly. They also live in caves and under ledges and are found worldwide, from the deep seas to the frozen poles.

It was American scientists conducting surveys in the Pacific in 1946, prior to nuclear testing, who discovered that zooxanthellae were providing corals with substantial amounts of their food.

The settling coral planula spends about an hour nosing about before gluing itself down. After this it is stuck to the spot, forever.

Coral may hold out hope for people who need bone reconstruction. The coral genus Goniopora is remarkably similar to human bone. Templates of the coral, cut to shape, could be used to replace bones in cases where it has been lost due to accident or cancer. Bone tissue will grow over the coral thus repairing the damage.

It is possible to grow your own name in coral. Wire left underwater becomes encrusted with coral, so if the wire is in the shape of your name … On a more serious note, engineers in South America are growing building supplies — pipes, bricks and roofing tiles — under the water. They form wire mesh into the required shape and run a very weak electrical supply through it. This attracts calcium ions from the sea water which form a calcium carbonate layer on the mesh. Barnacles, small clams and corals move in and the layers of their shells build up to eventually produce a solid rock-hard layer.

Bookshelf

Corals of Australia and the Indo-Pacific
J.E.N. Veron
University of Hawaii Press (1993)
Everything you ever wanted to know about corals and more! Most of this 644-page tome is an identification guide with colour photos, maps and diagrams but there is also good general coral information.

Scleratinia of Eastern Australia
J.E.N.Veron, et al.
AIMS Monograph series (1976-84)
For the coral expert. These five volumes have enough detail to completely confuse any amateur!

Oceanus Vol 29 No 2 Summer 1986
There are several relevant chapters in this issue which was devoted to the GBR.

Corals of the Great Barrier Reef
Ern Grant
E.M. Grant Pty Ltd (1991)
Apart from a short introduction, this book comprises 85 coloured photos of coral species commonly seen on the Reef at low tide.

Reader's Digest Book of the Great Barrier Reef
Reader's Digest Services Pty Ltd (Sydney) (1990)
One of the best general information books on the Reef, this attractive book has a good section on corals.

***Indo-Pacific Coral Reef Field Guide**
Dr Gerald R. Allen and Roger Steene
Tropical Reef Research (1999)

***Tropical Pacific Invertebrates**
Patrick L. Colin and Charles Arneson
Coral Reef Press (USA) (1995)

***Coral Reef Animals of the Indo-Pacific**
Terence M. Gosliner, David W. Behrens, Gary C. Williams
Sea Challenges (1996)

Reef Notes — colour brochures
The Great Barrier Reef Marine Park Authority
- **The Coral Polyp**
- **The Annual Coral Spawning Event**

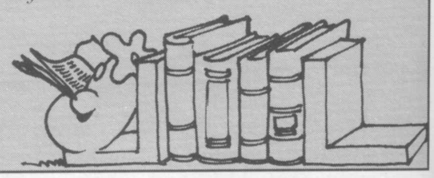
Available from GBRMPA and Reef HQ *(see page 79 for details.)*

Exploring Reef Science — fact sheets
CRC Reef Research Centre
- **Coral bands unlock climate history**
  Colleen Davis (August 1998)
- **Are corals failing to cope with the stresses of modern life?** (bleaching)
  Paul Marshall (November 1998)
- **Coral Reef Gardening**
  Don Alcock (September 1995)
  Experiments in coral transplanting.

Available from CRC Reef Research Centre *(see page 79 for details.)*

Video: Silent Sentinels
ABC (1999)
Available from ABC TV Programme Sales, Sydney. Ph: (02) 9950 3173; Fax: (02) 9950 3169. Cost: $100
This one-hour video, first shown on ABC in early 1999, looks at the severe coral bleaching events of 1998. Taking a worldwide perspective, with reference to the GBR and work done by Australian researchers, it studies the causes and effects, links with climate change, El Niño frequencies and future prospects. A sobering alarm call.

**Books containing large numbers of photographs, useful for identification. Although most photos are taken outside Australia, many of the corals included are also found on the GBR.*



Tourist talk

ENGLISH	GERMAN	JAPANESE	
coral	Koralle	sango	珊瑚
polyp	Polyp	polyp	ポリープ
colony	Kolonie	guntai	群体
reef	Riff	show/reef	礁 / リーフ
algae	Alge	mosurui	藻そう類
branching	verzweigt	edasango	枝珊瑚
species	Art	shurui	種類
climate	Klima	kiko	気候
spawn	laichen	sanran	産卵
bleach	Bleiche	hyohaku	漂白