

## WATER DEPTH AND WAVE ENERGY

With greater water depth slightly larger waves can pass over the reef and reach the beach (fig. 4.III vs. 3.III). Larger waves carry more energy and this is released when the wave breaks on the beach. The greater energy released on the beach means that larger particles of sand are suspended and carried up the beach (steepening the beach profile) or carried away along the beach.

The energy conditions in this region of sand suspension are not suitable for beach formation since the sand particles cannot settle. The beach reforms where the right conditions are found and the change is seen as erosion (fig. 4.IV).

## POST SCRIPT - WAVE REFRACTION AND ISLET FORMATION

Those readers of the newsletter who look at figs. 3.V. and 4.V carefully (and use a little imagination!) will notice that the waves are eventually bent so much by the effect of the reef that they are almost facing each other. If the island wasn't there and the waves came together they would effectively cancel each other out producing a still-water area where sand could collect to produce a spit.... and eventually an island.

The fundamental forces that create islands are extremely strong ones. We are lucky to have them as we do our unknowing best to keep the sand-icing on the coral-island cake.

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## WHAT TO DO?

There are several ways of coping with beach erosion caused by increased wave energy reaching the shore. These will be discussed in next month's newsletter.

## STOP PRESS

Readers of this COT newsletter may be interested to know what is happening to COT on the Great Barrier Reef. We quote selected extracts from an article entitled "where have all the starfish gone" in the Australian Newsletter 'COTS COMMS' of March 1990.

*"The Australian Institute of Marine Science manta tow team has been active over the summer (Maldivian winter! - Ed), surveying the Cooktown/Lizard Island (December) and Cairns/Innisfail Sectors (January). Only 2 cots and very slight coral scarring attributable to cots were observed on 24 reefs in the Cairns/Lizard Island Sector.....*

*No cots were seen on 20 reefs in the Cairns/Innisfail survey, however, potential feeding scars were noted in very small numbers on 9 reefs. Almost half of the reefs surveyed are currently classified as in a recovery state. The team's next cruise is planned for March 23 to April 8, and will involve surveys of the Whitsunday and Pompey sectors.".....*

Reading between the lines it looks as though there is good news from the Great Barrier Reef!

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NEWS LETTER



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## EDITORIAL

### ENVIRONMENTAL RESPONSIBILITY - PASSING THE BUCK AND MAKING IT?

A large number of words were spoken at the COT busters meeting last summer about who was responsible for helping to deal with the COT plagues faced by particular resorts. The Resorts facing the plagues were desperate to have help and prepared to provide facilities. However, the resorts that had no COT felt it was not their problem, breathed a sigh of relief, and went off to earn a buck.

Is there any justification for this attitude and if so what is it?

### RESPONSIBILITY OF GOVERNMENT

Until recently the attitude in both the developing, and the developed, world was that paying taxes - both individual and Corporate - passed the 'buck' of environmental responsibility to Government. In the past most Governments could cope with this responsibility. Population pressure, and other human derived environmental problems, were more limited and public awareness, and concern, about the environment was less well developed.

As the environmental situation deteriorates Government has to respond more effectively. This is a serious logistical problem for any country, let alone the Maldives. The Government, therefore, has to seek assistance from other sources.

### LOGISTICAL LIMITATIONS

The capacity of the Maldives Government to respond to environmental problems is very small at this time. Building up the infrastructure to research environmental issues, monitor the environment, and provide advice on environmental problems, is a major logistics problem for a country which had a population of just over 180,000 people in 1985\*. Only 43% of this population was over 19 years old. 136 Maldivians (1 in 1324) were University Graduates and 3 in 4 Government employees had not completed a secondary education.

With this background Government has

made training in Environmental Sciences a priority... a priority in a country where improving nutrition, reducing high infant mortality (48 per 1000 in 1988), improving primary health care, and upgrading educational facilities, are also major concerns. Government is sending about 6 people abroad to do Environmental related degrees.

So these 6 people, when they graduate, and those colleagues who remain, will have their work cut out to provide managerial advice let alone carry it out.

### RESPONSIBILITY OF THE PRIVATE SECTOR

It is quite clear, against this background, that Government can only provide a managerial response to any environmental problems that may arise. They cannot actually deal with the problems themselves. In this case Private Sector Businesses, particularly the Resorts, need to accept a long-term individual, and group responsibility to:-

- 1 **Report their environmental concerns to Government so that Government can provide the best managerial advice.**
- 2 **Provide support and encouragement to Government staff so the staff become better motivated.**
- 3 **Respond to the managerial advice given by Government.**

If these responsibilities are not taken on by the private sector then this sector must take part of the blame for any future environmental deterioration.

Clearly the Government cannot give appropriate environmental advice without a good understanding of the environmental processes that shape and maintain the fragile ecosystem of the Maldives. The logistical problems that Government faces point to a need for support from the Private Sector in obtaining a better understanding of the fragile

*\*Since then the population has grown by 19% to just over 214,000 people (1990 census). All information based on figures supplied by Ministry of Planning and Environment.*

Maldivian ecosystem.

### SAMPLING REEF FISH LANDINGS

One example of the support that can be given is assistance in sampling reef fish landings. The managers of 64 resorts were sent a request, in February, to sample their reef-fish landings.

The justification for the request was that *"An assessment of the state of the marine environment includes an assessment of the state of the reef fisheries. This requires that reef fish landings are sampled and catch composition is analysed. If reef fisheries are not researched and monitored then they may deteriorate to a point at which they are no longer useful as a source of food for resorts. Even more food will then have to be imported from overseas. This will adversely affect resort profitability, the livelihood of reef fishermen, and the quality of a holiday in the Maldives."*

Only six resorts have so far responded to this request.

What does, such a poor response mean and is it justified? We would certainly welcome comments on this from the Resorts. The replies, if any, will provide some interesting material for the next newsletter!

### NEWS ABOUT FILMING BY WIF

The team that went to Colombo to produce edited tape for the 30 second introduction to all programs in the COT series has now returned. A first edit has been done and this material is being used as a basis for producing the theme music for the series. WIF is negotiating with the Maldivian Composing Group, 'Zero Degree Atoll', to produce a catchy and effective theme tune.

COT filming is still continuing. Our team visited Nakatchafushi Resort with some local Maldivian divers including the famous shark-feeding Bandaye, and the underwater photographer Mustag. The aim was to get footage of a dead COT infested reef and of COT being collected by resort workers. We hope to visit Nakatchafushi again and get some more footage.

WIF also received a call from Bodu Hithi Resort (see 'News from Resorts') letting us know about COT sightings in the area. We have delayed underwater filming until the end of the fasting month.

We hope to finish editing the first episode of the COT series by the end of this month. Unfortunately the airconditioner has gone wrong in the editing room and the equipment can't stand the heat!

We have some good news. Our Secretary General, Mr Arne Fjortoft from Norway, during his recent visit to Maldives, has promised to send a Consultant to work with productions. With this expertise we hope the COT film series will be even better!

### NEWS FROM LOCAL ISLANDS

Most local islands have responded to a radio message requesting a status report on whether their reefs are affected by COT. There were no reports of any change in status of COT since the last questionnaires were returned last August.

### NEWS FROM RESORTS

#### NAKATCHAFUSHI

Representatives from WIF and MRS visited Nakatchafushi on the 19th March. We are extremely grateful to the Resort for the hospitality shown us.

Most of the house reef has been killed-off by COT. The dead corals are covered in algae but are still whole giving the reef a graveyard-like feeling. WIF returned a week later to film these scenes for the COT TV series. The reef must have been extremely beautiful when it was alive. There was no evidence for any coral settlement on the reef which is the first sign and stage of reef recovery (see 'The COT cycle' later).

6 adult COT were collected in a forty minute dive on the reef face in the morning and 8 adult COT were observed in a forty minute reef face snorkel in the afternoon. Resort staff collected 80 COT from the reef top on the 19th March and collected just over 7,000

COT during twenty days in March on which numbers collected were recorded. On the 1st March 1392 COT were collected!

The impression gained was that there is not much live coral left for the COT to feed on. For this reason the COT are probably travelling onto the reef top and into the lagoon in search of food. No sea-urchin were seen and the resort should keep an eye-out for these.

### BODU HITHI

Unfortunately a combination of rough weather, and the difficulty of doing fieldwork during the fasting month, means that we did not visit Bodu Hithi in April. We phoned the Manager, Mr Ibrahim Salim, on the 16th April and he was extremely helpful in explaining the COT situation on the Resort house reef. Apparently the first COT appeared as early as last August. Meanwhile several of the nearby islands were heavily infested. At the COT buster meeting last July the question was raised (see issue 1 of the COT newsletter) as to "... why some areas surrounded by infestations, such as Bodu Hithi are skipped?" Unfortunately, in December Bodu Hithi was no longer 'skipped' and the COT arrived with a vengeance.

Two dhoni boats were employed full-time for two months collecting between 150-200 COT a day. By the end of February the COT appeared to be decreasing. It seems that the change in monsoon has encouraged this trend and the remaining COT appear to be moving off the house reef to nearby reefs to the north. However, the recent rough weather appears to have encouraged the COT to come into the lagoon and this could be a health hazard for tourists who might tread on the spines (*the COT may simply be looking for food - Ed*). In the meantime Ibrahim reports that the reef has not been seriously damaged by the plague though he is prepared to bring back the dhoni's if the COT re-appear.

### AN 'UPDATE' QUESTIONNAIRE

A brief questionnaire was sent to all resorts in the last (March Newsletter) asking for an update of the COT situation on the resort house reef and local dive sites.

## THE COT CYCLE

### FOR THE PESSIMISTS

It is hoped to present a series of illustrations in the next few COT newsletters to highlight the principal effects of various pollutants and activities on reefs. It has been pointed out, in the last two newsletters, that COT may be part of a natural cycle on healthy reefs but that reef recovery following an infestation may be delayed or prevented if the state of the background environment is deteriorating. In next month's issue we will show the effect of sewage on reefs and also how a reef may fail to cope with the impact of a COT plague even if there is only limited sewage discharge into the reef water.

### FOR THE OPTIMISTS

For the optimists, this month gives an illustration (fig. 1) of what might be expected if a COT plague hits a healthy reef and the background environmental conditions are good. For those prepared to wait for fifteen or twenty years the result is a reef dominated by the most beautiful of fast growing corals. If you want to see a reef recovering from a COT plague then go to Fesdu Fun Island in Ari Atoll or Vabbinfaru in North Male' atoll.

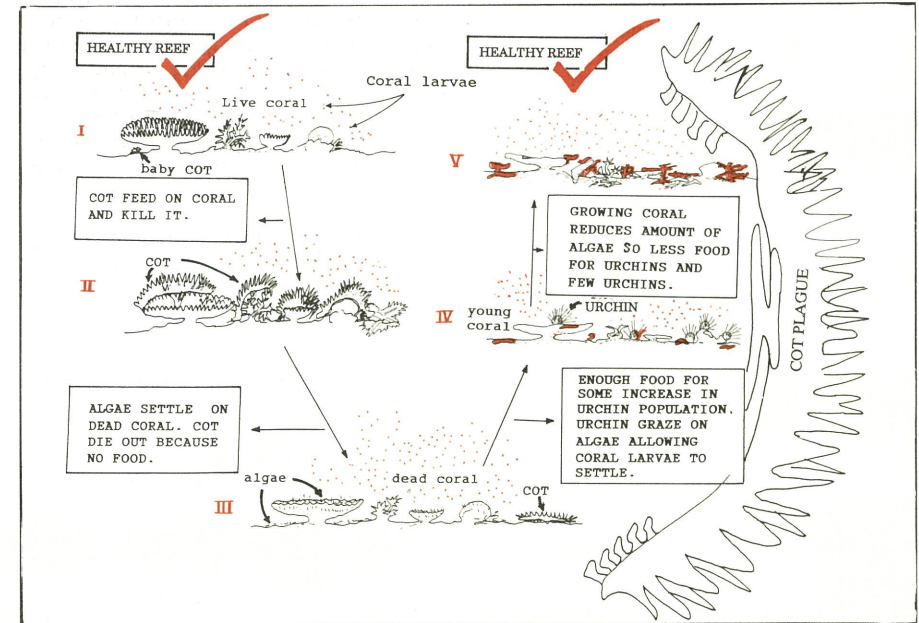
### BEACH EROSION AND COT

We mentioned, in the March edition of the COT Newsletter that COT infestations can have an effect on the process of beach formation and erosion.

### GOOD AND BAD EFFECTS

COTs can actually help produce coral sand by killing off coral colonies and allowing other mechanisms to break them up into smaller pieces. However, corals, create the shallow water conditions that cause waves to break. This reduces the energy of waves breaking on the beach and so allows the beach to form. If the corals are killed by COT and do not grow back the water will be deeper on the reef-top. Wave energy reaching the beach will increase so suspending larger particles of sand and carrying them along the shore. This will produce a new kind of beach profile and beach line that we will see as erosion.

Fig.1 THE COT CYCLE



(I) A healthy reef covered in live coral starts the COT Cycle. Look hard enough on such a reef and you might just see a baby COT! The water above the reef is full of coral larvae that are competing with each other and with animals and plants for space on the bottom.

(II) Adult COT appear from nowhere (though in fact they have been hiding in the reef and feeding on algae). The adults feed on the coral and kill it. One COT per hectare is reckoned to be about right for a healthy reef. When there is a COT plague there may be thousands!

(III) Normally algae cannot settle and grow on live coral because the coral kills them. Dead coral makes an ideal surface for the algae to settle and grow and the reef is soon covered with an algal lawn. Meanwhile the COT have killed off their live coral food supply and either migrate, (a matter of 100's of meters) in search of food, or starve.

(IV) Numbers of sea-urchins on a reef are normally limited by the amount of algae that is available. If the reef is healthy, and covered in live coral, there is little space for the algae.

If the reef is dead the algae are not limited by space. The algal cover increases and the urchins multiply. The urchins graze the algae off the reef and this also causes the dead coral to break-up much more quickly. The longer the urchins are around, and feeding, the more the dead coral is eroded down and the water depth increases.

Fortunately the environment is healthy and the algal cover, and number of feeding urchins, are limited by the availability of nutrients in the water. Also the water above the reef is teeming with coral larvae that are trying to settle on the dead reef. They settle where the urchin have grazed the algae off the reef. Once the corals have started to grow and reduce the algal cover there is less food for the urchins so their numbers decline.

(V) A healthy reef covered in profuse, beautiful, fast growing corals, ends the COT cycle. There is only a small amount of algal cover for baby COT and sea-urchins to feed on so their numbers do not increase. Since the reef has grown-up again the water is shallower and this helps prevent large, high energy, waves from getting through to the beach.

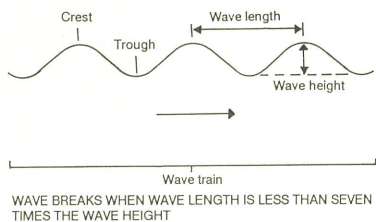
## CORAL MINING/SEA-LEVEL RISE

Both Coral mining and projected sea-level rise may also increase the amount of beach erosion since both increase the depth of the water on the reef-top. The greater the water depth on the reef top the more wave energy is likely to reach the beach.

### WHEN DOES A WAVE BREAK?

In deep water a wave breaks when it becomes too steep. This happens when the wave length (the distance between two adjacent wave crests - see fig. 2) is less than seven

Fig. 2 PARTS OF A WAVE:



times the wave height (the vertical distance between the crest of the wave and the trough). A wave that is 7 meters long has to be less than 1 meter high or it will break.

### FRICTION IN SHALLOW WATER

When a wave goes from deep into shallow water the front of the wave slows down before the back of the wave because it is the first to meet friction with the shallow bottom. The back of the wave piles up on the front of the wave reducing the wave length and increasing the wave height so that the magic ratio of 1:7 is exceeded. The wave trips over itself and crashes down.

Obviously the water depth determines how much friction there is with the bottom. The shallower the water the greater the friction with the wave and the sooner it will break and lose much of its energy as surf and foam. Theoretically a wave breaks when the wave height (fig. 2) equals the water depth. However, actual studies show great variation and there are cases where waves have broken when the water depth was twice the wave height.

## WAVE HEIGHT AND ENERGY

The sooner a wave breaks the better since a wave that breaks and loses as little as 50% of its height will have lost 75% of its energy (fig. 3.I vs fig. 3.III). If the wave doesn't break, or only partly breaks, before it reaches the shore much more energy will be released on the beach (fig. 4.I,III,IV). Fortunately, in the Maldives, nature has provided some protection against this happening.

### THE ATOLL RIM

The highly consolidated surf zone of the atoll rim breaks the pounding might of the Indian Ocean swell into a more manageable size. The atoll rim is formed from coral boulders that are brought up by freak-storms from deeper water. These boulders are then consolidated into a living-concrete by small plants that fill in the gaps with the cement of their calcareous bodies.

### THE LAGOON FRINGING REEF

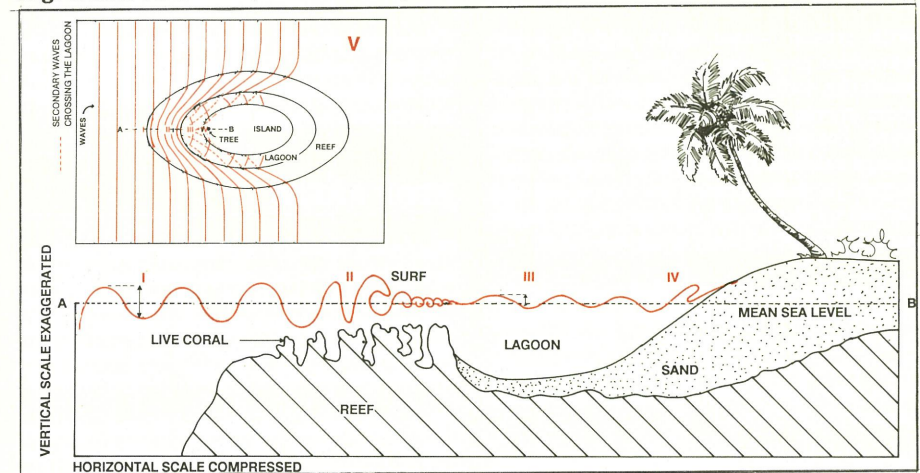
Within the shelter of the atoll more delicate corals can form in shallow water and create reef fringes around islands. These reefs break-up lagoon waves, including the larger waves produced by occasional squalls. Some waves get through these barriers and eventually reach the beaches (fig. 3.IV). Indeed some waves need to get through to sort the sand and form the beaches that contribute to the beauty of the Maldivian Islands.

### COT AND WATER DEPTH

No adult COT could survive in the pounding surf-zone of the atoll rim. However, in more sheltered waters where there is more coral to feed on they can increase to plague proportions. Eventually they can become so abundant that they kill-off all the available coral and either starve or move elsewhere in search of food. These COT leave behind a dead reef that is quickly colonised by algae (fig. 1.III). The dead reef is rapidly broken down by grazers and borers. Under healthy conditions it becomes recolonised by corals that grow-up to form a new reef (see fig. 1.V). However, in the meantime, or if the reef does not recover, the loss of coral means that the average water-depth increases on the reef-top (fig. 4.II).

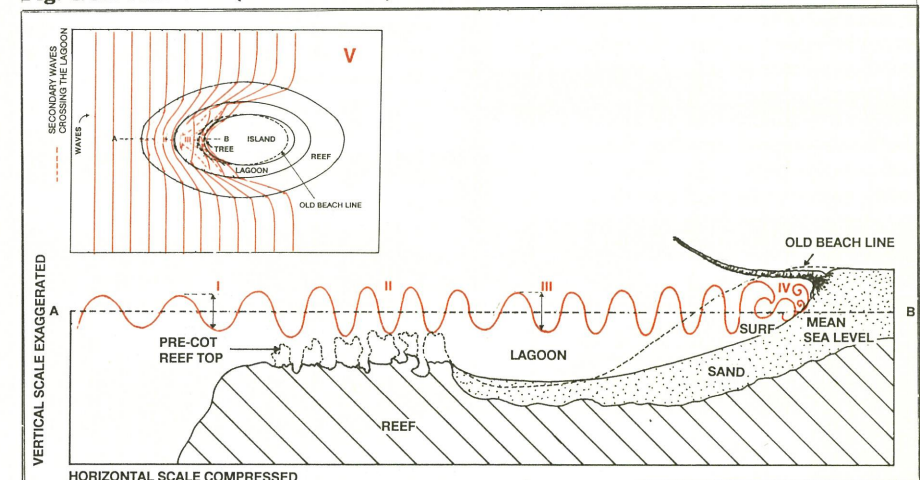
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Fig. 3. BEFORE COT (SCHEMATIC)



- i The wave doesn't break until the wave length is less than seven times the wave height.
- ii Friction with the shallow bottom causes the wave to break.
- iii Much of the wave height and energy is lost after it breaks.
- iv Only limited energy is available for release when the wave breaks on the beach.
- v A plan view of the island shows how the waves are altered so that they almost 'squeeze' the island and keep the sand in place.

Fig. 4. AFTER COT (SCHEMATIC)



- I The wave doesn't break until the wave length is less than 7 times the wave height.
- II The water on the reef-top is too deep and the friction with the bottom is not enough to cause the wave to break.
- III Little of the wave energy is lost when it enters the lagoon.
- IV All this energy is released on the beach. The sand is moved away.
- V A plan view of the island shows how the waves are altered so that they almost 'squeeze' the island. The island remains but the beachline cannot form where it used to and so forms where there is less wave energy.