# CHAPTER 15

# PROBLEMS FACING OUR CORAL REEFS

## 15. 1. INTRODUCTION; STRESS FACTORS AND CORALS

As discussed in Ch. 13, reef building corals prefer warm, clear, well-oxygenated ocean water that is free of sediments and relatively low in nutrients. Furthermore, each coral species prefers a certain specific combination of environmental conditions. All coral species are sensitive to conditions that differ even slightly from their ideal.

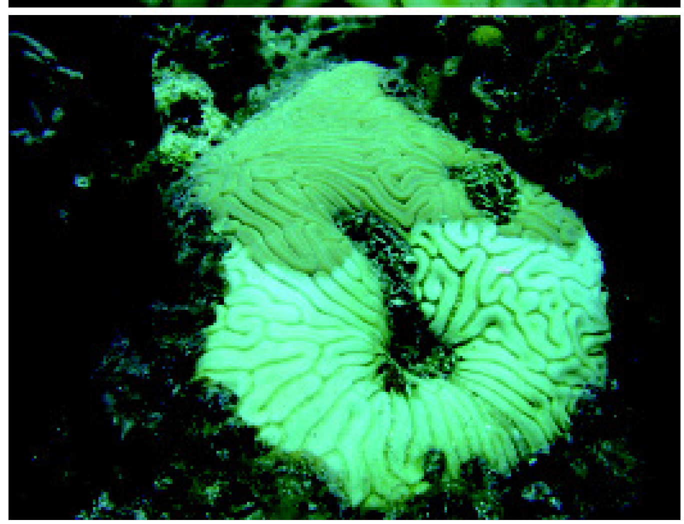
Changes in environmental conditions away from the ideal lead to **stress**. Stress leaves a coral in a weakened state. Weakened corals are vulnerable to disease. They are also often impaired in their abilities to maintain their normal growth, maintenance, and reproduction functions.

Adult corals are permanently attached to the reef. They cannot escape when conditions worsen. Severe environmental changes may even lead to widespread damage or death of sensitive species. Other species might not be affected at all.

Stresses of many kinds face our coral reefs, from *natural phenomena* as well as *human activities*. Natural problems may result from large storms, waves, volcanic eruptions, changes in sea level or temperature, and from infestations of disease or of predatory organisms like our crown-of-thorns starfish.

Stresses can also result from impacts of human activities. In our Northern Mariana Islands, human-induced stresses have often been associated with our economic development and our population growth. Such stresses include sedimentation from road building and site construction; toxic waste pollution; and inadvertent trampling of corals by local subsistence fisherfolk and visiting tourists.

It is now well known that natural stresses can be aggravated by human-induced stresses. As scientists and resource managers seek to investigate the exact causes of impacts, the line between natural damage and human effects is sometimes blurred.



*Changes in environmental conditions away from the ideal can leave coral more susceptible to disease and bleaching.*

*Human-induced stresses are increasing globally.*

*Sediments are very damaging to corals.*

Coral reefs may be affected by natural causes, either directly or indirectly. An example of a direct effect would be the breaking up of a large coral head by extra-large storm waves.

One example of an indirect effect might be the death of live corals by sedimentation. This leaves the weakened coral rock structure more susceptible to storm damage. The weakened rock structure might then break off, crashing into other live coral heads. Another example of indirect effects might be the gradual deterioration of a coral reef when temperature stress weakens the corals, leaving them incapable of their reef building, maintenance, and repair roles.

Even slight stresses caused by humans are known to interfere with reef habitats in an indirect fashion. Weakened corals might be unable to repair an eroded or damaged reef after a large storm event if human interference has also occurred.

We recall that even slightly unsuitable conditions disturb corals. Sediments are very damaging to corals. Prolonged, chronic sedimentation such as runoff from large rainstorms can severely stress corals. Construction projects, road building, and agricultural developments can be very stressful. These activities can kill large areas of our reefs. It's important to note, however, that some corals are more tolerant of sediments than others.

Toxic pollution, pesticides, herbicides, petroleum derivatives, heavy metals, and industrial wastes are also harmful to our corals. These can interfere with a coral species' reproductive cycle (see below).

Natural problems and problems caused by humans in our Mariana Islands have also been recognized as global problems relating to coral reefs. Though it is not often easy to distinguish between natural and human caused problems, this chapter is organized into two sections based on such a distinction.

Concern is growing that the effect on the environment from increases in population and economic development, both globally and here in the CNMI, may irreversibly affect the health of the entire earth.

In this chapter we are primarily concerned with local problems. This is because, if we try hard collectively, we may be able to do something about them, whereas we have little control over problems in other lands.

Many issues covered throughout this book have a relevance to our coral reefs. We urge each reader to bear in mind the possible impacts on coral reefs from all the various environmental problems discussed throughout this book. In particular, try to relate them to the reefs that we know the best, those right here in the CNMI.

Space considerations make it impossible to treat all of the world's important coral reef problems. Here, we discuss only a selection of the most serious ones. Keep in mind there are others.

## 15. 2. NATURAL PROBLEMS; INTRODUCTION

"Modern" coral reefs have surrounded the Marianas for approximately 40 million years. During this time, our reefs have faced many challenges. Recently, human actions have posed some new challenges to our reefs, and complicated the older, natural ones.

Impacts of human activities will be considered later in this chapter. First, we might ask, what kinds of natural problems have faced our coral reefs? Are these problems still with us today?

*Some problems, such as coral bleaching, appear to be naturally caused.*

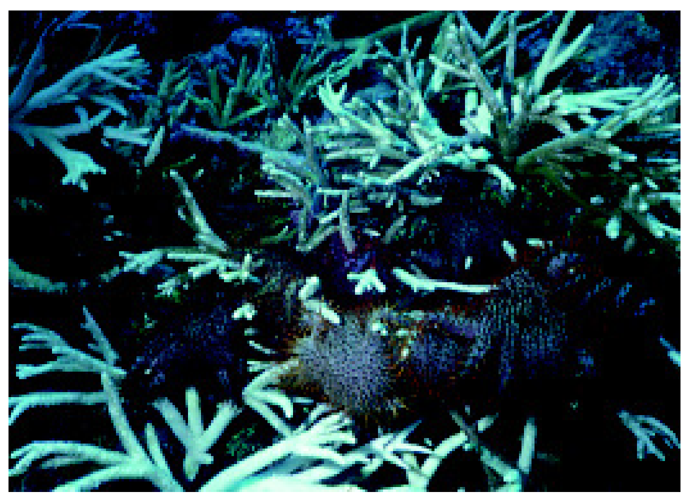
It is not always clear whether a problem is natural, or caused by humans. However, even natural problems can be worsened because of human impacts.

Human technology has side effects, or **impacts**. As our technology has grown more powerful (*able to accomplish our intended goals more easily*), so have the side effects. Some of the worst-feared and most often neglected side effects are those involving large scale impacts on the world's coral reefs.

We will consider a few problems closely: invasions of the crown-of-thorns starfish, *Acanthaster planci*; damage due to storms; sea level change; ciguatera fish poisoning; and coral bleaching. Only a few of these problems will be treated in depth.

The first of the natural problems we will consider—crown-of-thorns starfish invasions—have at times been believed to be intensified by human-caused degradation of reefs. It is now understood—as a result of intensive research into this problem—that episodes of starfish invasions have happened throughout the long history of the Great Barrier Reef, for example, even before humans ever occupied Australia.

As this chapter is being written, in 1998, another problem has become more intense, as newly discovered coral diseases are taking a serious toll, particularly in Florida, USA.



*Invasions of the crown-of-thorns starfish may be intensified by human-caused degradation of reefs.*

We predict more problems will be recognized in the future as equally serious, while new insights will show some of our most feared problems will later be understood to be relatively minor. Will the sea level actually rise in the 21st Century? Time will tell.

## 15. 3. *Acanthaster planci*—THE CROWN-OF-THORNS STARFISH

### 15. 3. 1. Introduction

The crown-of-thorns starfish, *Acanthaster planci*, lives among the coral reefs of the tropical Pacific Ocean, including the Northern Mariana Islands. The crown-of-thorns starfish eats corals. The crown-of-thorns starfish gets its name from its long, thorn-like, toxic spines, simulating the crown of thorns which Jesus of Nazareth was forced to wear at his crucifixion.

When conditions are appropriate, multitudes of crown-of-thorns starfishes have been known to invade a reef. Crown-of-thorns starfishes have been observed to consume most of the corals on a reef, leaving behind a wake of devastation.

Other starfishes, including the pincushion starfish, *Culcita novaeguineae*, also consume corals. However, only the crown-of-thorns starfish is able to seriously reduce the number of corals on an entire coral reef. Crown-of-thorns outbreaks have increased in recent years throughout the Pacific.

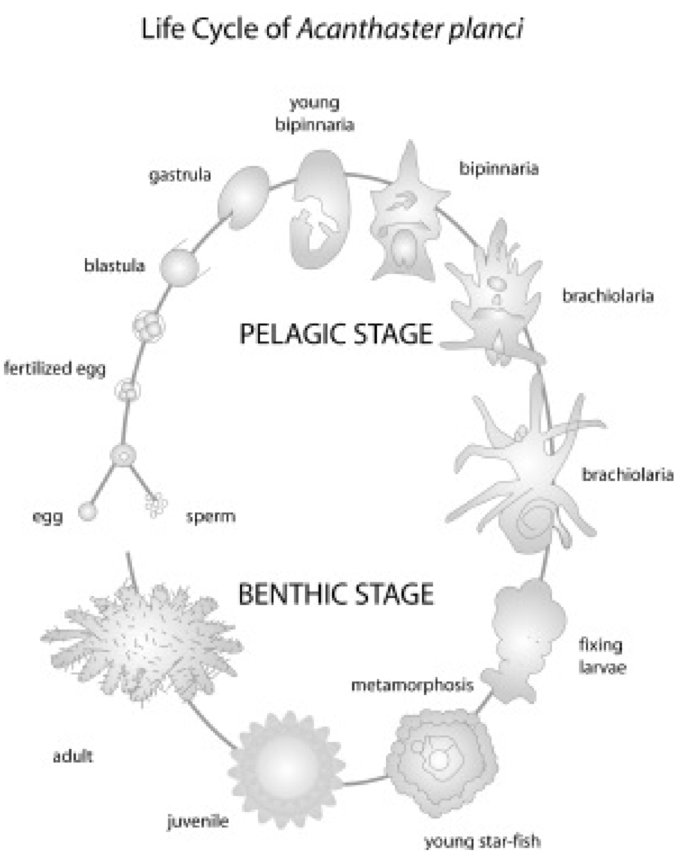
*The crown-of-thorns starfish eats corals and is found in the Mariana Islands.*

These outbreaks have occurred near high islands or continents. They often occur after there have been large inputs of sediments to the reefs resulting from the severe rains from typhoons and tropical storms.

According to one theory, outbreaks occur between two and three years after large storms with high rainfall. Large quantities of sediments (mud and silt) are carried into the ocean by runoff from islands. According to this theory, nutrients in the sediments fertilize rapid growth of **phytoplankton**, the food of young starfish. The **phytoplankton bloom** enables large numbers of starfish larvae to survive to adulthood. This theory rests upon knowledge of the life cycle of the starfish.

### 15. 3. 2. Life History of the Crown-of-Thorns Starfish

The image to the left is a model of the life cycle of *Acanthaster planci*. One theory proposes that the larvae are able to survive best during years when sufficient nutrients are available to support blooms of plankton, the food for the larvae of the starfish.




*Life cycle of Acanthaster planci.*

The crown-of-thorns starfish are **dioecious**; that is, sexes are separate. Each female can produce 12 Million (12,000,000) eggs per month. Thus, the potential exists for extremely rapid population growth.

Normally, very few eggs survive and the population remains small. However, when conditions are good, many of the larvae survive, and large numbers of the young starfish complete their life cycle. At such times, invasions of starfish happen.

It takes two to three years for the crown-of-thorns larvae to complete their life cycle. This lag period coincides with the observation of starfish invasions two to three years after massive sediment runoffs from a high island. Laboratory studies show that larvae of this starfish are more likely to survive during phytoplankton blooms, when large quantities of food are available.

### 15. 3. 3. Profile of an Invasion

Since high islands are able to contribute larger amounts of sediments, it is believed that crown-of-thorns invasions occur mainly near high islands. An atoll probably does not have sufficient land area or nutrient buildups to provide the necessary quantity of sediments.

An invasion by tens of thousands, or even millions, of crown-of-thorns starfishes can have a dramatic impact on a coral reef. Each starfish is capable of consuming a large area of coral surface. Working together, the great number of starfish can severely damage a coral reef.

### 15. 3. 4. Impacts of Invasions by the Crown-of-Thorns Starfish

In 1968 and 1969 the crown-of-thorns attacked the coral reefs of our Mariana Islands en masse. Within several months, they had consumed 90% of the corals on most of the reefs of Saipan (only

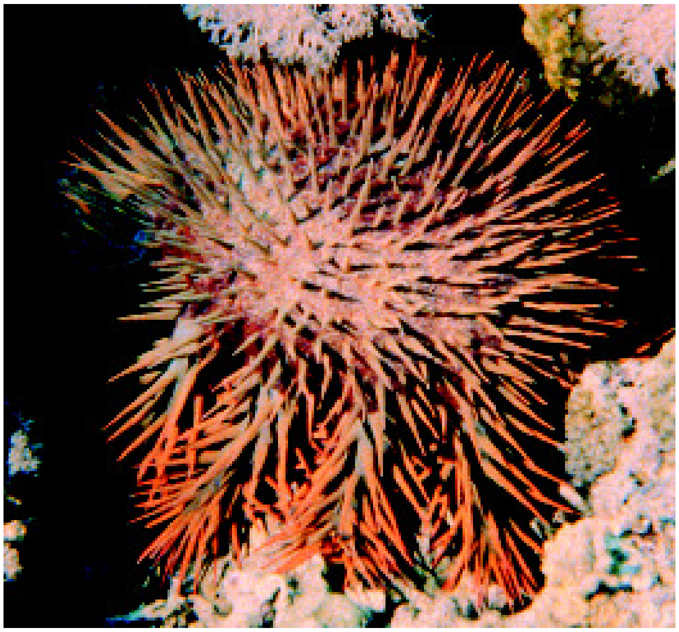
Laulau Bay and Bird Island were unaffected). Guam was also invaded in the same year. This prompted a large scale eradication effort by SCUBA divers. At first the starfish were merely cut into pieces but later it was learned that each piece regenerated. Later, other methods were employed to kill them.

The main effect of the crown-of-thorns results from its appetite for corals. Corals consist of a thin layer of living tissue on the surface of the stone skeleton that the corals produce. Each adult starfish consumes, on average, 5 to 6 square meters of coral surface per year; it must do so to obtain enough food nutrients to survive.

The living coral tissue protects the underlying stone from degradation. Once the tissue is dead, boring organisms can enter the stone in large numbers. They proceed to degrade the stone, and the reef itself. Boring sponges, boring mollusks, worms, excavating crustaceans, and algae may colonize the unprotected surfaces.

Algae colonize the bare surfaces after the corals have been eaten. Corallivores eat corals. When corals are depleted, so are populations of corallivorous fishes, like butterfly fishes, as their food supply dwindles.

The starfish also avoid certain corals, like *Pocillopora* species, resulting in a relative increase in those species. Actually, as we've learned, it is small crabs, which live as symbiotic partners of the corals, that are avoided by the starfish. We recall from Chapter 14 that the crabs protect the corals by pinching the tube feet of the starfish.



*A crown-of-thorns-starfish dines on coral.*

### 15. 3. 5. Global Impacts of Crown-of-Thorns Explosions

Professor Charles Birkeland of the University of Guam has made the crown-of-thorns starfish a major focus of his research on coral reef ecology. The following paragraphs are from his investigations.

His studies pointed out a recent increase in the number of outbreaks of the crown-of-thorns starfish and **red tides**. The studies pointed to a relationship between sedimentation from land clearing and these increases.

Crown-of-thorns outbreaks are not the only tropical marine phenomenon that has increased in the past two decades. Red tides, dinoflagellate blooms, and paralytic shellfish poisoning have been increasing at a geometric rate in the western Pacific since 1975.

The clearing of land for agricultural and urban use has also accelerated in the past thirty years. This increases the runoff of nutrients and sediments in coastal regions.

If phytoplankton blooms increase the development and larval survival rates, then it is probable that *A. planci* outbreaks are related, in part, to increased coastal development in southeast Asia and the western Pacific.

Large-scale efforts to control outbreaks, like attempts to control red tides, the warming of the climate, and rising sea level, are probably not feasible, or at least are exorbitantly expensive. The problem will recur however, unless the causes are dealt with.

*A close up of the toxic spines of the crown-of-thorns starfish.*

The greatest effort at this time should be put into probing causes. We may discover that reducing the frequency and magnitude of outbreaks is a more complex task than we now realize. It may require even more careful management when developing coastal lands.

*The clearing of land for agricultural and urban use has also accelerated in the past twenty years.*

One important effect of the invasions of the crown-of-thorns starfish is a potential for reduction of corallivorous fishes. The number of fish, such as butterfly fishes, might decrease.

Herbivores eat plants. As algae come to dominate the surface of the reef, the relative percentage of their coverage may increase. Thus, a shift occurs in the community of organisms on the reef, resulting from an invasion of the crown-of-thorns starfish.

## 15. 4. CIGUATERA FISH POISONING

### 15. 4. 1. Introduction

On tropical reefs, there is a long history of episodes of serious food poisoning or even death after eating coral reef fishes. The first written account of an incident was in 1606, in Vanuatu (previously New Hebrides). A common name for one type of poisoning is ciguatera fish poisoning, or just *ciguatera*.

Any long-time resident in the islands of Micronesia can recall incidents of such poisoning. Many deaths have resulted from ciguatera.

Ciguatera is linked to environmental factors, but the nature of this link remains uncertain. One aspect is now understood: ciguatera toxin passes through the coral reef food chain of predatory fishes.

Small fishes contain small amounts of the toxin; large predators accumulate the toxin of many small fishes. Thus, the largest predators are far more toxic than the smaller ones.

*A.planci outbreaks maybe related in part to increased coastal development.*

Initial symptoms of ciguatera fish poisoning occur within about six hours after eating toxic fish. Indications may include numbness around the mouth and a tingling sensation in the arms and legs. There may be nausea, vomiting, and diarrhea. Headaches may occur. The seriousness of attacks varies; deaths are associated with respiratory and heart failure.

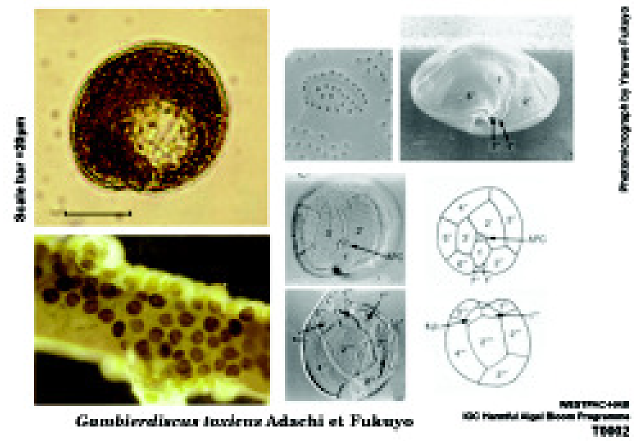
An incidence of ciguatera may involve an entire family, or an individual. Different people eating the same toxic fish will respond differently. A species of fish that is safe to eat on one reef may be poisonous on another reef only a short distance away.

It is difficult to generalize about ciguatera. A reef may be completely safe, yet suddenly, and without warning, fishes from that reef may be toxic. There is not generally a clear indication of when this might happen. Large predatory fishes are the most problematic. Even so, other types of fish poisoning are present on the coral reef that involve non-predatory species of fishes.

For many years, people associated ciguatera with large fishes that eat other fishes. A number of hypotheses were proposed, but no causitive agent could be found.

One hypothesis said ciguatera came from microscopic algae growing on reef surfaces that were damaged by dynamiting or other destructive incidents.

Finally, in the Gambier Islands of French Polynesia an organism was discovered that causes ciguatera. It is a dinoflagellate. In honor of the Gambier Islands, and because of its disc-like shape and toxic nature, it was named *Gambierdiscus toxicus*.




*The dinoflagellate Gambierdiscus toxicus.*

The discovery of the agent that causes ciguatera led to the discovery of the toxin responsible for the symptoms of ciguatera. The toxin was named *ciguatoxin*. Research on this toxin has led to a much better understanding of the disease.

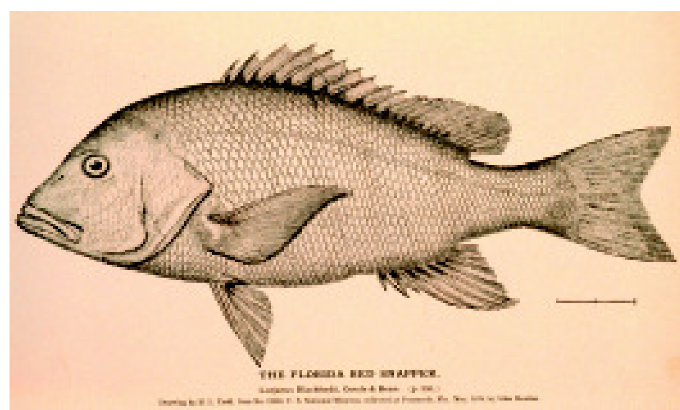
### 15. 4. 2. Biomagnification

Ciguatoxin moves through the food chain. It becomes more concentrated at each step, until significant quantities of the toxin may accumulate within the tissues of larger fishes.

At this point in the food chain, these fish are poisonous to humans. This process is called **bioaccumulation,** or **biomagnification**. The name indicates the way that the toxin becomes more and more concentrated as it moves through the food chain.

Like other dinoflagellates, *Gambierdiscus toxicus* has two flagella. One of these flagella is used as an anchor line to fasten the dinoflagellate to stones or algae. Often, these toxic dinoflagellates are attached to the brown algaes *Sargassum spp.* and *Turbinaria spp.* These algae are found in inshore reef areas.

The toxin is produced in minute amounts by each of the microscopic dinoflagellates. The teeth of *Ctenochaetus striatus*, the Bristle-toothed Tang, are specialized for brushing microscopic food off of surfaces. These fishes browse on *Gambierdiscus*, brushing them from stones or algae.




*Top-level predators on the reef, such as the Red Snapper, are often highly ciguatoxic.*

Individually, these fishes do not accumulate enough toxin to be dangerous. However, when many of these small fishes are eaten by predators, their lifetime accumulation of toxin is concentrated in the tissue of the predators.

Further along the food chain, larger predators consume smaller predators. The toxin becomes even more highly concentrated. Under certain conditions, larger fishes may become toxic. This is possible because the toxin does not readily break down as it moves through the food chain. It accumulates, or rather, bioaccumulates.

### 15. 4. 3. Human Responses

As mentioned, two people may eat the same fish and yet show different responses: one may become seriously ill, and the other show no symptoms whatsoever. This difference in response is associated with one's previous history of consumption of reef fish. Just as the toxin does not break down in the food chain, it does not break down in our systems.

Continued consumption of reef fish may result in accumulation of ciguatoxin in low levels. Finally, a single fish may provide a relatively small dose of ciguatoxin, elevating the level of one's internal toxin to a more serious quantity. The same dose in a second person, who does not consume much reef fish, may not be enough to trigger an episode of ciguatera. Only a small amount can trigger the disease by elevating the level of toxin above a threshold.

*Gambierdiscus toxicus is often found attached to Turbinaria spp.*

### 15. 4. 4. Avoiding Ciguatera

This information suggests a need to take extreme precautions when larger predators, like barracuda, snappers, and eels, are eaten. Fish-eating predators are involved (although other fishes may be toxic due to other reasons). Further along the food chain, larger fishes have the greater chance of bearing harmful amounts of toxin.

Local methods for identifying toxic fish, such as placing a nickel in a cut in the muscle of the fish, cannot be trusted. Kits are now available to test a fish for ciguatoxin. Until these kits become more available locally, however, it is wise to exercise caution in eating large, predatory fishes. As mentioned, there are other types of reef fish poisoning, but ciguatera is probably the most common.

### 15. 4. 5. Ciguatera and Environmental Factors

Ciguatera may be related to environmental conditions. However, no definite cause has been shown. Possible links have been pointed out with environmentally stressed, damaged reefs. Yet these factors do not seem to be required. Some scientists believe outbreaks are related to newly exposed surface areas. Nonpoint source nutrient pollution is also being studied as a possible factor.

## 15. 5. RED TIDES: THE BLOOD OF SAN VITTORES

Toxic dinoflagellates are the agents of another major problem: *red tides*. Red tides are dinoflagellate blooms. They are often associated with an excess of nutrients in the environment, such as occurs during **upwellings**.

*Ctenochaetus striatus, the Bristle-toothed Tang, browse on Gambierdiscus.*

Red tides involve such numbers of these organisms that, although they are microscopic, the water is often colored red. In many cases, red tides are bioluminescent: breaking waves appear lit up, typically with a greenish light.

An important example of a red tide in the Mariana Islands is "The Blood of San Vittores". It is an annual bloom of dinoflagellates in the northern end of Tumon Bay, Guam. This was the site where the killing of the Spanish missionary, Padre San Vittores occurred. Because of the red color of the water, it has become known as "The Blood of San Vittores."

It is a seasonal phenomenon because of the nutrient dynamics associated with the circulation and water table hydraulics at this site.

Other red tides also occur when nutrients are enriched, such as the red tides of Southern California. These red tides are correlated with large pulses of nutrients. The upwelling of nutrients is associated with annual cycles of currents.

## 15. 6. IMPACT OF TYPHOONS ON REEFS

Typhoons have a severe and direct impact on coral reefs by wave action. Waves can physically break off sections of reef and toss them up on the reef platform.

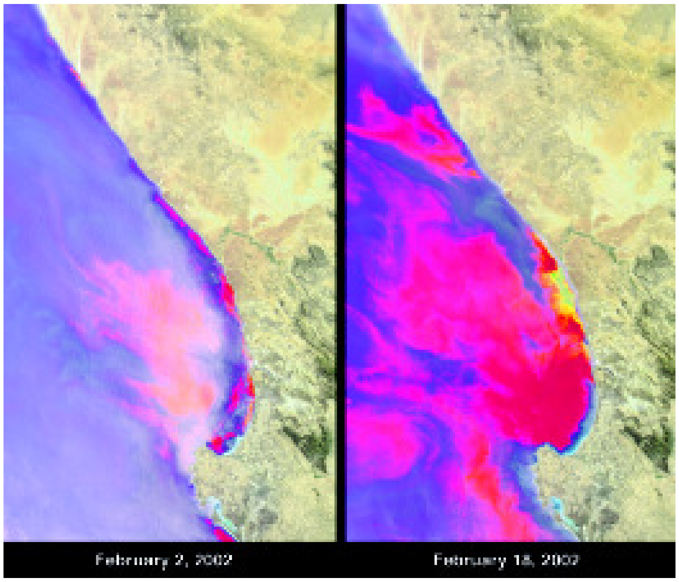
Typhoons alter the structure of reefs. Small **cays** (small sand islands on or near reefs), like Managaha Island at Saipan, and even large reef islets on atolls, are initially formed by waves throwing boulders, gravel, and sand up onto the reef.

Corals are adapted to recovery from this damage. Because they are colonial animals, corals are sometimes able to survive fragmentation. As long as a few polyps remain alive and healthy, the fragment can begin to grow at its new location.

The fragment is able to cement itself to the substrate at its new location. As a result of this process, many of the colonies of a single species of coral on any given reef may be **clones**. They are genetically identical, just like identical twins.

Some corals, such as *Porites sp.*, can continue to grow even though they are not attached to the reef. As waves roll them around, these fragments continue to grow, forming a spheroid.

Similarly, coralline algae can also be fragmented by storms. Like corals, they are able to reestablish themselves. Some species of coralline algae are characteristically 'free living'. They do not cement themselves to the reef substrate.



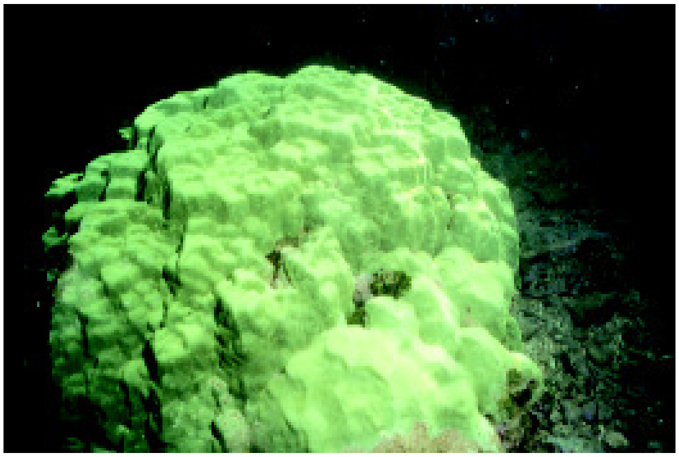

*Red tides involve such numbers of these organisms that, although they are microscopic, entire ocean areas are often colored red.*

## 15. 7. SEA LEVEL VARIATIONS

### 15. 7. 1. Sea Level Fluctuations

The islands of the Northern Mariana Islands have been uplifted during the past 50 million years. The sea level of the oceans, too, constantly changes, and the Mariana Islands have witnessed radical sea level fluctuations during their history. Fortunately, since the last ice age—about 6,000-10,000 years ago—the sea level has been relatively stable.

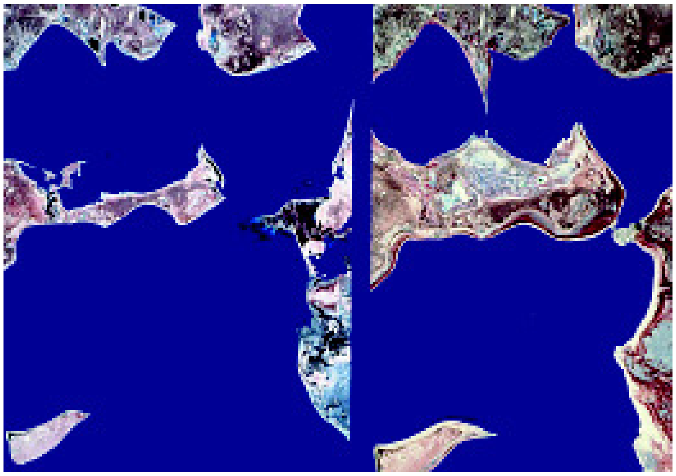
A cooling of the atmosphere causes more ice to form at the North and South Poles, drawing much water from the oceans. This results in a lowering of sea levels. During the ice ages, sea levels were about 300 feet lower than they are today. Warming of the atmosphere causes melting of polar ice, returning much water to the seas. This results in a sea level rise.



*Some corals, such as Porites sp., can continue to grow even though they are not attached to the reef.*

During the past three decades, the scientific community has grown increasingly concerned that the atmosphere may be warming. The scientists fear that sea levels may rise during the 21st Century due to melting of polar ice.

Such sea level change, if it happens, will have dramatic effects on coastal communities throughout the world. It is not clear that coral reefs would be able to continue their upward growth. Some reefs may survive such a sea level rise. Coral reefs that cannot continue their upward growth might die. Micronesian coral islands and atolls, as well as coastal plains, like Chalan Kanoa, would be severely affected.



*Satellite photos showing sea level change over a 20-year period in the Aral Sea.Not exactly from global warming but clearly human-caused, this change resulted from huge agricultural water diversion projects.*

### 15. 7. 2. Sea Level Change and Global Warming

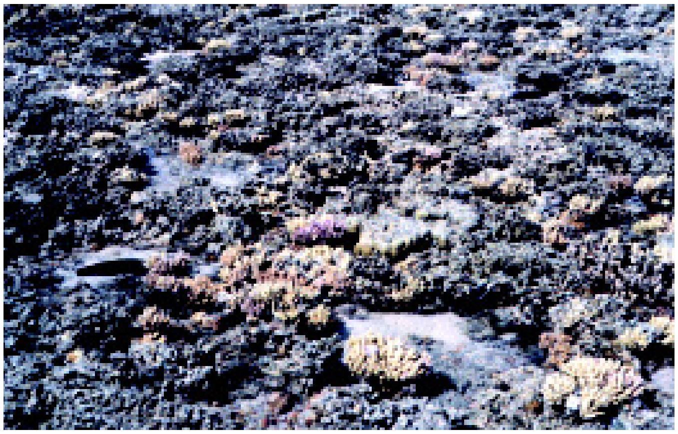
In recent years, concern has grown that the earth's atmosphere is changing due to human causes—especially the burning of fossil fuels and the cutting down of forests. Changes in the atmosphere include increases in carbon dioxide (**$CO_2$**) and other gases.

$CO_2$ enhances the atmosphere's ability to retain heat. Decreasing the loss of heat to space would result in a gradual warming trend on earth. Such an effect is called **global warming**. It is this global warming trend that may cause the feared melting of polar ice. As the water returns to the ocean, the sea level will rise.

During the 1990s weather was warmer than normal, triggering fears that global warming is indeed underway. A large number of research projects now focus on the issues involved in $CO_2$ (greenhouse gas) levels and on long term climate trends. It is hoped that we will better understand the phenomenon of global warming, and its possible effects as a result of this research.

During El Niño years, warmer than normal sea temperatures occur over much of the globe (see Chapter 8). El Niño by itself does not indicate a long term warming trend. An understanding of the effect on coral reefs of the warm waters of El Niño could help us better understand the possible effects of global warming. Perhaps we can be better prepared.

### 15. 7. 3. El Niño and Coral Reefs



*Abnormal low tides, such as the one in 1976, can kill hundreds of thousands of corals.*

Sea Level Anomalies

El Niño conditions are accompanied by drastic changes in sea levels. In the Eastern Pacific, near South America, sea levels may be higher than normal.

The Equatorial Counter Current is stronger during in El Niño years, enhancing its ability to carry water away from the W. Pacific to the E. Pacific. The result is that tides may be lower than normal in the Western Pacific. This often happens in November or December as the El Niño begins to develop.

Corals, coralline algae, and certain other reef organisms are distributed in very well defined zones. Some are found only in wave washed zones or very shallow water, but never very far from the tidal zones. Such species are especially adapted to tides. An abnormal drop of sea level by 20 centimeters may be fatal to many such organisms.

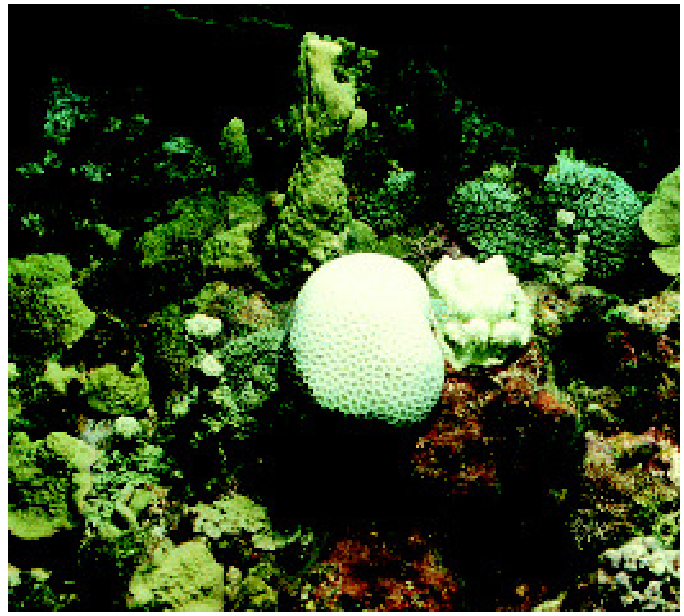
Because corals and coralline algae grow on the reef according to optimum depth, these abnormal tides cause widespread death of intertidal organisms. Such was the case in Guam and the Northern Mariana Islands in 1976 when abnormally low tides killed hundreds of thousands of corals.

Bleaching

Corals are extremely sensitive to temperature. They are tropical and are not found in cool waters; yet they cannot tolerate waters even one or two degrees higher than 28°C, even for a short period.

Exposure to higher temperatures may cause corals to expel their symbiotic partners, their zooxanthellae. Because the color of most reef corals is due to their zooxanthellae, the corals turn bleached white, and this phenomenon has been termed **coral bleaching**.

Coral bleaching has recently occurred over widespread areas of the globe, this is in response to episodes of higher than normal sea temperatures due to El Niño. Greenpeace reports several earlier bleaching events over past years. Most of the coral's food comes from the photosynthesis of the zooxanthellae. If the event is long-lived, corals may starve and die.



*Since the color of most reef corals is mainly due to zooxanthellae, corals turn white if the zooxanthellae are gone.*

Bleaching Events in 1997-1998

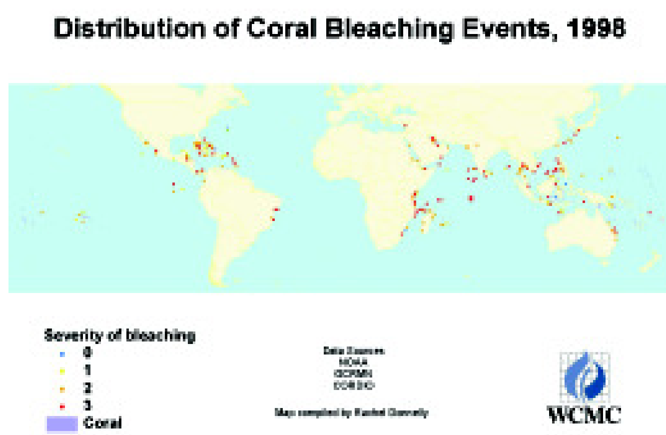
Associated with elevated sea temperatures attributed to the severe 1997-1998 El Niño were many bleaching events, scattered across the globe. This is the best documented series of bleaching events to date.

During those years, bleaching of corals was reported at many locations, including Indonesia, Oman (The Arabian Gulf), Papua New Guinea, Florida, Cambodia, Sri Lanka, the Seychelles, N. W. Brazil, Mozambique Channel, Réunion and Mauritius, Panama, Kenya, the Galapagos, the Great Barrier Reef, Belau, and American Samoa. Reports began to trickle in before the New Year, and continue into July 1998, the time of this chapter's writing.

## 15. 8. NATURAL PROBLEMS ARE AGGRAVATED BY HUMAN IMPACTS

We have been considering naturally occurring problems for coral reefs. Many of these problems are completely beyond any possibility of human control. However, in many cases, humans have altered the ecological balance on reefs so much that reefs are more vulnerable to the effects of natural physical changes.

For example, a reef that has been damaged by crown of thorns starfishes, or typhoon waves, may not recover if corals are affected by toxic pollution.




*Coral bleaching has recently occurred over widespread areas of the globe.*

## 15. 9. HUMANS AND THE CORAL REEF; INTRODUCTION

We now take up our consideration of human impacts on coral reefs. We can do little, or nothing, about the natural coral reef problems that we have been discussing. But we now turn our attention to problems that we can do something about—our own impacts on coral reefs.

Many of the things we do affect coral reefs, often in ways we would not expect. We may understand that dynamite fishing can damage a coral reef, but how can farming affect a coral reef that is miles away? Or building roads or hotels?

Many coral reefs in developing countries or on islands are being affected by activities associated with economic development. If we recognize and truly understand these activities, perhaps we can act together as a community to prevent or lessen their impacts. As you go through this section, pay special attention to those problems that involve reefs in the CNMI.

*Superior technology, both gear and methods, increase the harvesting capacity of fisherman on the reef.*

## 15. 10. FISHING AND OVERFISHING

### 15. 10. 1. Introduction

Much of the protein eaten by the earliest Mariana Islanders was from the sea. Much of it was from subsistence reef fishing based on an astute knowledge of local marine life and environments.

The early people also had a shrewd fishing technology. Fishing at its best is based on a harvest of renewable resources. By harvesting the reef at continuous, but low levels, the community would have had sufficient fish much of the time, essentially forever.

However, some time later in history, that began to change. New and vastly superior technology, both gear and methods, increased the harvesting capacity of each fisherman on the reef. SCUBA is one example.

Today, as most of us are aware, many reefs of the CNMI have been overfished. This is due to an increase in fishing pressure and vastly more effective fishing techniques. Coral reef fishes depend upon a food web that is unable to support large scale commercial harvests.

### 15. 10. 2. Net Fisheries

At the time of this book writing, net fishing on the coral reefs of the CNMI includes the use of both *talaya* and long nets. Modern nets are made of strong, and virtually invisible monofilament nylon. Even if they are biodegradable, when they are lost on the reef, these nets may remain in good condition for a very long time.

Gill nets, commonly available in the islands, catch fish passively. They are spread out across an area of reef. As long as they remain on the reef, fishes become entangled in them.

*Gill nets catch fish passively and are spread out across an area of reef. As long as they remain on the reef, fishes become entangled in them.*

These nets, sometimes called "long nets" continue to "fish" even years after they may have been lost or discarded on the reef.

If uncontrolled as to mesh size, these nets catch even the most minute fishes. It is important for the size to be controlled since small mesh nets can be particularly destructive. Though the CNMI applies a size requirement on these long nets, many non-target species are still caught unintentionally.

Even if a long net is only snagged lightly on the reef and is recovered, damage is likely to result. Corals are pulled free or broken by the fisherman. *Talaya* nets, or throw nets or cast nets, as they are sometimes called, do not trap fish without a fisherman present like long nets. However, some damage may result to corals when a fisherman attempts to free a tangled net.

[Ed. Update Note: Long nets have recently been outlawed in the CNMI.]

### 15. 10. 3. Hook and Line Fishing

Bottom fishing or spin casting is perhaps a bit less damaging than nets, especially long nets. Monofilament fishing line, however, is extremely tough and can easily become snarled and persist on the reef.

### 15. 10. 4. Other Destructive Fishing Practices

Fishing with explosives and poisons is destructive and unwise. Any fishing method that causes damage to the reef will result in smaller catches in the future.

Both explosive fishing and use of poisons kill fishes and other marine life unselectively. In addition to target species, small fishes and invertebrates—some of them food for larger fishes—are killed. Juvenile fishes are killed before they have a chance to grow to maturity—and to edible size. Killing fish before they reach reproducible size eventually depletes the fishery as a whole.

Explosives pulverize or damage corals, interfering with natural processes of reef building and maintenance. Physical damage and breakage leaves behind stony rubble. Gone are the hiding places of small fishes and the nooks and crannies that are home to the many reef inhabitants.

The entire reef community is deeply affected by these practices. Unfortunately, the effects of this kind of fishing are long lasting—a 600 year old coral, as big as a pickup truck, destroyed in a single thoughtless moment, will take many hundreds of years to grow back.

If the structure of the reef is spared (at least until the rock crumbles because it is not maintained by corals and coralline algae), poisons may still penetrate deep into the reef. There they kill a broad range of reef creatures. And poisons, like explosives, are unselective.

Even the tiniest reef organisms are killed. The reef is deprived of the services of plants and animals with a variety of individual roles. It is impossible to imagine all the possible consequences. Symbiotic partners are separated, food supplies are interrupted, and survivors are left sick, in a state of stress.

These fishing methods are illegal in the CNMI, but some people continue to use them.

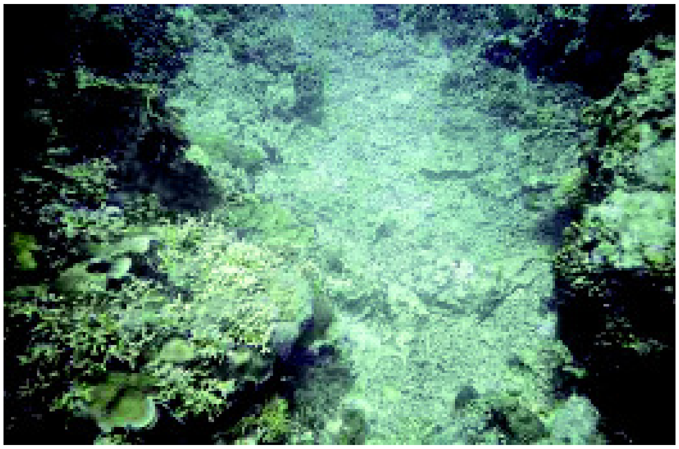
### 15. 10. 5. Commercialization vs. Subsistence Use

Commercialization of fisheries often leads to over-exploitation. The subsistence fisherman, on the other hand, may leave a few fish, octopi, or clams behind, and, in a sense, crop the reef.

If he leaves some fish today, his family will eat again. However, the commercial fisherman is not easily discouraged from taking another octopus that may mean $5.00 more in his pocket.

When expenses stack up for fishing gear, gasoline, oil, and fiberglass boats, commercial fishermen will feel the pinch. They will attempt to make up for this by fishing a bit harder, increasing their take beyond immediate need.


*Fishing with explosives and poisons is destructive and unwise.*



*The entire reef community is deeply affected by these practices.*

*Tourism has been marketed around recreational uses of the platform of the unique coral reef environments of our islands.*

*Pollution that comes from a diffuse source, or from multiple, poorly defined sources, is called nonpoint source pollution.*

The outlook is gloomy for coral reefs. We have seen that reef communities are living at the limits of the available nutrients. They are based mainly upon the symbiotic relationship between corals and zooxanthellae. There is not a wealth of nutrients available to these communities.

Island fishermen can attest to the ease of overfishing a particular reef. These observations may lie behind the traditional reef management systems that relied on reef closures.

## 15. 11. ECONOMIC DEVELOPMENT AND CORAL REEFS

Recreational use of coral reefs and beaches is an important part of island life. Tourism has been marketed around recreational uses of the unique coral reef environments of our islands.

As such, economic development on many of the islands has been built, at least in part, upon the underpinnings of the coral reef. It is important to recognize possible destructive aspects of such economic development, as well as the need to reinforce the integrity of the coral reef based on its economic value. On Saipan, the growth of the hotel industry has resulted in expansion, in some cases, beyond the capacity of the island's infrastructure.

For example, despite great efforts by the Commonwealth Utility Corporation, the Environmental Protection Agency and others, the sewage systems in the CNMI have not been able to keep pace with our economic development and our homestead developments. [Read more on this in our infrastructure (Ch. 33) and water pollution (Ch. 41) chapters.]

In the current section, we will take into account some of the impacts of economic development.

### 15. 11. 1. Nonpoint Source Pollution

When pollution comes from a specific, localized source, it is often referred to as *point source pollution*. Point source pollution is easily traced to its source. Examples of point source pollution include chemical pollution from factories, sewage pollution from a sewage plant, or gasoline leakage from an underground storage tank.

Pollution that comes from a diffuse source, or from multiple, poorly defined sources, is called *nonpoint source pollution*. An example of nonpoint source pollution is the water pollution from unknown or undefined sources that enters the ocean from runoff during a storm.

Nonpoint source pollution can be just as destructive as point source pollution, but is harder to deal with because offenders may not be known. It is best to deal with nonpoint source pollution on a watershed by watershed basis.

Several agencies in the government of the CNMI have begun a progressive program to focus on nonpoint source pollution. The program will examine the effects of nonpoint source pollution on local coral reefs. The initial phase of the program focuses on Lau Lau Bay.

### 15. 11. 2. Sedimentation

Corals flourish in clear ocean water; sediments like sand, mud, and silt are inimical to their health. Heavy rainfall washes large amounts of mud, silt, clay, and sand from the uplands, especially where the soil has been exposed, and carries it to the sea. This process of sedimentation creates severe problems for corals. Construction and road building, involving the scraping of vegetation from the surface of the earth, provide opportunities for increased sedimentation.

As you read this chapter, weigh the evidence. In the balance are the far-ranging impacts of specific development projects on the environment. These must be weighed against potential burdens to economic development by regulations designed to control and/or reduce sedimentation.

Our Mariana Islands are small, but there is rapid and large-scale economic development. Consequently, sedimentation is one of the most severe problems faced by our coral reefs.

*Sediment traps are an important monitoring tool.*

## 15. 12. THE MONITORING OF OUR CORAL REEF'S HEALTH

### 15. 12. 1. The Lau Lau Bay Marine Monitoring Project

The CNMI Division of Environmental Quality has implemented a pilot project to assess the health of our coral reef. It has done this with the Coastal Resources Management Program, Northern Marianas College, and the Division of Fish and Wildlife.

The study was initiated in response to an observed decline in the quality of the reef at Lau Lau Bay. The project is designed as a pilot or *demonstration* study. Several techniques are being used to monitor the health of reefs all over the CNMI. This intensive monitoring was begun at Lau Lau Bay in 1997.

### 15. 12. 2. Observing Butterfly Fishes as Reef Health Indicators

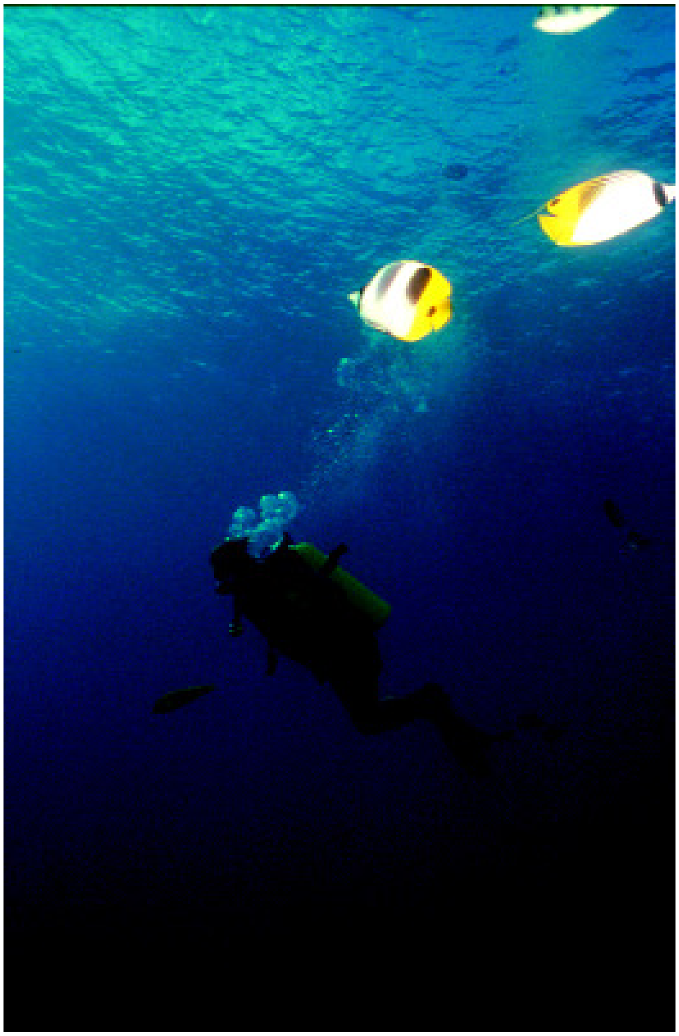
Changes in the health and vitality of corals are difficult to detect. Malnutrition, borderline starvation, or toxic effects due to pollutants are not easy to observe. In the laboratory, effects of starvation or exposure to toxic pollutants may be studied; however, even there, studies are difficult and hard to interpret.

*Researchers in the CNMI are implementing an innovative coral reef monitoring program, employing butterfly fishes as reef watchmen.*

Researchers in the CNMI who are implementing an innovative coral reef monitoring program, are employing butterfly fishes as reef watchmen.

Research by Dr. Ernst Reese of the University of Hawaii and Dr. Michael Crosby of NOAA has shown that butterfly fishes can recognize the changes in coral reef health more easily than biologists. Slight changes in the health of corals is reflected in observable changes in butterfly fish behavior and ecology.

For example, a decrease in food supply (due to unhealthy corals on a reef) may be reflected in a decrease in the number of coral-eating butterfly fishes on the reef. Some corallivores would have to leave the reef, starve, or die.



*Butterfly fishes can recognize the changes in coral reef health more easily than biologists.*


*Human activities have a significant impact on coral reefs.*

Simple counts of the number of butterfly fishes in certain areas may tell the biologist that the quality of the reef has declined. At the time of this book's writing, local biologists were adopting methods to estimate the population of coral-eating butterfly fishes on the reefs of the CNMI.

When the food supply dwindles, corallivore butterfly fishes compete more. Increased aggression may be directed against other corallivores. Observant biologists can notice these increases in aggression, and draw conclusions about the health of the reef. Such work requires a thorough knowledge of the reef and behavior of fishes.

Some butterfly fishes are territorial, and maintain **home ranges** or territories by excluding other members of the same species. **Monogamous** butterfly fishes live their entire lives in pairs. Some maintain territories, from which other pairs are excluded. According to one hypothesis, butterfly fishes respond to a decline in the quality of the food supply by increasing the size of these territories.

Drs. Crosby and Reese worked with CNMI divers to test this hypothesis. Territories can be measured by following the fish around, and dropping markers at the spots where they feed. Later, when markers are picked up, the territory can be measured and mapped.

It is anticipated that data on the size of the territories will provide an indication of stress on specific sections of a reef. Corals are expected to respond to environmental stresses by a decline in vigor and health. Fishes are expected to enlarge their territories in response to a decline in the quality of their food, the corals.

The CNMI is fortunate that an innovative set of programs has formed to support coral monitoring programs. The Northern Marianas College (NMC) has offered training in Scientific Diving for Marine Technicians from the DEQ, CRM, and DFW offices. The courses included instruction on ecology and on data collection techniques and safety. Divers study marine biology, including the biology of the butterfly fishes and corals.

### 15. 13. THE CORAL ANIMAL TRADE

Aside from reef fisheries, many coral reef organisms are trade items. Shells of giant tridacnid clams and coral skeletons are sold for decorative purposes. The mollusk shell trade is for shell collecting and for display as curios. The now-internationally-banned turtle shell market is another example of trade for decoration.

The live fish aquarium trade is likewise, an example of this type of enterprise. A direct consequence of the export of aquarium fishes and invertebrates is the depletion of native populations on the reef. The CNMI bans the export of live reef life for this reason. The ban includes fishes, invertebrates, corals, and live rock.

The impact of animal trade is direct: the commercialization of reef products. Commercialization of any natural product presents strong temptations.

When the reef was under traditional controls, there was **reef tenure**. Over-exploitation or over-harvesting of reef species was seen as detrimental to the community or the individual reef *owner*. Measures to prevent over-exploitation evolved. These include reef closures and ownership of specific species.

Subsistence fisheries avoid the problem of over-exploitation. The fishermen recognize the possibility of depletion of their food supply. They take only what they need. They leave enough behind for future harvests. However, commercialization raises the specter of spectacular short-term increases of private income.

Unlike subsistence fishermen, commercial fishermen are faced with the prospect of as much as $22.00/lb. for processed sea cucumbers. Given this, they are unlikely to leave very many behind. Commercial fishermen need to understand that they have to leave some behind if they want to take more tomorrow. However, recent scientific research is suggesting that coral reefs may not be able to support commercial "export" fisheries at all.

For the same reasons, animal trade presents a similar temptation. It is often disguised as a harvest that is innocuous because the resource is not utilized within the local culture. This is the case for sea cucumbers on many islands. However, such harvests can have indirect effects, such as the loss of the sand-cleaning sea cucumbers, for many years to come.

*Faced with the prospect of as much as $22.00/lb. for processed sea cucumbers, commercial fishermen are unlikely to leave very many behind.*